ARTICLE IN PRESS
JID: EOR [m5G;June 24, 2019;10:43]
European Journal of Operational Research xxx (xxxx) xxx
Contents lists available at ScienceDirect
European Journal of Operational Research
journal homepage: www.elsevier.com/locate/ejor
Interfaces with Other Disciplines

Optimal risk management for the sharing economy with stranger danger and service quality

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A R T I C L E I N F O

Article history:
Received 15 July 2018
Accepted 11 June 2019
Available online xxx

Keywords:
OR in marketing
Consumer perceived risk
Sharing economy
OR in government
Policy making

A B S T R A C T

The recent transition in consumers' consumption behavior from owning to sharing has led to rapid growth in the sharing economy. Despite the advantages of the sharing economy such as convenience and affordability, consumers' perceived risk formed by possible physical injury from strangers or unexpected poor service quality disturbs their active participation in the sharing economy. In this paper, we develop an analytic framework for managing two different types of perceived risk associated with the sharing economy: *physical risk*, incurred by safety concerns, and *performance risk*, caused by unsatisfied service quality. Our model considers both the platform provider's investment to alleviate the physical risk, and the effectiveness of the word-of-mouth mechanism to reduce the performance risk. We find that as the performance risk increases, the abundant word-of-mouth of the sharing platform may lead to an increase in demand, but it does not increase profit. When the physical risk increases, the word-of-mouth effect does not contribute to both demand and profit growth. Unlike word-of-mouth, the investment in safety improvement brings higher profit, along with higher demand. Furthermore, we explore three possible policy scenarios where government intervenes to reduce the physical risk, and then identify an optimal policy depending on circumstances.

1. Introduction

The recent proliferation of sharing economy platforms has received growing attention from both academics and practitioners. Two sharing economy platforms have recently been at the center of this interest: Airbnb, an online peer-to-peer platform providing room or home sharing service, which enables people to rent short-term lodging; and Uber, an online peer-to-peer platform providing ride sharing as a pick-up service, which connects passengers with private drivers. These two leading platforms have been valued at $25.5 billion and $62.5 billion, respectively, despite being less than a decade old (Ramirez, Ohlhausen & McSweeny, 2016). Besides such room or ride sharing, the scope of sharing is further widening from office sharing and meal sharing, to even clothes sharing, by transferring control over transactions to consumers (Marchi & Parekh, 2015). Economic gains by saving money and time, as well as enjoyment of the activity, have played an important role in the rapid growth of the sharing economy (Hamari, Sjoklint & Ukkonen, 2015).

In spite of the aforementioned advantages, this method of consumer-to-consumer transactions among non-professionals may bring up an issue of risks that the consumers perceive from participation in the sharing economy. The perceived risk, which refers to the consumers' subjective belief of suffering a loss in pursuit of a desired transaction outcome, has extensively been addressed in the social academic domain, and more recently in the context of online transactions (Bauer, 1967; Pavlou, 2003). Since the sharing platforms are based on an online transaction, the perceived risk also resides in the sharing economy. Nevertheless, the risk management issue has been little examined for the sharing economy. In this paper, we divide the perceived risk into two types, *performance risk* and *physical risk*, and then study how to manage these two risks.

First, the performance risk is the possibility of feeling buyer's remorse, such as the sense of regret after having made a purchase, due to the discrepancy between the expected value and the actual value. In the sharing economy, this risk may result from the lack of professionalism. Compared to traditional business, such as hotels or taxi companies that comprise professional and trained personnel, the sharing platforms usually offer less professional and less standardized products or services, because the sellers can post their assets on the list of sharing platforms, with little or no investment in establishing business reputation or obtaining a

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https://doi.org/10.1016/j.ejor.2019.06.020
0377-2217/

Please cite this article as: J.H. Hong, B.C. Kim and K.S. Park, Optimal risk management for the sharing economy with stranger danger and service quality, European Journal of Operational Research, https://doi.org/10.1016/j.ejor.2019.06.020

certificate. The consumers may thus often experience inconvenience, due to unstable product, or poor service quality. For example, Uber drivers sometimes choose unfamiliar or inefficient routes, because they are not full-time professional drivers. An Airbnb guest may suffer an unpleasant experience owing to a complete misrepresentation, because the rented apartment was dirty, remote from what is presented in the advertisement, or even had no amenity. Thus, consumers perceive the risk from undesirable performance, which frequently occurs in online commerce, including the sharing platforms.

Second, the physical risk is the possibility that products or services are harmful to an individual's physical and mental health (Kaplan, Szybillo & Jacoby, 1974). This risk implies the possibility of traumatic physical injury, caused mainly by strangers or unfamiliar environments, which is often called "stranger danger." Transactions with strangers inherently accompany a feeling of insecurity, such that the stranger may hurt the consumer, and the users of sharing platforms remain at uncontrollable risk, which might lead to catastrophic consequences. For instance, in 2017, a family renting a house through Airbnb in Greece was robbed on their first night. More serious incidents have occurred in the ride sharing business, such that a young female was killed by a San Francisco Uber driver in 2014, and a woman was sexually assaulted by a Texas Lyft driver in 2017. A point to be noted is that Uber's terms and conditions state that the entire risk of using the service lies on the user-side (Smith & McCormick, 2016). It is also important to note that Airbnb guests have responded that Airbnb secures the consumer safety worse than traditional hotels do, thereby suggesting to Airbnb the need for safety improvement (Guttentag, 2016).

Meanwhile, word-of-mouth through consumer review is the most common risk-hedging tool in the sharing economy, because it leads to positive feedback loops (Cusumano, 2015). Most of the consumer reviews in the sharing platforms are related to their service quality, rather than the safety aspect. The rating system can therefore alleviate the performance risk, because it helps consumers choose satisfactory goods or services. However, although the review systems are becoming more sophisticated, the concerns of physical injuries, such as crime or an unpredictable incident, are increasing worldwide. In a survey conducted on the city leaders in America, 61% of cities answered that safety is their top concern about peer-to-peer services (Peltz, 2015). In other words, whereas sharing platforms deal heavily with establishing effective rating systems, efforts to prevent physical risk are still insufficient. Despite the existence of physical risk and the need for safety improvement in the sharing economy, the question of how to address the safety issue still remains unanswered among researchers.

In this paper, we therefore study the implications of the two types of risks that are perceived by consumers in the sharing economy: physical risk, caused by safety concerns, and performance risk, led by low quality. Specifically, an analytical model is built to examine the possible impact of the platform provider's investment in reducing physical risk on the profit of the platform. This model is based upon the concept of the self-selection of consumers, originally developed by Mussa and Rosen (1978) and later employed to model various problem settings, including product line design (Moorthy, 1984; Moorthy & Png, 1992). The self-selection concept used in this paper means that, if the utility from the sharing platform exceeds that from the traditional company, the consumer will choose the service offered by the sharing platform. Our model also covers the word-of-mouth effects on the platform efforts to manage the two types of risks. This analytical model is still extended to explore three possible scenarios of government intervention to reduce physical risk: (a) direct-fixed intervention, (b) direct-variable intervention, and (c) indirect-variable subsidy. An analysis of identifying an optimal policy is then demonstrated herein.

Some of the key findings of this study are as follows: When the performance risk increases, the abundant word-of-mouth increases demand, but it does not increase profit. If the physical risk increases, then word-of-mouth may not contribute to demand and profit growth. Unlike word-of-mouth, investment in safety may lead to more demand and higher profit. If the platform provider invests to improve consumer safety, it is expected that she can set a higher price and hence create more demand than the case of no investment. On the other hand, as the word-of-mouth effect increases, the effect of profit enhancement increases. This is because the optimal amount of investment is positively related to word-of-mouth. As for the three policies of government intervention, an optimal policy varies depending on whether the top priority of the policy maker is given to consumer safety or growth of the sharing economy.

1.1. Remarks

The above findings are based on the fact that the word-of-mouth in the sharing economy is mostly related to the performance risk, rather than the physical risk. We therefore assume in our analytical models that the word-of-mouth can alleviate the performance risk, but it does not reduce the physical risk. However, as time passes, if some positive reviews about safety appear in the sharing economy, then it is needed to consider the case that the word-of-mouth for safety can alleviate the physical risk. This case is considered in Appendix B, where the word-of-mouth is divided into two; one for service quality and the other for safety, both of which are assumed to alleviate the performance and physical risk, respectively. We then provide the results from these analyses, some of which are somewhat different from the findings in the body of this paper.

The remainder of this paper is organized as follows. Section 2 reviews related literature. Section 3 outlines the general model with consumer utility, including the two types of risks. Section 4 examines the impact of word-of-mouth and investment in safety improvement on the risks for use in risk management. Section 5 then extends the model to policy scenarios, and discusses policy implications. Finally, the paper closes with concluding remarks in Section 6.

2. Literature review

The term 'sharing economy' describes a socio-economic phenomenon characterized by non-ownership, temporary access, and redistribution of material goods or service, such as an automobile, space, or time (Belk, 2014; Botsman & Rogers, 2011). In practice, the huge success of some companies using the sharing concept, such as Airbnb, Uber, and Zipcar, has stirred much attention, and poses a serious threat to some incumbent industries. In the sense that those companies play the role of a platform intermediary, the platforms in the sharing economy can also be perceived as a two-sided market, where a platform invigorates interaction between end-users, and attempts to involve the two sides by efficiently setting the prices (Rochet & Tirole, 2006). Interest in understanding two-sided markets has started to discern differences from traditional business strategies, such as platform competition and price setting (Armstrong, 2006; Eisenmann, Parker & van Alstyne, 2006; Rochet & Tirole, 2003), and network externalities (Liebowitz & Margolis, 1994; Parker & van Alstyne, 2005). Other works on the two-sided markets include Lee and O'Connor (2003) and Caillaud and Jullien (2003). With the characteristics of two-sided markets, the sharing platforms focus on facilitating the exchange of durable goods and other assets that are not in use. Contrary to general two-sided markets where the demand for one side depends on its

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price and on network externality on the other side (Katz & Shapiro, 1985; Parker & van Alstyne, 2005), the demand of sharing platforms, in particular, the demand of the consumer side, depends on the traditional firm's price and quality (Weber, 2014). Thus, we focus on the sharing platform providers who strive to attract as many consumers as possible from incumbent companies, such as taxi companies or hotels.

As the sharing economy is an entirely new paradigm of consumer behavior, it has mainly been dealt with by consumer research, in an attempt to analyze the phenomenon of sharing, and then understand the mechanism (Bardhi & Eckhardt, 2012; Belk, 2010). In terms of car sharing, Bardhi and Eckhardt (2012) examine the nature of access as it contrasts to ownership, via an interpretative study of Zipcar; and Cohen and Kietzmann (2014) discuss shared mobility business models, to find the optimal relationship between agents and governments. More recently, Operations Research and its related areas are also starting to pay attention to the sharing economy. Speranza (2018) states that it will not take long to see a shared vehicle connected to a wide network of road infrastructure and public transportation options. Jiang and Tian (2018) investigate the impact of product sharing on a retailer or a manufacturer in the domain of marketing and the operations management interface. Our study belongs to this stream, in that we unify the sharing concept on platforms, and the consumer behavior on risks, into a single framework that can be used in various sharing platforms.

On the other hand, an extensive body of research in the fields of information systems and marketing explores quality issues in the online environment. The four e-service quality dimensions proposed by Wolfinbarger and Gilly (2003) have been widely used for website design, fulfillment/reliability, privacy/security, and customer service (Bauer, Falk & Hammerschmidt, 2006; Field, Heim & Sinha, 2004; Heim & Field, 2007). As a sharing platform is a form of e-service, the lack of quality corresponding to these dimensions can have negative emotional effects on a potential customer (Chang & Chen, 2009). In particular, the inconsistency of sharing transactions that deteriorates the reliability of customer service is emerging as a key problem in the sharing economy. A survey conducted by PricewaterhouseCoopers (2015) shows that among the United States consumers familiar with the sharing economy, 72% feel that their experience with the sharing platforms is inconsistent. In this paper, the performance risk defined in the introduction section represents any of the four quality factors that degrade consumer utility.

As the sharing platforms are an emerging business, many concerns still remain unresolved. A current misalignment between the speed at which sharing spreads, and the speed at which rules are adopted for the sharing consumption, leads to the dark sides of the sharing economy (Kathan, Matzler & Veider, 2016; Malhotra & van Alstyne, 2014). A major bottleneck to participation in the sharing economy is a concern of risk for personal safety from strangers or unfamiliar experiences. Fischhoff, Slovic, Lichtenstein, Read and Combs (1978) identify nine characteristics that determine the perceptions of risk, including severity of consequences, controllability, dread, and newness. Solvic and Weber (2002) demonstrate that the dread element becomes the most critical factor regarding the risk perceptions. In fact, the dread is caused mainly by physical and mental injuries from serious incidents or crimes. Such safety issues are regarded as the physical risk described in the introduction section of this paper.

Lastly, in the marketing paradigm, the risk perception influences the valuation of uncertainty, and accordingly, a consumer willingness to pay is reduced (Grewal, Gotlieb & Marmorstein, 1994; Prasad, Stecke & Zhao, 2011; Teo & Yeong, 2003). In this paper, we therefore consider a consumer utility model where the presence of the risk perception diminishes a consumer willingness to pay. In summary, we aim at understanding a platform mechanism with two types of risks, the performance risk and the physical risk, and suggest the need for risk management, in particular of the physical risk, via identifying the potential for creating higher revenue.

3. Basic model

Consider a general monopolistic sharing platform provider that devises risk management to maximize its profit. In the sharing economy, there are two types of participants, consumer and provider. Consumers access goods or services, and pay for the experience of temporarily accessing them (Bardhi & Eckhardt, 2012), while providers or lenders own assets that are not in use, such as a house, vehicle, or labor, and can receive net profit by sharing them for a short period of time. In other words, the sharing economy is formed by the demand from consumers and the supply from asset owners, and matching the demand and the supply is the key to the business. However, in this paper we consider the scenario of the one-sided market, in which consumers can obtain any amount of goods or services from a sharing platform, in order to focus more on the consumer side. An Airbnb market report shows that the average occupancy rate of Airbnb rooms in 13 global markets, including San Francisco and Paris, is 42.6%, which implies that there is an adequate supply to satisfy demand (STR, 2017). Assuming that the supply exceeds the demand, we can concentrate on the impact of risks that the consumers perceive, and the need for risk management.

We first consider a platform provider who just starts its operation as a benchmark in the sharing economy. In general, since a start-up company does not have room for further investment and sufficient experience of how to increase its demand, we do not display the investment in consumer safety and the impact of demand increase in the benchmark model. The demand of a sharing platform is determined by the self-selection of consumers. This self-selection concept can trace back to Mussa and Rosen (1978) and then there have been a great deal of applications to analytical model buildings, including Moorthy (1984) and Moorthy and Png (1992). According to the concept, we assume that each customer voluntarily participates in the sharing economy, since the firm cannot identify the consumer type. The consumer self-selection utility can then be defined as follows:

$$\theta - p - r - R \geq \theta_0 - p_0.$$

The right-hand side represents the consumer utility when using a product or service (hereafter collectively called service) offered by a traditional firm, such as a hotel or taxi company. The left-hand side signifies the consumer utility when choosing a service listed on the sharing platform. Thus, when the utility from the sharing platform is greater than or equal to that from the traditional company, the consumer is assumed to choose the service offered by the sharing platform.

First, the symbols θ and θ_0 denote the customer heterogeneities indicating a customer willingness to pay for the service provided by the sharing platform, and the traditional enterprise, respectively. These θ and θ_0 are supposed to be independent of each other, and follow a uniform distribution on [0, 1]. This assumption of a uniform distribution for customer heterogeneity has been commonly adopted in the economics literature since Mussa and Rosen (1978). An extensive study on two-sided markets has also assumed a uniform distribution to signify the buyer and seller willingness-to-pay for goods (Chatterjee & Samuelson, 1983; Rochet & Tirole, 2006). Note that we consider a situation in which both the sharing platform and the traditional firm provide a service of the same quality, such as the same room size, or the same level of vehicle. Next, p is the posted price in the sharing platform, including a surcharge rate fixed by the intermediary, and p_0 is the price suggested by the traditional firm. Finally, the notations R and r denote the physical risk and the performance risk, respectively. Again, as described in the previous sections, the physical risk represents the fatal issues related to the customer lives and injuries, whereas the performance risk mainly comes from an unstable or lower service quality. Thus, as in the left-hand side, the sum of the performance risk and the physical risk that the consumer perceives reduces the consumer utility in the sharing platform. These two types of risks might also exist in the traditional enterprise side, but the R and r can be thought of as relatively bigger risks in the sharing economy than in the traditional firm, as emphasized in the introduction section.

From the self-selection utility constraint, the endogenous demand for the platform is given by $D = \frac{1}{2} - p - r - R + p_0$, with the assumption that both θ and θ_0 are independently and uniformly distributed on [0, 1]. Considering the monopolistic platform provider, we have the following profit maximization problem:

$$\max_p \quad \pi = Dp = \left(\frac{1}{2} - p - r - R + p_0 \right) p$$

We now analyze the firm's optimal choice on price, and examine the effect of each risk on demand and profit. In practice, as the main source of the sharing platform's income stems from the commission fee, such as a surcharge rate or an agency fee, the platform's actual monetary transfer should become $p\times$ commission rate; however, for simplicity, we just use p that reflects such a commission rate. By the first order condition, we obtain the optimal price $p^* = \frac{1+2p_0-2(r+R)}{4}$, and the resulting demand and profit are as follows:

$$D^* = \frac{1+2p_0-2(r+R)}{4},$$

$$\pi^* = \frac{\{1+2p_0-2(r+R)\}^2}{16}.$$

To ensure that the firm can profitably offer the service to the consumers, we only consider the case that $p^* \geq 0, \quad 0 \leq D^* \leq 1$. We also assume that $r+R$ is not too small, $\frac{1}{2} - p_0 \leq r + R \leq \frac{1}{2} + p_0$, so that the platform provider should more affordably serve the consumers than the traditional firm ($p^* \leq p_0$). A further equilibrium analysis of each risk leads to the following proposition:

Proposition 1. *When there is neither word-of-mouth nor investment in safety improvement, both demand and profit decrease with the risks.*

All proofs are in Appendix A. Proposition 1 means that in the absence of the word-of-mouth effect and investment in safety, both the performance and physical risk hurt demand and profit. This result implies that when a new platform enters the collaborative consumption market, the consumer perceived risks can be an obstacle to the growth of the platform, which provides a reasonable incentive to the platform provider to make efforts to mitigate the risks. This in turn raises interesting questions of what factors attribute to the risk reduction, and whether they can even bring higher profit to the platform provider. These questions are addressed in the next section.

4. Models for risk management

In this section, we consider a platform that has been in operation for a period of time in the sharing economy. Therefore, the platform is supposed to have word-of-mouth, which is exogenously determined among the customers. We also assume that the sharing platform makes an additional effort to enhance the physical protection of the consumers, such as the development of a more precise identification system. In this case, the consumer self-selection utility can be given by

$$\theta - p - r(1 - wD) - R(1 - s) \geq \theta_0 - p_0$$

where w is the exogenous word-of-mouth effect on the D demand, and s is the amount of investment in safety improvement. Thus, the utility function in the sharing economy now captures both word-of-mouth and the investment in safety.

First, as for the word-of-mouth effect, the utility function indicates that the w boosts demand directly, and the boosted demand wD alleviates the performance risk r. This is consistent with the previous work arguing that the online consumer reviews work as sales assistants (Zhao, Yang, Narayan & Zhao, 2013). Common to the current successful platforms is that word-of-mouth affects demand positively and helps to reduce the performance risk. For example, an increase in the number of positive reviews and the high rating of a private house listed in Airbnb increase both the reliability of the house quality that a customer perceives, and the demand of the house (Liang, Choi & Joppe, 2018).

Next, regarding the physical risk R, the s investment in safety is assumed to reduce the physical risk. Because such an investment incurs a fixed or development cost, we define cs^2 as the cost function for the safety improvement, where c is a scale parameter ($c > 0$). Compared to the cost, it is worthwhile to investigate whether the sharing platform investment in securing safety can result in improved demand and profit. We assume that $wD < 1$ and $s < 1$, implying that it is impossible to completely eliminate the two risks. Table 1 summarizes the notations used in this paper.

Note that the number of reviews permits insufficient counting of the physical risk, such as a terrible crime, because the reliability of service quality and the crime rate are totally different in nature. The fact that the accidental crimes accounting for a significant part of total crimes cannot be controlled by the consumer reviews implies that the relationship between the degree of word-of-mouth and the crime rate is scant. Thus, in the immediately above utility function, we assume that word-of-mouth does not mitigate the physical risk (see Appendix B for the opposite case).

On the other hand, the Metropolitan police reported that charges against Uber drivers for sexual attacks in the year to February 2017 increased by 50% over the previous year (Saner, 2017). This implies that not only has the crime rate in the sharing economy increased, but also the sharing platforms have failed to correctly check the identity or crime history of asset providers, and they should take more responsibility for safety issues. This needs leads to our consideration of the investment in safety, and the following analyses to see if this investment can alleviate the physical risk and give the platform provider an incentive to create higher profit.

Recall that θ and θ_0 are assumed to be independently and uniformly distributed on [0, 1]. The endogenous demand for the platform becomes $D = \frac{1+2p_0-2p-2r-2R(1-s)}{2(1-rw)}$. As w and s increase, the demand D increases. Henceforth, the safety-seeking endeavor yields the following profit maximization problem:

$$\max_p \quad \pi = Dp - cs^2 = \left(\frac{1+2p_0-2p-2r-2R(1-s)}{2(1-rw)} \right) p - cs^2$$

Similarly, we investigate the firm's optimal choice on price and examine the effect of each risk on demand and profit. Using the first order condition, we obtain the following equations:

$$p^* = \frac{1+2p_0-2r-2R(1-s)}{4},$$

$$D^* = \frac{1+2p_0-2r-2R(1-s)}{4(1-rw)},$$

$$\pi^* = \frac{\{1+2p_0-2r-2R(1-s)\}^2}{16(1-rw)} - cs^2.$$

Table 1
Notations.

Symbol	Description
θ	Customer's willingness to pay for a product/service from a sharing platform
θ_0	Customer's willingness to pay for a product/service from a traditional firm
p	Price by sharing platform
p_0	Price by traditional firm
r	Performance risk
R	Physical risk
D	Demand for a sharing platform
w	Effect of word-of-mouth
s	Investment in the safety improvement
c	Scale parameter for cost

The optimal price p^* appears to be independent of w, but dependent on s. Therefore, it is needed for the platform provider to stick to affordable pricing policy, regardless of the degree of word-of-mouth, where affordability proves one of the main advantages recognized by the consumers participating in the sharing economy. However, when there is an investment in safety improvement, the platform provider can set a higher price, because the investment makes the utility from the sharing platform closer to the utility from the traditional company, by showing that the platform has some responsibility for customer safety. The higher price also indicates that it is worthwhile for the platform provider to invest in safety to reduce physical risk.

We solve for the equilibrium equations to set up Proposition 2, which presents the effectiveness of word-of-mouth on demand and profit. From the conditions that $p^* \geq 0, D^* \geq 0$, and $wD^* < 1$, we set the upper bound of word-of-mouth w as $\bar{w} = \frac{4}{1+2p_0+2r-2R(1-s)}$. The following proposition presents the impact of each risk on demand and profit when there is the effect of word-of-mouth in the sharing platform.

Proposition 2. *In the presence of the word-of-mouth effect and the investment to improve safety, demand decreases as the physical risk increases. On the other hand, when the word-of-mouth effect is sufficiently high* ($\frac{2}{1+2p_0-2R(1-s)} < w < \bar{w}$), *demand increases as the performance risk increases. In terms of profit, the increase in any risk type results in reduced profit, regardless of the degree of word-of-mouth.*

Proposition 2 means that the abundant word-of-mouth of a sharing platform may lead to an increase in demand, although the performance risk increases. This result confirms the importance of the reputation system in sharing platforms. Gebbia (2016), the co-founder of Airbnb, mentioned that the way of overcoming anxiety about using the new platform is a well-designed reputation system, and if the consumers have more than 10 reviews, high reputation beats a high natural social bias. Such sufficient reviews of the service help more in the direct expansion of demand, which in turn allows the consumers to perceive the performance risk as being less. Consequently, the consumers may have faith in the service listed on the sharing platform, while accepting minor drawbacks caused by unprofessionalism.

Proposition 2 also implies that, even though the sharing platform possesses a high level of w, the increase in any of the physical and performance risk leads to a decrease in its profit. Recall that p^*, while independent of w, decreases as r and R increase. Therefore, the results suggest that the platform provider needs to make an extra effort to reduce the physical risk, even if the reputation system is the most fundamental risk management tool for peer-to-peer-based activity.

When the additional effort to enhance the consumer safety is not very costly, the platform provider may try to have a safety system as perfect as possible or full responsibility for the physical risk. This is because, given low cost and high benefit, the platform provider can maximize its profit by providing perfect security. However, in practice, since the platform provider cannot fully control the possibility of crimes, a perfect safety system is almost impossible. Therefore, we only consider the case that $c > \frac{R(1+2p_0-2r)}{8(1-rw)}$, implying that the consumer safety enhancement is comparatively costly. Denote $\underline{c} = \frac{R(1+2p_0-2r)}{8(1-rw)}$ as the lower bound of c. Note that $\pi^*(s)$ is the equilibrium profit at the s investment in securing safety. This is a concave function of s, because $\frac{d^2\pi^*(s)}{ds^2} < 0$, which is also satisfied by the condition, $c > \underline{c}$. Therefore, we can derive the optimal amount of investment s^* that maximizes the platform provider profit as follows:

$$s^* = \frac{R(1+2p_0-2r-2R)}{2\{4c(1-rw)-R^2\}}$$

The $c > \underline{c}$ condition ensures both the concavity of $\pi^*(s)$ and the condition $s^* < 1$, implying that the investment in safety can mitigate the physical risk, but cannot completely eliminate it. A further analysis leads to the following proposition:

Proposition 3. *As a sharing platform has more word-of-mouth, the platform provider invests more in safety, as long as the maximum possible investment is bounded* ($s^* < \frac{R(1+2p_0+2r-2R)}{8c-2R^2}$).

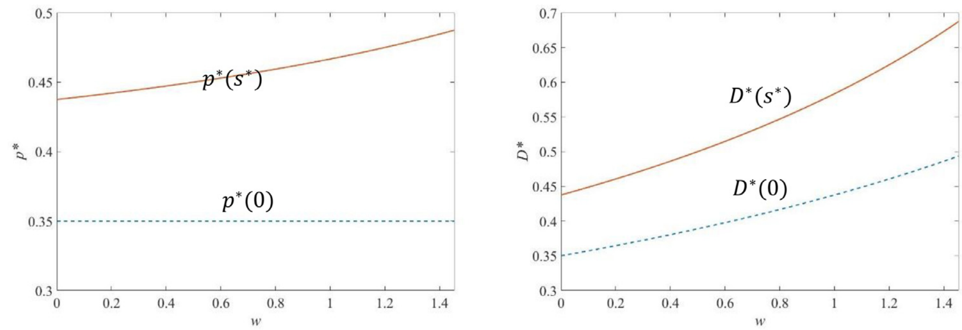
Proposition 3 highlights that word-of-mouth provides the platform provider with an incentive to improve safety, rather than a discouragement. When the positive word-of-mouth spreads over time, the platform provider would be better off increasing the investment in safety. We also find that, as the number of positive reviews or the rating for the service increases (i.e., strong word-of-mouth), the effect of increasing demand from the investment in safety rises ($\frac{dD^*}{ds} = \frac{R}{2(1-rw)}$ is increasing in w). Consequently, the platform provider may find it profitable to spend money on securing the consumer safety.

To investigate the impact of investment in safety, we compare the optimal levels of price and demand under the cases of with and without the investment. We assume that once the platform provider decides to invest, the amount of investment to maximize its profit equals s^*. Thus, the equilibrium price and demand under the investment in safety, respectively, become:

$$p^*(s^*) = \frac{c(1-rw)(1+2p_0-2r-2R)}{4c(1-rw)-R^2}$$

$$D^*(s^*) = \frac{c(1+2p_0-2r-2R)}{4c(1-rw)-R^2}$$

and $p^*(0)$ and $D^*(0)$ represent the equilibrium price and demand under no investment. A further analysis leads to the following proposition:



(a) Price (b) Demand

Fig. 1. The impact of investment in safety.

Proposition 4. *When the platform invests in safety, stronger word-of-mouth leads to higher price, higher demand, and hence higher profit.*

Proposition 4 indicates that the word-of-mouth effect is intensified with investment in safety. In the absence of investment to improve safety, even if the sharing platform gains higher word-of-mouth, the price should be fixed to maintain affordability, as mentioned earlier. However, with the investment to enhance safety, stronger word-of-mouth allows the platform provider to set a higher price through a synergy effect. Recall that Proposition 3 implies the positive relationship between word-of-mouth and the investment in safety. In other words, the fact that the platform provider invests more in safety, as the word-of-mouth effect increases, eases the requirement of affordability. Therefore, the platform provider can set a higher price with stronger word-of-mouth in the presence of the investment in safety.

In general, there is an inverse relationship between price and demand by the law of demand. However, when it comes to the sharing platform investing in safety, as the price of the service increases, the demand may also increase, because the increase in demand due to the reduction of risks exceeds the decrease in demand due to the price rise. Basically, the platform provider may create more demand even without the investment in safety, as the word-of-mouth effect becomes stronger while maintaining the same price, by mitigating the performance risk. However, when the investment in safety enters, the increasing rate of demand is higher ($\frac{dD^*(s^*)}{dw} > \frac{dD^*(0)}{dw}$), because the effectiveness of the demand growth from the performance risk reduction is enhanced, and the additional demand growth from the physical risk reduction occurs.

Moreover, similar to the analysis of the equilibrium price, since the platform provider may generate the demand $\frac{4c}{4c-R^2}$ times more through the investment in safety, even in the case of no word-of-mouth, the relationship $D^*(s^*) > D^*(0)$ is satisfied for all w. Fig. 1 visualizes Proposition 4 with a numerical example using $p_0 = 0.8, \quad c = 0.2, r = 0.2,$ and $R = 0.4$. Since the upper bound of w is recalculated as $\frac{4c-R^2}{c(1+2p_0+2r-2R)}$ to satisfy $wD^*(s^*) < 1$, the upper bound of w becomes 1.4545 in this numerical example. In Fig. 1(a), the equilibrium price under no investment is fixed as 0.35 while the equilibrium price under investment increases from 0.4375 to 0.4875 as w increases, which is always higher than the case of no investment. Similarly, Fig. 1(b) represents a comparison of the demands under investment and no investment, showing that the demand under investment is also always higher than the case of no investment ($D^*(s^*) \in [0.4375, \ 0.6875]$ and $D^*(0) \in [0.35, \ 0.4936]$). Consequently, the sharing platform providers may face higher profits from investing in safety, implying that the additional effort to alleviate customer anxiety about the possibility of physical injuries may not merely be a cost-generating investment, but a profitable strategy that improves the platform provider profit.

5. Government intervention

5.1. Intervention policies

The rapid growth of the sharing economy has generated several controversies. One of the conflicts stems from the enormous rise of non-professional or non-regulated asset providers (Rauch & Schleicher, 2015). The unprofessionalism of services provided by the asset owners, as well as the safety concerns, can create consumer dissatisfaction. For example, an Airbnb host does not need to meet hotel fire standards, and an Uber or Lyft driver has no need to obtain taxi certification. Since the emergence of the sharing economy, city leaders have relied on voluntary efforts to protect consumers. However, many city leaders are increasingly concerned about consumer protection, as the number of victims increases due to insufficient self-regulation of the sharing platforms. In light of the situation, government intervention needs to be considered for consumer protection in the sharing economy.

Government may design a variety of policy instruments. One of these policies is that government intervenes directly with a fixed support, which means that the government puts its efforts into directly reducing the physical risk, and the level of support is independent of the sharing platform effort. We refer to this intervention as "direct-fixed intervention". For example, building the government's own system of background checks may be a direct-fixed way of striving to prevent serious incidents in advance. The city of Houston decided that the fingerprint test done by Uber and Lyft as part of background checks was insufficient. When the city additionally asked the FBI to conduct criminal background checks on Uber and Lyft drivers, they detected several drivers with prior criminal histories from aggravated robbery to assault (Begley, 2015). A city developing a stricter background check system and precluding the sharing platforms from registering asset providers with prior criminal histories would be an example of direct-fixed intervention.

Governments may also intervene directly with a variable support, which implies that the level of support is a function of the sharing platform effort, referred to as "direct-variable intervention". A policy maker may set up task forces to develop a reliable sharing platform or provide the platform with support staff specializing in consumer protection. The policy maker who considers direct-variable support determines the size of the task force team or the number of support staff depending on the sharing platform effort, in order to incentivize the platform provider to invest more in improving safety.

Lastly, governments may provide a subsidy, which helps the sharing platform mitigate its financial burden on the reduction of physical risk and indirectly encourages the platform to work to improve safety. The policy maker will then determine the level of subsidy as a function of the sharing platform effort, referred to as

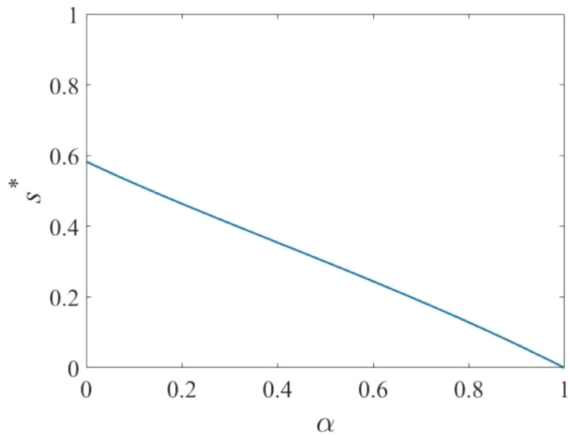


Fig. 2. The optimal level of investment for the direct-fixed intervention.

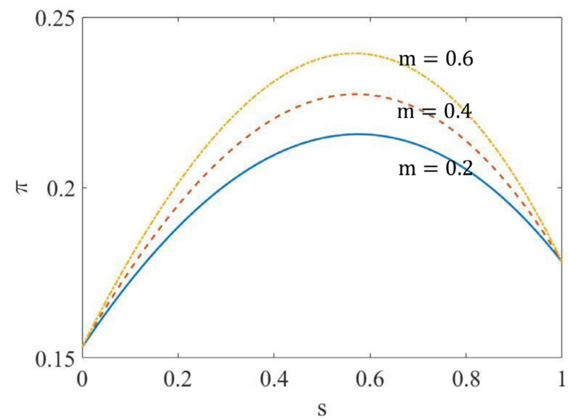


Fig. 3. The profit of the platform provider under direct-variable intervention.

"indirect-variable subsidy". This policy may best be adopted when governments find it difficult to come up with an appropriate alternative to reduce physical risk, or when the solution designed by a sharing platform is considered more effective. Therefore, it is necessary to examine how government should intervene to incentivize platform providers, and protect consumer safety in the sharing economy. To answer these questions, we study a platform provider who receives government support under the three policy scenarios.

5.1.1. Policy 1: direct-fixed intervention

Let α be the strength of government support for the safety improvement. The physical risk then decreases to $(1-\alpha)R(1-s)$ through the support, and α is fixed, and is independent of the platform provider investment s. The consumer self-selection utility becomes:

$$\theta - p - r(1-wD) - (1-\alpha)R(1-s) \geq \theta_0 - p_0.$$

Denote P1 in the superscript as Policy 1, the direct-fixed intervention. Employing Policy 1, we have the following profit maximization problem of the platform provider:

$$\max_p \ \pi^{P1} = D^{P1}p - cs^2 = \left(\frac{1+2p_0-2p-2r-2(1-\alpha)R(1-s)}{2(1-rw)}\right)p - cs^2$$

Through the optimal levels of price and demand, the equilibrium profit turns out to be $\pi^{P1*} = \frac{\{1+2p_0-2r-2(1-\alpha)R(1-s)\}^2}{16(1-rw)} - cs^2$. The optimal level of the investment in safety becomes $s^{P1*} = \frac{R(1-\alpha)\{1+2p_0-2r-2(1-\alpha)R\}}{8c(1-rw)-2(1-\alpha)^2R^2}$, where $c > \frac{R(1-\alpha)(1+2p_0-2r)}{8(1-rw)(1+\alpha)}$. Fig. 2 illustrates the relationship between the optimal investment and the level of support with a numerical example using $p_0 = 0.8, \quad c = 0.2, r = 0.2,$ and $R = 0.4$. This shows that under Policy 1, as the level of support increases, the platform provider reduces the amount of investment, because the platform provider is not motivated to put further efforts into mitigating the physical risk. In other words, for the policy maker, the direct-fixed intervention may not be an effective policy for the motivation of the platform.

5.1.2. Policy 2: direct-variable intervention

This policy is similar to Policy 1, except that the level of government support varies with the platform provider effort for safety enhancement. Let ms be the strength of government support for the reduction of the physical risk, where m is a support parameter. Under this direct-variable intervention, if the platform provider does not make any investment to decrease the physical risk, there is no government support, and as the investment of the platform provider increases, the amount of support increases. The self-selection utility becomes:

$$\theta - p - r(1-wD) - (1-ms)R(1-s) \geq \theta_0 - p_0.$$

Denoting P2 in the superscript as Policy 2, the direct-variable intervention, we then have the following profit maximization problem of the platform provider:

$$\max_p \ \pi^{P2} = D^{P2}p - cs^2 = \left(\frac{1+2p_0-2p-2r-2(1-ms)R(1-s)}{2(1-rw)}\right)p - cs^2$$

Although we cannot represent the optimal level of investment s^{P2*} in a closed form, unlike Policy 1, we can find s^{P2*} through numerical analysis. Fig. 3 shows that s^{P2*} exists under this direct-variable intervention when $p_0 = 0.8, \quad c = 0.2, r = 0.2,$ and $R = 0.4$. Meanwhile, as the support parameter m increases, s^{P2*} decreases very slightly (as $m = 0.2 \rightarrow 0.4 \rightarrow 0.6, \quad s^{P2*} = 0.5756 \rightarrow 0.5705 \rightarrow 0.5667$). Even though the government support appears to diminish the platform provider effort to improve consumer safety, the diminishing degree is much smaller and hence insignificant. In other words, direct-variable intervention can be an incentive policy that allows the platform provider to make sufficient effort to lower the physical risk, without blindly resorting to government support.

5.1.3. Policy 3: indirect-variable subsidy

In this scenario, the government subsidizes the platform provider. Let ks^2 be the amount of subsidy for the safety improvement, where k is a subsidy parameter. Under this policy, if the platform provider does not make any investment to lower the physical risk, there is no government subsidy, and as the investment of the platform provider increases, the amount of subsidy increases. The self-selection utility remains the same as the case of no intervention in the previous section:

$$\theta - p - r(1-wD) - R(1-s) \geq \theta_0 - p_0.$$

Let P3 in the superscript denote Policy 3, the indirect-variable subsidy. The profit maximization problem of the platform provider is as follows:

$$\max_p \ \pi^{P3} = D^{P3}p - cs^2 = \left(\frac{1+2p_0-2p-2r-2R(1-s)}{2(1-rw)}\right)p - cs^2 + ks^2$$

The equilibrium profit becomes $\pi^{P3*} = \frac{\{1+2p_0-2r-2R(1-s)\}^2}{16(1-rw)} - cs^2 + ks^2$, and the optimal level of investment in safety is $s^{P3*} = \frac{R(1+2p_0-2r-2R)}{8(c-k)(1-rw)-2R^2}$, where $c-k > \frac{R(1+2p_0-2r)}{8(1-rw)}$. Fig. 4 shows the relationship between the optimal investment and the level of support with the same numerical example as Fig. 2. In contrast to the previous policies, as the subsidy parameter k increases, the level of

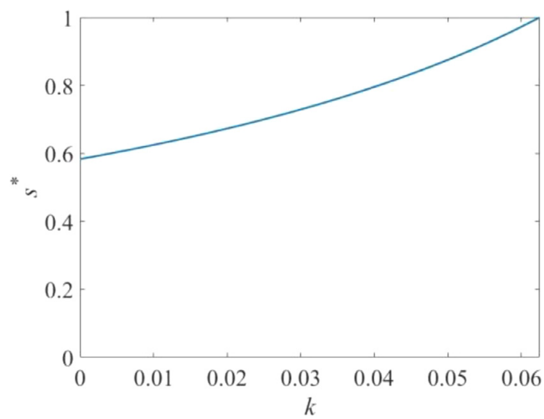


Fig. 4. The optimal level of investment for the indirect-variable subsidy.

platform provider investment increases, which means that in terms of motivating the platform provider, the indirect-variable subsidy turns out to be the most effective policy.

Since all three policies are more profitable than the case of no intervention discussed in the previous section, the platform provider would be pleased with any government support. However, the policy maker needs to consider the impact of policies on consumer protection, in addition to the growth of the sharing platform. In the next section, we demonstrate a comparative example for the three policies in a sharing platform, and then illustrate which policy is more appropriate under what circumstances.

5.2. Comparison of the three policies

Let there be a policy maker, determined that the rapid growth of the sharing economy requires government intervention to protect consumers participating in the sharing economy, and to help sustainable growth of the sharing platforms. The policy maker's main concern must be which policy is most effective in reducing physical risk, and which policy is most welcome by the platform providers. To compare the three policies at the same time, we have the following inputs: (a) when the level of support is low, $\alpha = 0.2$ (direct-fixed intervention level), $m = 0.4$ (direct-variable intervention level), and $k = 0.03$ (indirect-variable subsidy level), (b) when the level of support is high, $\alpha = 0.3,\ \ m = 0.6$, and $k = 0.05$, and the remaining parameters stay the same in both cases, with $p_0 = 0.8,\ \ r = 0.2,\ R = 0.4$, and $w = 1$.

The first concern of the policy maker is the effectiveness of a policy, that is, how much can the policy reduce physical risk. When the platform provider invests s^{Pi*} $(i = 1, 2, 3)$ to maximize its profit under each policy, the levels of the physical risk are $(1-\alpha)R(1-s^{P1*})$, $(1-ms)R(1-s^{P2*})$, and $R(1-s^{P3*})$, respectively. Fig. 5 shows how the physical risk varies with the cost parameter c. Under all three policies, as c increases, the physical risk increases (i.e., the government intervention is less effective), because a high c implies severe difficulty in safety improvement. When the safety improvement cost is low, the indirect-variable subsidy (Policy 3) can reduce the physical risk the most, and its effectiveness is more predominant in high support. However, since the impact of the subsidy policy is most sensitive to changes in cost, as the safety improvement cost increases, the direct-fixed intervention (Policy 1) and the direct-variable intervention (Policy 2) become more effective. This implies that when safety enhancement is difficult, the direct involvement of the government can reduce physical risk more effectively than indirect involvement, which leaves the risk management to the discretion of the platform provider. When the safety improvement cost is moderate, the direct-variable intervention (Policy 2) is most effective in mitigating the physical risk. On the other hand, when the safety improvement cost is sufficiently high, the direct-fixed intervention (Policy 1) appears to be the most effective policy, because the direct-variable intervention no longer motivates the platform provider to invest more, due to the very high difficulty in safety improvement. In addition, the differences in effectiveness among the policies are greater for the high level of support, which implies that as the level of government support increases, the policy maker should pay more attention to the policy decision.

Fig. 6 demonstrates the platform provider profits depending on the cost c, when investing at the optimal level s^{Pi*} $(i = 1, 2, 3)$ under each policy. As c increases, the platform provider profits decrease, and regardless of c, the indirect-variable subsidy (Policy 3) is the least profitable policy among the three policies. This implies that the solo effort of the platform provider to reduce the physical risk with government subsidy creates the smallest synergy effect. When the safety improvement cost is sufficiently low, the platform provider may achieve similar profits through the two direct interventions. However, as the cost c increases, the direct-fixed intervention (Policy 1) is more and more profitable than the direct-variable intervention (Policy 2), because the platform provider may shift the increased cost burden to the government support. In other words, as the reduction of the physical risk becomes more expensive, the platform provider relies more on the government support and then reduces the investment, which in turn gives rise

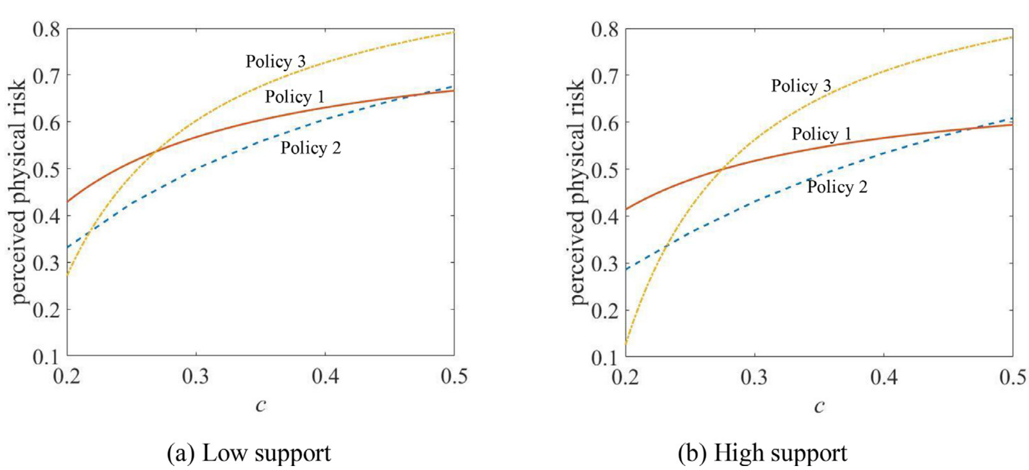


Fig. 5. The physical risk that consumers perceive under each policy.

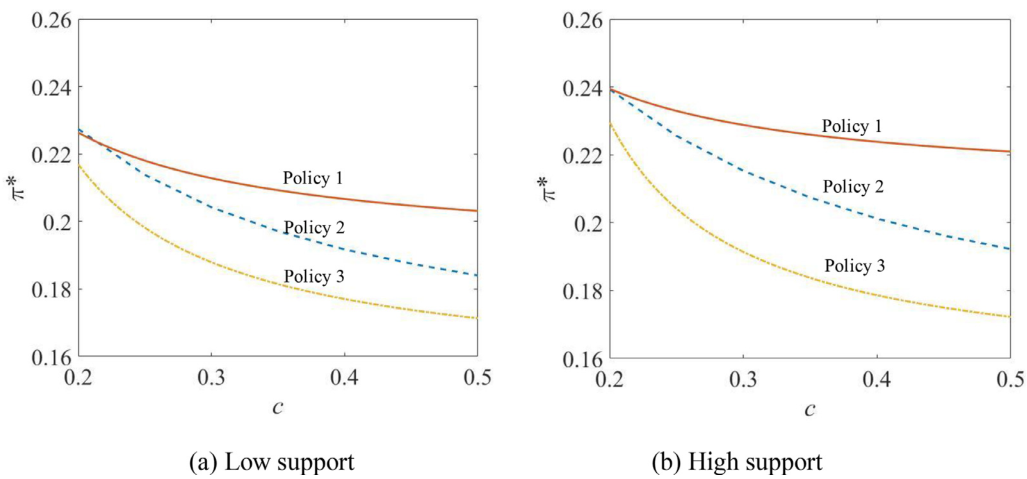


Fig. 6. The profit of the platform provider under each policy.

to lowering the government support. Such a vicious cycle, the simultaneous reduction of the platform investment and government support for customer safety, results from the "variable" approach (Policy 2). This more sharply declines the platform provider profits than the single reduction of the investment s^{P1*} (while α is fixed), resulting from the "fixed" approach (Policy 1). A similar interpretation can apply to another variable approach, Policy 3.

If consumer safety is the top priority of the policy maker, the indirect-variable subsidy can be the most effective policy when the cost is low. However, if consumer safety and growth of the sharing economy are pursued at the same time, providing subsidy may not be the best option. Moreover, the more difficult the reduction of physical risk, the less attractive the subsidy policy. Therefore, when the safety improvement cost is moderate or high, it is desirable for the policy maker to choose between direct-fixed intervention and direct-variable intervention; if she puts more emphasis on consumer safety, she would choose the direct-variable intervention, otherwise she would choose the direct-fixed intervention.

6. Conclusions

The consumers participating in the sharing economy recognize risks, because the sharing economy has developed on the basis of peer-to-peer transactions. As the sharing economy grows, concerns about the risks, such as unstable quality of products or services, or physical injuries by strangers, are on the rise; and hence, the issue of risk management becomes of vital importance. Nevertheless, the sharing platforms have focused on their role as intermediaries, relying only on word-of-mouth. Moreover, not much research has paid attention to the inherent perceived risks and limitations of word-of-mouth. In this paper, we propose an analytical model that considers two types of risks in the sharing economy: the physical risk, and the performance risk. From an economic perspective, we examine the effectiveness of the risk management mechanisms, including word-of-mouth, and the platform investment in safety improvement. In particular, we investigate whether the investment to alleviate physical risk is effective in terms of increasing a sharing platform profit, while identifying some limitations of the word-of-mouth effect.

We also examine the effectiveness of word-of-mouth in a sharing platform with an investment in safety. We find that when the performance risk increases, the abundant word-of-mouth contributes to increased demand, but it does not increase profit. Moreover, when the physical risk increases, word-of-mouth may not contribute to demand and profit growth. Unlike word-of-mouth, investment in safety may lead to more demand and higher profit. When the platform provider invests to improve consumer safety, not only may she set a higher price, but she may also create more demand than the case of no investment. In addition, as the word-of-mouth effect increases, the effect of profit enhancement increases. This result is based on the finding that the optimal amount of investment is positively related to word-of-mouth. Our findings imply that investment in safety can be another means of increasing demand along with word-of-mouth, that is, the investment can be a profitable strategy, rather than a cost-generating strategy. Finally, we explore policy implications in the sharing economy. Comparing three possible policies, we suggest which policy is most effective in terms of lowering the physical risk, and which policy is most profitable for the platform provider.

These findings extend the sharing platforms' understanding of how their profits are affected by the perceived risks. First, the platform providers need to distinguish the risks, and apply appropriate risk management methods accordingly, because there is no single solution that can effectively reduce all kinds of risks in reality. Specifically, our results show that the review systems on which most of the sharing platforms have relied may not work effectively to reduce the physical risk. Second, the results provide a significant direction to the platform providers regarding how they manage their platforms. We show that additional investment in safety is an effective way to create more demand and profit. In other words, for sustainable growth, the platform providers need to be active supporters for the safety of participants, not just pure intermediaries. Furthermore, the efforts to manage different types of risks may play a central role in moving from the current sharing economy to a huge market place that generates tremendous economic benefits beyond one of the current trends. This is because there are still numerous areas to which the sharing economy can be applied with a larger number of participating customers, some of whom have previously been reluctant to participate in the sharing economy.

Note that the findings in the body of this paper are based on the fact that the word-of-mouth in the sharing economy is mostly related to the performance risk, rather than the physical risk. We therefore assume in our analytical models that the word-of-mouth can alleviate the performance risk, but it does not reduce the physical risk. Nevertheless, if some positive reviews about safety appear in the future, then the case that the word-of-mouth for safety can alleviate the physical risk needs to be considered, which is done in Appendix B. Some of the findings are somewhat different from those described in the body of this paper. For example, the word-of-mouth for quality and safety may lead to more demand and higher profit. We also find that when consumers are more concerned about the physical risk than the performance risk, the optimal amount of investment in safety is greater under the word-of-mouth for safety than under no word-of-mouth for safety (see Appendix B, for more details about the findings).

Finally, we close this paper with some future research opportunities. First, we have assumed that the word-of-mouth in the sharing economy is exogenously formed in a particular time period. However, it may decrease or increase over a period of time. Its decrease over time would negatively affect the demand, whereas its increase would positively influence the demand. The dynamics of the word-of-mouth may therefore be of interest to study in the future. Second, we have focused on the consumer side in the sharing economy. However, asset providers may also perceive risks similar to what consumers perceive. For example, hosts of Airbnb may be concerned about damage to their assets, due to unpredictable actions by bad-mannered guests, and Uber drivers may be afraid of unobservable physical attacks from violent passengers. Therefore, risk management considering both sides may be an interesting question for future research. Lastly, whereas we have examined a platform-centric approach to mitigating the perceived risks, the investigation of government regulation based on the public interest will also be a future research direction. In particular, one of the characteristics of today's sharing economy is a fierce conflict between sharing platforms and incumbent companies. For example, Uber suffers from a number of lawsuits filed by taxi industry groups, and their services are still blocked or restricted in several countries, such as Italy, Denmark, and Korea. Therefore, an analysis of the sharing economy from a government perspective to maximize social welfare would be another interesting further study.

Appendix A. Proofs

Derivation of demand function: Recall the consumer self-selection utility is $\theta - p - r - R \geq \theta_0 - p_0$. The endogenous demand is thus $D = P(\theta - \theta_0 \geq p + r + R - p_0)$. Since θ and θ_0 are independently uniformly distributed in $[0, 1]$,

$$\begin{aligned}
&P(\theta - \theta_0 \geq p + r + R - p_0)\\
&= P(\theta \geq \theta_0 + p + r + R - p_0)\\
&= \int_0^1 P(\theta \geq \theta_0 + p + r + R - p_0 | \theta_0 = \vartheta_0) f_{\theta_0}(\vartheta_0) d\vartheta_0\\
&= \int_0^1 \{1 - (\vartheta_0 + p + r + R - p_0)\} 1 d\vartheta_0\\
&= [\{1 - (p + r + R - p_0)\}\vartheta_0]_0^1 - \left[\frac{1}{2}\vartheta_0^2\right]_0^1\\
&= \frac{1}{2} - (p + r + R - p_0).
\end{aligned}$$

We therefore obtain the demand function $D = \frac{1}{2} - (p + r + R - p_0)$.

Proof of Proposition 1. This proposition examines the impacts of physical and performance risk on the emerging sharing platform, where there is neither word-of-mouth, nor investment in safety. Recall that the demand and profit function: $D^* = \frac{1+2p_0-2(r+R)}{4}$ and $\pi^* = \frac{\{1+2p_0-2(r+R)\}^2}{16}$. Differentiating D^* and π^* with respect to R and r, we have:

$$\begin{aligned}
&\frac{dD^*}{dR} = -\frac{1}{2} < 0, \quad \frac{dD^*}{dr} = -\frac{1}{2} < 0,\\
&\frac{d\pi^*}{dR} = -\frac{1 + 2p_0 - 2(r + R)}{4} < 0 \quad (\because 1 + 2p_0 - 2(r + R) \geq 0),\\
&\frac{d\pi^*}{dr} = -\frac{1 + 2p_0 - 2(r + R)}{4} < 0.
\end{aligned}$$

■

Proof of Proposition 2. When the sharing platform has the word-of-mouth effect and makes investment to improve safety, the demand and profit functions are $D^* = \frac{1+2p_0-2r-2R(1-s)}{4(1-rw)}$ and $\pi^* = \frac{\{1+2p_0-2r-2R(1-s)\}^2}{16(1-rw)} - cs^2$. Differentiating D^* with respect to R and r, we have:

$$\begin{aligned}
&\frac{\partial D^*}{\partial R} = -\frac{1-s}{2(1-rw)} < 0 \ (\because rw < 1)\\
&\frac{\partial D^*}{\partial r} = \frac{w\{1 + 2p_0 - 2R(1-s)\} - 2}{4(1-rw)^2}.
\end{aligned}$$

The sign of $\frac{\partial D^*}{\partial r}$ is determined by w. When $\frac{2}{1+2p_0-2R(1-s)} < w < \bar{w}$, $\frac{\partial D^*}{\partial r} > 0$.

In terms of profit, differentiating π^* with respect to R and r, we have:

$$\begin{aligned}
\frac{\partial \pi^*}{\partial R} &= -\frac{(1-s)\{1 + 2p_0 - 2r - 2R(1-s)\}}{4(1-rw)}\\
&< 0 \ (\because rw < 1,\ 1 + 2p_0 - 2r - 2R(1-s) \geq 0)\\
\frac{\partial \pi^*}{\partial r} &= -\frac{\{1 + 2p_0 - 2r - 2R(1-s)\}}{4(1-rw)} + \frac{w\{1 + 2p_0 - 2r - 2R(1-s))\}^2}{16(1-rw)^2}\\
&= -\frac{\{1 + 2p_0 - 2r - 2R(1-s)\}}{4(1-rw)}\left\{1 - \frac{w\{1 + 2p_0 - 2r - 2R(1-s)\}}{4(1-rw)}\right\} < 0.
\end{aligned}$$

■

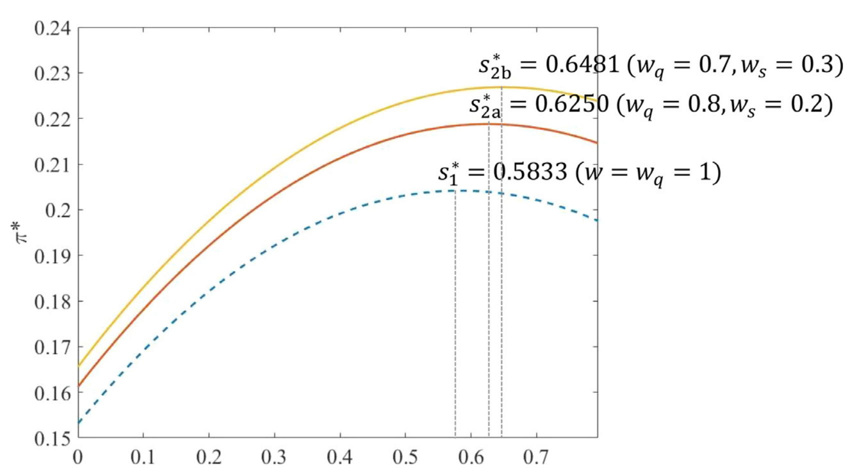


Fig. A1. A comparison of the profits and the optimal investments with and without w_s.

Proof of Proposition 3. Since the platform provider cannot completely eliminate the perceived risk, $wD^*(s^*) < 1$ must hold. This leads to the condition $w < \frac{4c-R^2}{c(1+2p_0+2r-2R)}$. Thus, the platform provider can invest up to $s^*(\frac{4c-R^2}{c(1+2p_0+2r-2R)}) = \frac{R(1+2p_0+2r-2R)}{8c-2R^2}$. ■

Proof of Proposition 4. We compare $p^*(s^*)$ with $p^*(0)$, and then obtain $p^*(s^*) - p^*(0) = \frac{R^2(1+2p_0-2r-2R)}{4\{4c(1-rw)-R^2\}} > 0$ for all w. Thus, as the word-of-mouth effect increases, the platform provider can set a higher price. Similarly, we compare $D^*(s^*)$ with $D^*(0)$, and then have $D^*(s^*) - D^*(0) = \frac{R^2(1+2p_0-2r-2R)}{4(1-rw)\{4c(1-rw)-R^2\}} > 0$ for all w. Therefore, as the word-of-mouth effect increases, the platform provider can create more demand. ■

Appendix B. What if the word-of-mouth for safety emerges?

In the body of this paper, we assume that the word-of-mouth in the sharing economy alleviates the performance risk, but it does not reduce the physical risk. This is based on the fact that the word-of-mouth is mostly related to the performance risk, rather than the physical risk. However, some positive reviews about safety possibly appear in the future. Of course, some might be negative, but it is assumed that good points outweigh the bad points, so the set of reviews on safety has a positive impact on the physical risk. In light of the situation, in this appendix, the word-of-mouth is divided into two; one for service quality and the other for safety, both of which are assumed to alleviate the performance and physical risk, respectively. In this case, the consumer self-selection utility can be given by

$$\theta - p - r(1 - w_q D) - R(1 - s - w_s D) \geq \theta_0 - p_0$$

where w_q is the word-of-mouth for service quality affecting demand D, w_s is the word-of-mouth for safety, which also influences D. We assume that $w = w_q + w_s$.

We then have the following profit maximization problem of the platform provider:

$$\max_p \quad \pi = Dp - cs^2 = \left(\frac{1 + 2p_0 - 2p - 2r - 2R(1 - s)}{2(1 - rw_q - Rw_s)}\right)p - cs^2$$

Through the optimal levels of price and demand, the equilibrium profit becomes $\pi^* = \frac{\{1+2p_0-2r-2R(1-s)\}^2}{16(1-rw_q-Rw_s)} - cs^2$, and the optimal level of the investment in safety is $s^* = \frac{R(1+2p_0-2r-2R)}{2\{4c(1-rw_q-Rw_s)-R^2\}}$, where $c > \frac{R(1+2p_0-2r)}{8(1-rw_q-Rw_s)}$.

First, the demand and optimal profit functions imply that both types of word-of-mouth can lead to more demand and higher profit. This is somewhat different from the finding in the body of this paper, that is, word-of-mouth increases demand but does not increase profit. Assuming that word-of-mouth exists only for the performance risk in the body entails this difference. Second, the optimal amount of investment s^* is positively related to both types of word-of-mouth, which implies that the investment in safety increases the platform provider profit. Third, when the sharing platform invests in safety, then regardless of the types of word-of-mouth, stronger word-of-mouth gives rise to higher price, more demand, and thus higher profit than the case of no investment.

Next, we newly investigate how the presence of word-of-mouth for safety affects the optimal level of investment in safety and profit, and compare the two cases of with and without the word-of-mouth for safety. For the comparison purpose, subscript 1 stands for the notations used in the body of this paper, while subscript 2 signifies those in this appendix.

Proposition A1. *If the physical risk is higher than the performance risk, the optimal level of the investment in safety is greater under the word-of-mouth for safety than under no word-of-mouth for safety. Moreover, as the proportion of the word-of-mouth for safety increases, the gap between the two optimal levels of investment widens.*

Proof. We compare s_2^* and s_1^*, and then show that $s_2^* - s_1^* > 0$ if and only if $R > \frac{r(w-w_q)}{w_s}$. Because the total word-of-mouth w equals $w_q + w_s$, $\frac{r(w-w_q)}{w_s}$ becomes r. Thus, if $R > r$, then $s_2^* > s_1^*$. Moreover, in the presence of w_s, the demand function is $D^* = \frac{1+2p_0-2r-2R(1-s_2)}{4(1-rw_q-Rw_s)}$. Differentiating D^* with respect to s_2, we have:

$$\frac{dD^*}{ds_2} = \frac{R}{2(1 - rw_q - Rw_s)} = \frac{R}{2(1 - rw - w_s(R - r))}$$

We can see that when $R > r$, $\frac{dD^*}{ds_2}$ is increasing in w_s, which means that the demand increasing rate is on the rise at s_2. In other words, as w_s increases, the effect of increasing demand from the investment in safety also increases. This in turn increases profit and moves the point of the equilibrium investment to the right. ■

One might expect that in the presence of the word-of-mouth for safety w_s, the sharing platform may reduce the amount of investment in safety, owing to w_s alleviating the physical risk R. Interestingly, however, Proposition A1 shows that when consumers perceive the physical risk more significantly than the performance risk (i.e., $R > r$), the sharing platform's equilibrium investment in the presence of w_s is greater than that in the absence of w_s (i.e., $s_2^* > s_1^*$). This is because the word-of-mouth for safety helps to increase the demand, which in turn increases the platform provider profit (i.e., $\pi_2^* > \pi_1^*$). This increased profit pulls the amount of investment in safety upward. Furthermore, when R is greater than r, as the proportion of the word-of-mouth for safety increases, the difference between s_2^* and s_1^* increases, because the effect of increasing demand from the investment grows ($\frac{dD_2^*}{ds_2} = \frac{R}{2(1-rw-w_s(R-r))}$ is increasing in w_s), and hence the sharing platform creates higher profit, and then invests more in safety to maximize its profit.

Fig. A1 illustrates Proposition A1 with a numerical example using $p_0 = 0.8$, $c = 0.2, r = 0.2$, $R = 0.4$, and $w = 1$. The dashed line represents the platform provider's equilibrium profit π_1^* when $w = w_q = 1$ without w_s, and the two solid lines represent the equilibrium profits π_2^* when (a) $w_q = 0.8$ and $w_s = 0.2$, and (b) $w_q = 0.7$ and $w_s = 0.3$. Since the complete elimination of risks is impossible, $0.7937 = \min\ \{1 \text{ (for } s_1),\ 0.8625 \text{ (for } s_{2a}),\ 0.7937 \text{ (for } s_{2b})\}$ is used for the upper bound in the horizontal s axis. We then find that in the presence of the word-of-mouth for safety, the platform provider may create higher profit, which in turn shifts the point of the equilibrium investment to the right (from $s_1^* = 0.5833$ to $s_{2a}^* = 0.6250$). Moreover, a higher proportion of w_s allows the platform provider to invest more in safety, which leads to greater profitability. Consequently, when consumers are more concerned about physical injury than unstable service quality, and the sharing platform has enough reviews about safety that may ease consumer anxiety about physical injury, then the sharing platform may make higher profit from investing more in safety, rather than relying on the reviews about safety.

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