

Perceived risks from drone food delivery services before and after COVID-19

Ja Young (Jacey) Choe

Faculty of Business Administration, University of Macau, Taipa, Macao

Jinkyung Jenny Kim

*School of Hotel and Tourism Management,
Yongsan University – Haeundae Campus, Busan, Republic of Korea, and*

Jinsoo Hwang

*The College of Hospitality and Tourism Management,
Sejong University, Seoul, Republic of Korea*

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Abstract

Purpose – The purpose of this study was to explore if five subdimensions of perceived risk (financial, time, privacy, performance and psychological risks) negatively affects image. In addition, this study aims to investigate if image has a positive effect on intentions to use. Lastly, the purpose of this study was to examine the moderating effect of Coronavirus disease-2019 (COVID-19), before and after the outbreak, in the relationship between perceived risk and image.

Design/methodology/approach – Data were collected from 331 people before the COVID-19 outbreak and 343 people after the COVID-19 outbreak. To test hypotheses, this study used structural equation modeling.

Findings – Time, performance and psychological risks negatively affected image before the outbreak of COVID-19. Meanwhile, performance risks and psychological risks had a negative influence on image only after the outbreak of COVID-19. In addition, there was demonstrated to be a positive relationship between image and intentions to use, both before and after the COVID-19 outbreak. Finally, the outbreak of COVID-19 positively moderates the relationship between performance risk and image.

Practical implications – The current study provides the following practical implications. First, industry practitioners need to develop a performance guarantee system which enhances the quality assurance of drone food delivery services (DFDS). Second, live streaming or creative activities would help to visualize DFDS in a way that stresses the stable operation of these services.

Originality/value – The importance of contactless services has been emphasized ever since the beginning of the COVID-19 outbreak. However, there has been very little research on the future of contactless services after COVID-19. This study investigated the perceived risk from DFDS as a form of contactless service which has not been conducted before. The findings of this study will improve the understanding of the changes that have occurred in consumers' perception of risk from DFDS during the COVID-19 pandemic.

Keywords Intentions to use, Image, Perceived risk, COVID-19, DFDS

Paper type Research paper



Introduction

Hospitality and travel industry worldwide is suffering because social distancing strategies and restrictions on mobility are adopted by most countries since early 2020 owing to Coronavirus disease-2019 (COVID-19) (Gössling *et al.*, 2020; Pham, 2020). Particularly, many restaurants have striven to consider ways to survive. Owing to COVID-19 pandemic, a new

delivery service model seems to be inevitable with the support of high technologies. As contactless services become more important after COVID-19, technology-based services are attracting attention in the hospitality industry (Jiang and Wen, 2020; Jones and Comfort, 2020; Lin *et al.*, 2020; Ongsakul *et al.*, 2020). One of them is drone food delivery services (DFDS). DFDS are defined as “services that use drones to deliver food to customers” (Hwang *et al.*, 2019b, p. 94). Using drones as a tool for delivering food has become a reality over the past several years. There are high expectations and many positive predictions about the potential of DFDS.

More importantly, from an epidemiological perspective, DFDS can play a significant role in providing contactless food services to customers. When DFDS are used, there is no face-to-face interaction between a service provider and a consumer, significantly reducing the possibility of spreading COVID-19. Despite the many advantages of using DFDS, in many countries, drone delivery services have not yet become fully commercialized. This is not because of technical issues but because of the many risks that consumers perceive. For example, there are significant privacy and security issues around the use of commercial drones (Khan *et al.*, 2019). Another concern that has discouraged the commercial development of drone delivery services is the possibility of psychological resistance among members of the public and anxiety about the ways in which drones might be used (Kim *et al.*, 2016). However, this situation is now changing. The outbreak of COVID-19 has highlighted the importance of providing contactless services to consumers. More and more consumers, for example, want to be able to use contactless technology when they use hospitality facilities (Kim and Lee, 2020; Shin and Kang, 2020; Torabi Farsani *et al.*, 2016). Especially, there has been a clear increase in both the need and the demand for DFDS under pandemic (Chandler, 2020). This is because when DFDS are used, there is no face-to-face interaction between a service provider and a consumer, minimizing the risk of transmission of the virus.

Previous studies on drone delivery services have focused mainly on their role in mitigating industries’ environmental impact (Park *et al.*, 2018), studying consumer innovativeness (Hwang *et al.*, 2019a) and evaluating acceptance of these services among consumers (Khan *et al.*, 2019). Recently, there is a study that explored the perceived risks of DFDS conducted by Hwang and Choe (2019) before the outbreak of COVID-19.

During this pandemic, industry and consumers have had to adapt to a new environment in which contactless services are preferred and are considered desirable as a means of preventing the spread of disease. Nevertheless, there has not to date been any study that has investigated whether consumers’ perceptions of the risks around DFDS are different after COVID-19 nor have there been any empirical studies that have focused on investigating ways to enhance consumers’ behavioral intention to use DFDS during the pandemic.

Furthermore, the COVID-19 generated a high level of “uncertainty” about what will happen after the pandemic (Bratianu, 2020). “Low-touch and high-tech” would be a new service normal to cater the needs of customers under pandemic (Shin and Kang, 2020). However, entrepreneurs in the restaurant business sector have anxieties about post-pandemic period because they have not prepared the new business model that can be adapted well in post-pandemic (Madeira *et al.*, 2021). Therefore, in the long-term perspective, it is critical for researchers to offer new insights and implications to the hospitality and tourism industry about not only how to cope with the COVID-19 pandemic crisis but also how to prepare post-pandemic period according to newly emerging customers’ needs and wants (Gursoy and Chi, 2020). In this regard, it is critical to compare consumers’ perceived risk of DFDS before and after COVID-19 pandemic because it can help hospitality managers

who consider using DFDS under pandemic. Also, this type of comparison study is expected to help the hospitality practitioners to prepare the new service model after pandemic.

There are four research objectives in this study. The first objective is to examine the various risks perceived by consumers in connection with DFDS. The second objective is to investigate if overall image of DFDS is influenced by perceived risk. The third objective is to find the effect of the overall image of DFDS on consumers' intentions to use these services. The last objective is to investigate the moderating effect of COVID-19 on the relationships between perceived risk and the overall image of DFDS.

Literature review

Perceived risk theory

Consumers feel uncertainty about the possible negative consequences when they use a product or service. This is called perceived risk (Featherman and Pavlou, 2003). When perceived risk is associated with product purchase, it can make consumers less likely to purchase a product (Peter and Ryan, 1976; Choi *et al.*, 2013). Perceived risk has been studied by numerous hospitality and tourism scholars interested in understanding consumer behavior and in studying the intangible nature of hospitality and tourism services (Park and Tussyadiah, 2017; Sohn *et al.*, 2016; Xu *et al.*, 2018). Moreover, perceived risk is a critical construct for identifying consumers' willingness to accept new technologies (Ko *et al.*, 2004). Perceived risk is comprised of several facets. Cunningham (1967) categorized these facets of perceived risk as falling within six dimensions. He labeled these dimensions of risk as financial, time, performance, safety, social and psychological. Previous consumer behavior literature has considered various facets of perceived risk in attempting to understand consumers' assessments of and intentions to use products and services (Featherman and Pavlou, 2003). Sometimes, facets of perceived risk are modified according to the context of the study. For example, Park and Tussyadiah (2017) proposed a comprehensive model of perceived risk for mobile travel booking that considered financial, performance, social, physical, psychological, time, privacy, security and technology risks.

Although there are certainly numerous benefits to be gained from DFDS, at the same time, there is a growing concern and anxiety among consumers about the use of drones for these services (Ramadan *et al.*, 2017). First, financial risk is perceived when consumers think of financially negative outcomes associated with new technology products (Park and Tussyadiah, 2017). The price of new products that operate using high-end technology was found to be a crucial concern for consumers. If the price of a new technology product is too high, consumers will be discouraged from searching for further information about it (Hirunyawipada and Paswan, 2006). As food delivery by drone is a new technology, consumers may worry that they will be overcharged for using it. Second, when adopting a new technology, consumers have to invest time and effort into obtaining information. They also need to familiarize themselves with new operating methods, and some consumers may consider this to be too time-consuming (Aldás-Manzano *et al.*, 2009). In this situation, consumers may decide that it is easier to continue to make use of traditional food delivery services to save time. Third, consumers may perceive privacy and security concerns around drone delivery services (Kaminski, 2013; Ramadan *et al.*, 2017). Consumers may suspect that drone technology is being improperly used for surveillance purposes, and this will make them anxious that their personal data or private information might be exposed to others. Ravich (2015) has demonstrated the necessity for drone engineers, security companies, local governments and aerial authorities to be aware of this issue and to try to protect consumers' privacy. Fourth, consumers may perceive there to be performance risk from drone delivery services. For example, there is a possibility that drones might crash into each other or fall from the sky, putting people in danger (Ravich, 2015). Moreover, drones might

not be able to deliver products successfully to consumers who wish to have their meals delivered directly to particular floors of apartments or skyscrapers. This may cause consumers to have doubts about drones' delivery performance (Ramadan *et al.*, 2017). Fifth, consumers may perceive psychological risks from the selection of a high-end technology service. Previous studies have described psychological risk as the possibility of experiencing mental distress resulting from a product or service purchase (Lee, 2016). Such mental distress can result from situations in which consumers cannot directly see or touch products prior to purchase. For example, psychological perceived risk is an important factor in the reluctance of some consumers to engage in online shopping (Forsythe and Shi, 2003) or e-commerce transactions (Featherman and Wells, 2010). In a similar way, some consumers may experience negative emotions, such as anxiety or nervousness when using DFDS.

After reviewing the previous literature, we found only a handful of studies that investigated the use of DFDS from the perspective of consumers' perceived risk. For example, the study of Ramadan *et al.* (2017), which explored consumers' intention to accept service-delivery drones, proposed that risk, functional benefits and relational attributes have a significant influence on people's attitudes toward using a drone and that this in turn affects people's intentions to use drones for delivery services. However, they failed to empirically test their model. Khan *et al.* (2019) conducted research on the perceptions of Pakistani consumers of drone delivery technology and found that privacy concerns are the most significant perceived risk negatively affecting consumers' acceptance of the technology. Recently, Hwang and Choe (2019) identified time, financial, performance, psychological and privacy risks as important factors that should be considered to increase the usage of DFDS.

The focus of the current study is perceived risk rather than perceived benefits or value of DFDS for the following reasons. First, if consumers have to choose between minimizing risks and maximizing utilities when buying a product, many of them would choose the former (Mitchell, 1999). This becomes obvious when the product or service involves using high technology. Second, perceived risk theory has been used widely to predict consumer behavior because of its intuitive appeal, and it helps marketers think from customers' eyes (Mitchell, 1999). Therefore, identifying perceived risk of DFDS was considered prior to the topic being explored.

Influence of perceived risk on the overall image of drone food delivery services

Overall image is defined as the set of associations linked to the product, service, brand, company or destination that consumers hold in their memory (Keller, 1993; Kotler *et al.*, 1993). It has been suggested that, because of its important role in affecting consumers' behavioral intentions, image needs to be fully incorporated into theoretical frameworks of customer decision-making (Lee *et al.*, 2010). In this study, image refers to the set of associations that consumers hold toward DFDS.

Previous studies have shown how perceived risk negatively affects the overall image of a product (Aldás-Manzano *et al.*, 2009; Hwang and Choe, 2019, 2020; Noh and Vogt, 2013). That is, the more risk that consumers perceive to be associated with a product or service, the less likely they are to form a positive image of that product or service. For example, Noh and Vogt (2013) empirically tested a tourism behavior model to explain US tourists' intention to visit China, Japan and South Korea. They found that perceived risk was an important factor that negatively affects the image of the three countries. Similarly, Hwang and Choe (2020) attempted to identify the relationship between perceived risk and image of insect restaurants. They found that the more consumers perceive high risks of insect restaurants, the less consumers generate positive image of the restaurants. This becomes obvious particularly in cases of products that involve new technology. Hwang and Choe (2019)

explored the impact of perceived risks on the overall image of DFDS and demonstrated that perceived risks have negative impacts on the image of these high technology-involved services. However, Hwang and Choe's study was conducted before the outbreak of COVID-19. There is thus a need to examine how the pandemic has affected the ways in which consumer risk perception influences the image of DFDS.

The results of previous studies have suggested that when consumers perceive there to be risks associated with using a product or service that involves new technology, there is a high possibility that they will form a negative image of that product or service. It is expected that investigating the direct influence of different facets of perceived risk on image will reveal useful information that will better enable us to understand the ways in which consumers perceive risk. Based on previous studies, it can be inferred that if consumers perceive a high level of risk regarding DFDS, they are more likely to form a negative image of the services. Therefore, the following hypotheses are proposed:

- H1.* Financial risk has a negative influence on the image.
- H2.* Time risk has a negative influence on the image.
- H3.* Privacy risk has a negative influence on the image.
- H4.* Performance risk has a negative influence on the image.
- H5.* Psychological risk has a negative influence on the image.

Influence of image on intentions to use drone food delivery services

Intention refers to "the degree to which a person has formulated conscious plans to perform or not perform some specified future behavior" (Warshaw and Davis, 1985, p. 214). For consumers to form an actual intention to use a product or service, they first have to form a positive image of that product or service (Han and Hyun, 2017; Hwang and Kim, 2019; Liu *et al.*, 2020).

In many hospitality and tourism studies, overall image of a hospitality product is generally proposed to have a positive influence on customers' intention to use it. For example, Ryu *et al.* (2008) concluded that image has both direct and indirect positive influence on customers' intention to revisit the quick-casual restaurant and intention to recommend the restaurant to others. Han and Hyun (2017) proposed that enhancing image of a product/service (e.g. luxury hotel restaurant product) will lead to customers' increased intention to be loyal. In their study, they proved the positive indirect relationship between overall image of a luxury hotel restaurant and intention to revisit the restaurant (Han and Hyun, 2017). Recently, Hwang and Kim (2019) examined the effect of drones' environment-friendly image on consumers' attitudes and consumers' behavioral intentions. They showed that when consumers had a favorable image of DFDS as being environmentally friendly, they also had positive attitudes toward the use of these services and displayed high levels of intention to make use of them (Hwang and Kim, 2019). Based on previous studies, it can be inferred that consumers are more likely to use DFDS once they have a positive image about the service. Thus, the following hypothesis is proposed:

- H6.* Image has a positive influence on people's intentions to use DFDS.

Moderating role of COVID-19 on the perceptions of drone food delivery services

There is a high possibility that COVID-19 has influenced consumers' perception of the risks involved in DFDS. Consumers may now perceive DFDS to be less risky than before because

of the importance of contactless food delivery services under the circumstances of the pandemic. As the use of drones guarantees “zero human-contact,” drone delivery services represent a creative and effective solution to the particular problems generated by the COVID-19 pandemic (McFarland, 2020). Engineers working on drone technology believe that both the development of effective drone technology and consumers’ acceptance of such technology will be accelerated owing to the pandemic (Chandler, 2020; McFarland, 2020). In fact, COVID-19 has played a significant role in boosting the use of drone delivery services. For example, one Chinese e-commerce company recently launched a drone food delivery project that involved the company in designing appropriate flight paths and getting approval from the local government. This shows how drones can be useful tools for the provision of food services to consumers under the conditions of public health emergencies (Gascueña, 2020).

Recent studies have shown that customers are very anxious when they visit hospitality properties under pandemic (Kim and Lee, 2020; Shin and Kang, 2020). Therefore, technology-based services that involve no human contact can make consumers more comfortable. For example, Shin and Kang (2020) found that when consumers know that a hotel provides technology-based services and cleaning services, they perceive a lower level of health risk. Previous studies regarding crisis management also show that consumers will choose consumption choices that are perceived to be less risky (Dryhurst *et al.*, 2020; Kim and Lee, 2020; Rittichainuwat and Chakraborty, 2009). Therefore, there is a possibility that consumers consider DFDS to be less risky than before.

On the other hand, consumers may create a higher level of risk toward the drone delivery service after COVID-19 than before because now they begin to think of adopting the new technology in their real life, concerning and questioning about the actual practicability of using drones as delivery. Moreover, the perceived risk of coronavirus is known to seriously affect people’ mental health. Yıldırım and Güler (2020) empirically found that perceived risk of coronavirus was highly related to death depression and death obsession. In this stressful situation, consumers may be very sensitive about perceived risks of new technology.

Elliot (2006) introduces the concept of approach and avoidance motivation energized by positive and negative stimuli, respectively. That is, before COVID-19, approach motivation could have affected consumers’ perceptions of DFDS. Consumers could have been motivated to use DFDS because of diverse hedonic and social reasons (Hwang *et al.*, 2019a) even though some degree of risks existed. However, after COVID-19, restaurants and bars have been repeatedly locked down, and consumers try to minimize human interaction as much as possible. Consumers may be motivated to choose DFDS to avoid a bigger risk (e.g. coronavirus disease). In this case, using DFDS is regarded as behavior for surviving rather than thriving. Thus, consumers may question the practicability of using drones as delivery, creating a negative image of DFDS.

In fact, previous hospitality literature indicates that when innovative technology is actually applied in the reality, consumer begin to recognize many problems such as security, technical flaws, unfamiliarity and inconvenience of the application of new technology (Mishraa *et al.*, 2018; Wirtz *et al.*, 2018). For example, although there has been a lot of positive expectation and interest of the world’s first robot hotel in Japan, this new technology (e.g. service robots) has been found to annoy guests and make people complain about the services (Bhimasta and Kuo, 2019). Therefore, there is a possibility that consumers may consider DFDS to be more risky than before when they begin to think of using it in their real life under pandemic.

Based on the above discussions, it is rational to assume that the ongoing COVID-19 crisis may be exerting an influence on the relationship between perceived risk and the overall image of DFDS. Thus, the following hypothesis is proposed:

- H7a.* The relationship between financial risk and the image of DFDS has been significantly moderated by the outbreak of COVID-19.
- H7b.* The relationship between time risk and the image of DFDS has been significantly moderated by the outbreak of COVID-19.
- H7c.* The relationship between privacy risk and the image of DFDS has been significantly moderated by the outbreak of COVID-19.
- H7d.* The relationship between performance risk and the image of DFDS has been significantly moderated by the outbreak of COVID-19.
- H7e.* The relationship between psychological risk and the image of DFDS has been significantly moderated by the outbreak of COVID-19.

The conceptual model of this current study is represented in [Figure 1](#).

Methodology

Measures

First, measurement items of perceived risk had been used from previous studies including [Chen \(2013\)](#), [Hwang and Choe \(2019\)](#); and [Martins *et al.* \(2014\)](#). Second, measurement items of image had been adopted from [Jani and Han's \(2014\)](#) study. Third, measurement items of intentions had been used from [Zeithaml *et al.* \(1996\)](#). This study used a seven-point scale [e.g. “strongly disagree” (1) and “strongly agree” (7)]. The current study conducted a pretest using an online questionnaire survey based on 50 actual food service patrons in Korea. The

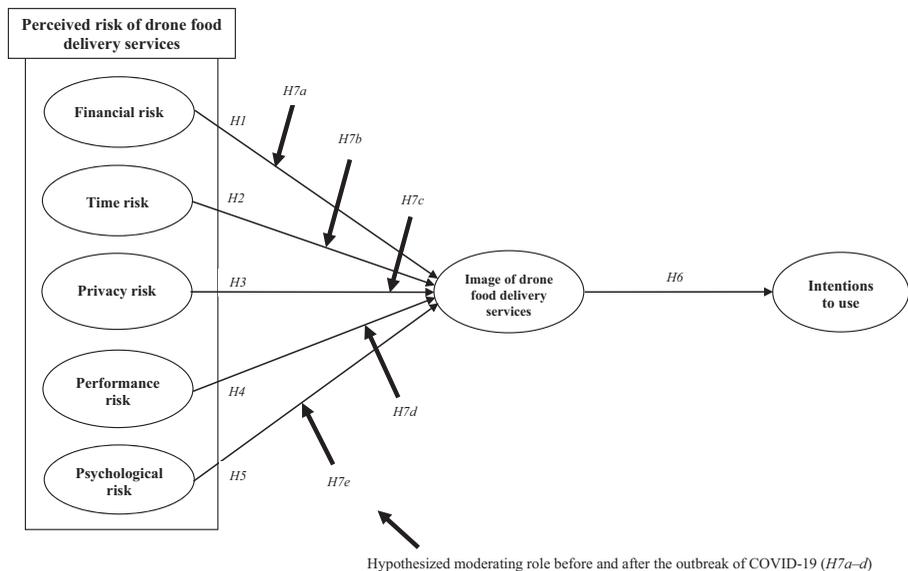


Figure 1.
Proposed conceptual model

results of the data analysis indicated that Cronbach's alpha values were greater than 0.7. That is, the reliability of items was assured.

Data collection

In this study, two surveys were conducted to identify changes in consumers' perceived risk following the outbreak of COVID-19. First, this study collected data to measure perceived risk before the outbreak of COVID-19 using a convenience sampling technique based on the online survey in February 2018 in Korea. We chose the online survey named "EMBRAIN" because the company has a panel of 1.3 million, and it is one of the largest companies in the nation. The data were not collected for this study but for carrying out other studies related to the consumers' perceptions of risk of DFDS. To enhance respondents' understanding of DFDS, we provided a 2 min and 30 s video, which clearly explained how to operate DFDS, before the commencement of the survey. Among the company's panel members, 2,794 members were contacted. Among them, 346 members answered the questionnaire. After deleting 15 outliers owing to multivariate outliers and visual inspections, 331 samples were used for the final data analysis.

In addition, in the same way, data collection was carried out again in May 2020, following the outbreak of COVID-19. Respondents were able to participate in the survey after watching the video mentioned above. The same survey company as before was used to send emails to a total of 1,479 members. Among those sent the survey, 343 members completed it, and their responses were used for the analysis.

Data analysis

Demographics of respondents

First, in the case of respondents who completed the survey prior to the COVID-19 outbreak, the number of males ($n = 192$ and 58.0%) were more than the number of females ($n = 139$ and 42.0%). In terms of age, respondents in their 20s ($n = 124$ and 37.5%) formed the majority, with the next highest demographic group comprising those in their 30s ($n = 102$ and 30.8%). In total 30.8% of the respondents were college graduates. In total 30.8% indicated they were single. In terms of income level, 22.4% of the respondents ($n = 74$) reported that their monthly income was between US\$2,001 and US\$3,000. Second, in the case of respondents who completed the survey following the COVID-19 outbreak, the number of 177 (51.6%) males were more than 166 (48.4%) females. Respondents in their 30s ($n = 107$ and 31.2%) formed the majority, and 226 (65.9%) were college graduates. A total of 198 (57.7%) were single, and the highest percentage of respondents ($n = 97$ and 28.3%) reported that they earned between US\$2,001 and US\$3,000.

Measurement-invariance assessment

First, following [Steenkamp and Baumgartner's \(1998\)](#) suggestion, a measurement invariance assessment was conducted. The first group was called "before the COVID-19 outbreak," and the second group was named as "after the COVID-19 outbreak." The nonrestricted model and the full-metric invariance model had acceptable fit statistics. Major model-of-fitness indices such as normed fit index (NFI), comparative fit index (CFI) and Tucker-Lewis index (TLI) were higher than 0.9 ([Table 1](#)). In addition, the full-metric invariance was statically supported because the chi-square values between two models were not significant ($p > 0.01$) ([Table 1](#)).

Table 1.
Measurement
invariance models

Models	χ^2	df	NFI	CFI	TLI	RMSEA	$\Delta\chi^2$	Full-metric invariance
Before and after the outbreak of COVID-19	708.990	336	0.958	0.977	0.972	0.041	$\Delta\chi^2(21) = 31.247$ $p > 0.01$ (insignificant)	Supported
Full-metric invariance	740.237	357	0.955	0.976	0.971	0.041		

Notes: NFI = normed fit index, CFI = comparative fit index, TLI = Tucker-Lewis index and RMSEA = root mean square error of approximation; $\Delta\chi^2(21) = 38.930$ and $p > 0.01$

Confirmatory factor analysis

As presented in [Table 2](#), the confirmatory factor analysis (CFA) results for the three models fit the data well because major model-of-fitness indices such as NFI, CFI and TLI were greater than 0.9 ([Byrne, 2001](#)). Finally, values of factor loadings were acceptable because all the numbers were equal or greater than 0.823.

All constructs confirm convergent validity because average variance extracted (AVE) values are greater than 0.50 ([Fornell and Larcker, 1981](#)). All values of composite reliabilities for the three models were satisfactory as well because all the scores were greater than 0.70 ([Hair et al., 2006](#)). Finally, discriminant validity of the models was confirmed because all the AVE scores are higher than the values of squared correlations between any pair of constructs ([Bagozzi and Yi, 1988](#)) ([Table 3](#)).

Structural equation modeling

To check the proposed hypotheses, this study used structural equation modeling (SEM) analysis ([Figure 2](#)). The model fit showed a satisfactory fit because major model-of-fitness indices such as NFI, CFI and TLI were greater than 0.9 ([Figure 2](#)). Among six hypotheses, three hypotheses were supported at $p < 0.05$. More specifically, financial, time and privacy risks did not affect image, so *H1*, *H2* and *H3* were not supported. On the other hand, performance and psychological risks negatively affected image. Therefore, *H4* and *H5* were supported. Finally, it was found that image positively affected intentions to use. Thus, *H6* was supported.

Moderating effect of the outbreak of COVID-19

The current paper used multiple-group analyses to test the moderating effect of the COVID-19 outbreak ([Table 4](#)). First, the moderating role of the outbreak of COVID-19 was significant in the relationship between performance risk and image ($p < 0.05$). Therefore, *H7d* was supported. That is, the path coefficient for the first group (before the COVID-19 outbreak) ($\beta = -0.157$ and $t = -2.594^*$) was higher than the second group (after the COVID-19 outbreak) ($\beta = -0.339$ and $t = -5.927^*$). However, *H7a*, *H7b*, *H7c* and *H7e* were not supported.

Discussion and conclusions

Conclusions

The focus of this study is on analyzing how people's perceptions of the risks posed by DFDS have changed since the COVID-19 outbreak. Likewise, the present study examined the consumers' perceived risk in connection with DFDS and investigated its influence on the overall image of the services before and after pandemic. Furthermore, the effect of overall image on intentions to use was examined. The current study involves the following discussion and implications for academia and the food delivery industry. Finally, further research avenues are suggested based on the acknowledgement of several limitations of the study.

Discussion

The actual use of DFDS is still perceived to pose various risks to some extent ([Ramadan et al., 2017](#)). There have therefore been attempts to explore consumers' perceptions of the potential uncertainties and unpleasant consequences that might result from the use of drones for food delivery services ([Hwang and Choe, 2019](#)). In the meantime, the recent outbreak of COVID-19 has changed the way that people consume food and beverages

Construct and scale item	Standardized loading ^a		
	BC	AC	MAC
<i>Financial risk</i>	CA = 0.974	CA = 0.964	CA = 0.970
The cost of using drone food delivery services is likely to be burdensome	0.975	0.959	0.968
Drone food delivery services are likely to cost more than I thought	0.960	0.947	0.954
I might get overcharged if I use drone food delivery services	0.952	0.939	0.946
<i>Time risk</i>	CA = 0.952	CA = 0.939	CA = 0.959
The possible time loss from learning about using drone food delivery services is high	0.948	0.944	0.947
If I use drone food delivery services, I am more likely to lose time by switching to a different delivery service	0.955	0.936	0.952
It will take time to learn how to use drone food delivery services	0.893	0.867	0.884
<i>Privacy risk</i>	CA = 0.965	CA = 0.952	CA = 0.958
Using drone food delivery services may not protect my personal information (e.g. credit card number, phone number, address, etc.)	0.974	0.986	0.980
Personal information (e.g. credit card number, phone number, address, etc.) when using drone food delivery services may be stolen	0.930	0.885	0.918
Personal information (e.g. credit card number, phone number, address, etc.) could be exposed when using drone food delivery services	0.946	0.928	0.929
<i>Performance risk</i>	CA = 0.937	CA = 0.919	CA = 0.929
The probability that something's wrong with the performance of drone food delivery services is high	0.919	0.871	0.896
Drone food delivery services do not seem to perform well	0.899	0.853	0.876
Considering the expected level of the performance of drone food delivery services, it would be risky to use them	0.920	0.939	0.925
<i>Psychological risk</i>	CA = 0.910	CA = 0.927	CA = 0.920
The usage of drone food delivery services would lead me to a psychological loss	0.895	0.900	0.899
Using drone food delivery services would not fit in well with my self-image	0.922	0.940	0.929
Using drone food delivery services makes me feel anxious	0.823	0.864	0.827
<i>Image</i>	CA = 0.959	CA = 0.961	CA = 0.960
The overall image for using drone food delivery services is good	0.952	0.944	0.945
The overall image I have about drone food delivery services is great	0.959	0.954	0.958
Overall, I have a good image about drone food delivery services	0.915	0.938	0.929
<i>Intentions to use</i>	CA = 0.957	CA = 0.972	CA = 0.965
I will use drone food delivery services when ordering food	0.950	0.954	0.953
I am willing to use drone food delivery services when ordering food	0.907	0.959	0.934
I am likely to use drone food delivery services when ordering food	0.962	0.966	0.966

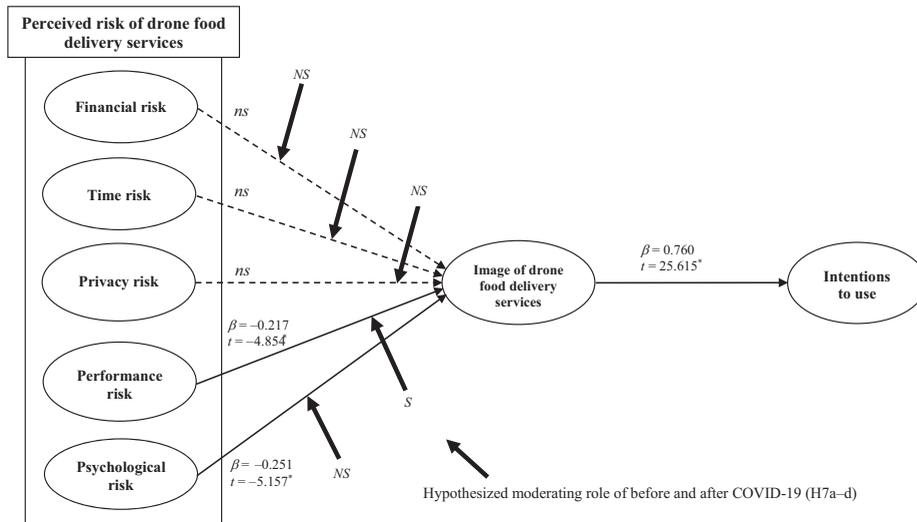
Notes: Goodness-of-fit statistics; before the outbreak of COVID-19: $\chi^2 = 324.771$, $df = 168$, $\chi^2/df = 1.933$, $p < 0.001$, NFI = 0.961, CFI = 0.981, TLI = 0.976 and RMSEA = 0.053; after the outbreak of COVID-19: $\chi^2 = 384.221$, $df = 168$, $\chi^2/df = 2.287$, $p < 0.001$, NFI = 0.954, CFI = 0.974, TLI = 0.967 and RMSEA = 0.061; merging before and after the outbreak of COVID-19: $\chi^2 = 413.685$, $df = 168$, $\chi^2/df = 2.462$, $p < 0.001$, NFI = 0.975, CFI = 0.985, TLI = 0.981 and RMSEA = 0.047; BC = before the outbreak of COVID-19, AC = after the outbreak of COVID-19 and MAB = merging before and after the outbreak of COVID-19 CA = Cronbach's alpha; ^aAll factors loadings are significant at $p < 0.001$; and NFI = normed fit index, IFI = incremental fit index, CFI = comparative fit index, TLI = Tucker-Lewis index and RMSEA = root mean square error of approximation

Table 2.
Confirmatory factor analysis: items and loadings

	Mean (std. dev.)	AVE	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Financial risk	4.61 (1.69)	0.926	<i>0.974</i>	0.083 ^a	0.287	0.295	0.348	-0.052	-0.146
	<u>4.92 (1.39)</u>	<u>0.899</u>	<u>0.964</u>	0.281	0.139	0.297	0.252	-0.152	-0.180
Time risk	4.77 (1.55)	0.914	0.970	0.158	0.222	0.283	0.303	-0.101	-0.168
	4.29 (1.64)	0.869	0.007 ^b	<i>0.953</i>	0.372	0.205	0.276	-0.226	-0.232
Privacy risk	4.13 (1.46)	0.840	0.079	<i>0.940</i>	0.273	0.263	0.364	-0.187	-0.151
	4.21 (1.55)	0.886	0.025	0.959	0.328	0.249	0.279	-0.141	-0.241
Performance risk	3.74 (1.63)	0.903	0.082	0.138	<i>0.965</i>	0.316	0.506	-0.169	-0.227
	3.96 (1.45)	0.872	0.019	0.075	<i>0.953</i>	0.172	0.352	-0.161	-0.163
Psychological risk	3.85 (1.54)	0.889	0.049	0.108	0.960	0.282	0.454	-0.166	-0.209
	4.54 (1.37)	0.833	0.087	0.042	0.100	<i>0.937</i>	0.426	-0.288	-0.228
Image	4.48 (1.29)	0.789	0.088	0.069	0.030	<i>0.918</i>	0.462	-0.467	-0.456
	4.51 (1.33)	0.809	0.080	0.062	0.080	0.927	0.469	-0.326	-0.325
Intentions to use	4.49 (1.46)	0.777	0.121	0.076	0.256	0.181	<i>0.912</i>	-0.339	-0.433
	4.40 (1.38)	0.813	0.064	0.132	0.124	0.213	<i>0.929</i>	-0.443	-0.444
Intentions to use	4.44 (1.42)	0.779	0.092	0.078	0.206	0.220	0.913	-0.340	-0.392
	4.49 (1.28)	0.888	0.003	0.051	0.029	0.083	0.115	<i>0.960</i>	0.781
Intentions to use	4.45 (1.35)	0.894	0.023	0.035	0.026	0.218	0.196	<i>0.962</i>	0.767
	4.47 (1.31)	0.891	0.010	0.020	0.028	0.106	0.116	0.961	0.758
Intentions to use	4.51 (1.42)	0.884	0.054	0.054	0.052	0.052	0.187	0.610	<i>0.958</i>
	3.90 (1.38)	0.921	0.032	0.023	0.027	0.208	0.197	0.588	<i>0.972</i>
Intentions to use	4.20 (1.43)	0.905	0.028	0.058	0.044	0.106	0.154	0.575	0.966

Notes: The unmarked values are for before the outbreak of COVID-19; the underlined values are for after the outbreak of COVID-19; values in boldface type are for merging before and after the outbreak of COVID-19; AVE = average variance extracted; italic composite reliabilities are along the diagonal; and ^aCorrelations are above the diagonal and ^bsquared correlations are below the diagonal

Table 3. Descriptive statistics and associated measures



$\chi^2 = 459.476$, $df = 173$, $\chi^2/df = 2.656$, $p < 0.001$, $NFI = 0.972$, $CFI = 0.983$, $TLI = 0.979$, and $RMSEA = 0.050$

Notes: ns = not significant; * $p < 0.05$

Figure 2. Standardized theoretical path coefficients

Table 4.
Moderating role of
the outbreak of
COVID-19

Path	Paths		Standardized estimate	t-value	Hypotheses
	Before the outbreak of COVID-19	After the outbreak of COVID-19			
H1 Financial risk		Image	0.034	0.857	Not supported
H2 Time risk		Image	-0.033	-0.841	Not supported
H3 Privacy risk		Image	0.007	0.161	Not supported
H4 Performance risk		Image	-0.217	-4.854	Supported
H5 Psychological risk		Image	-0.251	-5.157	Supported
H6 Image		Intentions to use	0.760	25.615	Supported
Path	Unconstrained model		Constrained model		Tests of moderator
	Before the outbreak of COVID-19	After the outbreak of COVID-19			
	β	B	$\Delta\chi^2$ (346) = 753.021	χ^2 difference	Hypotheses
H7a F → I	0.043	0.019	$\Delta\chi^2$ (347) = 753.690	$\Delta\chi^2$ (1) = 0.669	Not supported
H7b T → I	-0.129	0.007	$\Delta\chi^2$ (347) = 755.692	$\Delta\chi^2$ (1) = 2.671	Not supported
H7c PR → I	0.054	-0.004	$\Delta\chi^2$ (347) = 753.478	$\Delta\chi^2$ (1) = 0.457	Not supported
H7d PE → I	-0.157	-0.339	$\Delta\chi^2$ (347) = 758.854	$\Delta\chi^2$ (1) = 5.833	Supported
H7e PS → I	-0.243	-0.299	$\Delta\chi^2$ (347) = 753.074	$\Delta\chi^2$ (1) = 0.053	Not supported

Notes: F = financial risk, T = time risk, PR = privacy risk, PE = performance risk, PS = psychological risk and I = image; ^{ns} = not significant; **p* < 0.05; $\Delta\chi^2$ (1) = 3.84, *p* < 0.05

(Wong, 2020). An untact environment has become an essential precautionary measure for many service encounters to stem the spread of coronavirus. Likewise, the development and adoption of DFDS, which do not require human-to-human contact, has entered a new phase. Numerous studies have demonstrated how the use of drones for food delivery services is an effective and beneficial solution to some of the problems caused by the pandemic (Chandler, 2020; McFarland, 2020). The current study took a step further in considering the impact of COVID-19 and determined there has been a major shift in consumers' perceptions of the risks regarding DFDS.

It was found that the overall image of DFDS is negatively affected by performance risk. That is, this study echoed previous findings that perceived risk negatively influences the overall image of products and services in various contexts (Aldás-Manzano *et al.*, 2009; Hwang and Choe, 2019; Hwang and Choe, 2020; Noh and Vogt, 2013). The results of analysis from the current study demonstrated that time risk, performance risk and psychological risk negatively affected the image of DFDS before the outbreak of COVID-19. On the other hand, only performance risk and psychological risk were found to be influential factors that negatively affect the image of DFDS after COVID-19 outbreak. The present research attested that consumers' perceptions of time risk are no longer affecting the image of DFDS following the outbreak of coronavirus. We believe that this result can be attributed to the extensive articulation in the media of the efficiency of using DFDS during the COVID-19 pandemic. Nonetheless, performance risk and psychological risk still negatively affected the image of DFDS after the incident of COVID-19. This is because such services are not currently fully commercialized in South Korea, meaning that people there have less reliance on its functionality as they do not have practical experience of these services.

In addition, the result indicates if the consumers perceive more performance risk toward DFDS, they are more likely to build a less positive image toward the DFDS, particularly after the outbreak of COVID-19. There are new and various rules and regulations in our daily lives since the coronavirus began, and they indeed affect consumer behavior (McFarland, 2020). Thus, it can be said that people are more cautious in every aspect about using new products/services. The results demonstrating the moderating effect of the COVID-19 outbreak provides the best clue to what importance we attach to the complete service delivery under the pandemic.

Finally, the current study confirmed that image of DFDS has a positive influence on consumers' intentions. This is similar to the results suggested by Hwang and Choe (2019) and Hwang and Kim (2019). It also makes an additional contribution by confirming that such relationships continue to exist even after pandemic. Theoretical and managerial values are suggested in the next section.

Theoretical implications

First, the current study successfully validated an essential role of perceived risk of DFDS in the formation of consumer behavior. Perceived risk theory suggests that consumers' actual purchase decision is influenced by an individual's perception of uncertainty when they attempt to use a product or service. Presently, more technology-powered products and services are used in the operations of hospitality, and the majority of studies have placed the focus on the positive outcomes of novel technologies in the hospitality (Kim *et al.*, 2020; Mercan *et al.*, 2020). Also, service innovation has been explained as a beneficial influence in hospitality (Hollebeek and Rather, 2019; Hwang *et al.*, 2020). Meanwhile, some prior studies determined how perceived risk negatively affects the consumer behavior toward products/services that involve new technology (Park and Tussyadiah, 2017). Similarly, the attempts were made to explore the perceived risk and its impact on consumers' responses in the

context of DFDS (Khan *et al.*, 2019; Ramadan *et al.*, 2017), but the evidence is rather rare. This study is one of the few studies that empirically examined the various perceived risks associated with DFDS and its effect on the consumer behavior.

Second, the present study explored the impact of COVID-19 in the context of DFDS for the first time. In other words, this research conducted the data analysis and confirmed the underlying risks which affect the overall image of DFDS before and after the incident of COVID-19. Of various risks associated with DFDS, this study observed how people change their perception in the wake of COVID-19. Therefore, it implies the high potential to develop the extension of perceived risk theory in light of the catastrophes such as epidemic.

Moreover, the current study confirmed the moderating role of COVID-19 in the link between performance risk from DFDS and image of the services. The pandemic caused by the coronavirus has indeed caused substantial changes to be made in the foodservice industry (Wong, 2020), and drones have drawn attention as an innovative solution for the provision of food delivery services in an untact environment (Chandler, 2020; McFarland, 2020). One of the principal attractions of drone-based food delivery services for consumers is that they are contactless (Gascueña, 2020; McFarland, 2020), and this has encouraged many consumers to try out services under the circumstances of the current pandemic rather than continuing to use more traditional modes of food delivery. The result is also in line with the findings of Jiang and Wen (2020), suggesting contactless services to transform adversity under COVID-19 pandemic into opportunity. In this regard, this study contains meaningful theoretical value as it provides the first empirical evidence of the ways in which the coronavirus pandemic affects consumers' perceived risk around DFDS and its influence on the image of the services.

Managerial implications

First, industry practitioners should concentrate on reducing performance risk from DFDS. To mitigate performance risk, DFDS providers need to establish a performance guarantee system in which they officially commit to providing flawless services with a high level of accuracy and promise heavy compensation in case of failure. Such programs, which guarantee a certain standard or condition of product or service delivery, have been determined to lead to better results in consumers' responses (such as fairness in the context of hospitality) (Jiang and Erdem, 2018; Pusparini and Setiaji, 2019). Therefore, using such a system would help to mitigate performance risk and would enhance the quality assurance of DFDS. Additionally, the positive impact of excellence certificates on firms' performance was proven for businesses in the hospitality industry (Kim *et al.*, 2016). Acquiring third-party certifications would be an effective way for service providers to reduce consumers' risk perception regarding the performance of drone-based food delivery services.

Second, service providers should seek ways to minimize psychological risk. It is suggested that companies that provide DFDS highlight the ways in which the services that they provide are designed to be stress-free and convenient for the consumer. Marketing communications focused on the various benefits of drone-based food delivery services would be helpful in minimizing consumers' mental distress. In addition, this study suggests that professionals in the field emphasize the beneficial role of DFDS from the epidemiological standpoint in responding to the current pandemic. In other words, these services should be described as a smart solution that abides by precautionary measures to overcome COVID-19. Many of those employed in traditional methods of food delivery have been among those infected with COVID-19 (Global Times, 2020; India Today, 2020), highlighting the need for contactless food delivery services. Drone delivery services can therefore be promoted as an effective way of delivering food without the need for any sort of

human contact. With this respect, public health authorities are also recommended to proactively introduce drone delivery services as a potential solution in the pandemic. For instance, government institutions such as the Centers for Disease Control and Prevention constantly promote the guidelines for food handling and packages to prevent the spread of COVID-19 (Center for Disease Control and Prevention, 2020; Food and Agriculture Organization of the United Nations, 2020). Then, the services like a drone-based food delivery are to be addressed as an innovative solution in such reports to minimize the number of COVID-19 cases. Furthermore, the trials and findings during the coronavirus pandemic should be properly documented for the long-term perspective. That is, the current learning would be used as an evidence to establish strategic plans for any new cases of novel respiratory diseases in the future.

Third, given that the intensity of the association between performance risk and people's intentions to use was significantly greater after the outbreak of COVID-19, industry professionals should pay close attention to consumers' changing perceptions of the performance risk from DFDS. Practitioners might consider live streaming or creative activities that enable potential consumers to visualize DFDS in a way that highlights the smooth operation of these services. Indeed, the increasing role of drones in diverse areas of industry and everyday life has received enormous attention since the outbreak of COVID-19 (Chandler, 2020), and these developments need to be effectively shared with consumers in ways that make them more comfortable with the use of drones for food delivery services. Furthermore, companies that provide these services should encourage the sharing of positive experiences by private individuals via social networking platforms. These initiatives will contribute to generating more opportunities for positive word-of-mouth communications regarding the superior performance of drone-based food delivery services and consequently reduce performance risk associated with these services.

Limitations and future research

First, the current study investigated perceived risks and consumer responses in the context of DFDS, a topic which has sparked renewed discussion following the outbreak of COVID-19. Nonetheless, the appropriateness of our proposed theoretical model is unknown for other technology-powered products or services. There are, indeed, several other innovative solutions, such as parachutes and robots, that have been proposed as solutions for overcoming problems created by the present pandemic. Therefore, the framework of the current study can be tested in other settings. Second, respondents who joined this study before and after the COVID-19 outbreak were different. However, in such cases, differences in the results of measurement items may arise, so it is recommended to collect data from same respondents to compare before and after a certain event. Finally, seven variables were measured at the same period. Therefore, in the future study, there is a need to gather data in different periods (Podsakoff *et al.*, 2003).

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Corresponding author

Jinsoo Hwang can be contacted at: jhwang@sejong.ac.kr