

Service innovation in the restaurant sector during COVID-19: digital technologies to reduce customers' risk perception

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Abstract

Purpose – This paper investigates the extent to which the COVID-19 pandemic has accelerated service innovation in the restaurant sector. It explores the use of digital technologies (DT) as a safety-empowerment and resilient strategy in the food-service industry during the pandemic. It also investigates the impact of DT on customers' risk perception (CRP) and customers' intention to go to restaurants (CIR) in Italy.

Design/methodology/approach – Based on the theory of planned behaviour and perceived risk theory, this study investigates a sample of customers residing in Italy. Multiple regression and mediation analyses are conducted to test the research hypotheses, adapting the logic model developed. Using the bootstrapping technique, this study also explores whether the pandemic has moderated the relationship among several variables adapted from the literature. Robustness tests are also performed to corroborate the analysis.

Findings – The pandemic has accelerated the food-service industry's digital transformation, forcing restaurateurs to implement DT to survive. Findings show that DT support restaurateurs in implementing innovative services that reduce interactions and empower cleanliness among workers and customers, reducing CRP and preserving CIR. Thus, managing risk perception is helping the restaurant sector to recover.

Practical implications – Practical implications are presented for policymakers to catalyse the digital transformation in small- and medium-sized restaurants. The results may also be beneficial for entrepreneurs who can implement innovative service practices in order to reduce interaction and empower cleanliness levels. Moreover, academics can use these results to conduct similar research in other geographical contexts.

Originality/value – The present research represents the first study investigating the relationship between the use of digital technologies and the intentions of customers to go out for dinner during the ongoing pandemic in Italy.

Keywords Restaurant sector, Service innovation, COVID-19, Digitalisation, Customer risk perception, Theory of planned behaviour, Perceived risk theory

Paper type Research paper

1. Introduction

The recent Covid-19 pandemic outbreak has damaged the economy worldwide. In particular, the restaurant sector (RS) –considered a high-risk industry (Song *et al.*, 2021) – has been sharply affected by Covid-19, which has raised revolutionary trials to tackle. The rapid spread of the virus led to restaurant restrictions with a consequent reduction in turnover, job



loss and – in some cases – permanent closure of commercial activities (Min *et al.*, 2021). In addition, a significant change in customers' behavioural intentions to stay home has emerged (Rizou *et al.*, 2020). Customers' attitudes to visit restaurants have significantly reduced due to the fear of being exposed to the potential Covid-19 risks (Galanakis, 2020; Esposito *et al.*, 2021). Similarly, restaurant operators have been demonstrated to be susceptible to contracting the virus, and their willingness to go to work has been considerably reduced.

The restaurants have been called to reorganize their activities to continue in a context characterized by the need to ensure health safety, reduce the risk perception and comply with governments measures to survive. Although the World Health Organization has declared that food is not a means of Covid-19 transmission, the operations undertaken during the restaurant supply chain (SC) have been considered hazardous due to the numerous interactions among the actors involved in the (SC) (Min *et al.*, 2021). As a result, a lot of restrictive measures – such as the constraining on opening hours and the cutting of seating capacities – have been implemented worldwide. However, in the more recent month following the advent of the vaccination campaign, the intensity of such measures has been reduced because society needs to help the economic and social recovery of businesses. In this perspective, the Service Innovation (SI) to enhance traditional restaurant services and create new service opportunities has emerged as the only way of coping with these critical issues. Although SI has always been considered as a strategic factor for competitiveness and at the discretion of the managers (Feng *et al.*, 2020; Helkkula *et al.*, 2018; Kowalkowski and Witell, 2020), the pandemic has posed an imperative to innovate in the RS in order to ensure the organization's survival and resilience (Edvardsson *et al.*, 2018; Heinonen and Strandvik, 2021). This “imposed service innovation” has been expected to reduce negative implications by sparking a change of thinking and exciting business opportunities never considered before (e.g. Nenonen and Storbacka, 2020; Batat, 2020). In this light, the adoption of digital technologies (DT) – such as contactless digital payment, advanced cleaning systems, digital menus accessible via QR codes, service robots, touchless elevators, food delivery apps, *etc.* – has been used as service innovation tools to implement risk-reduction strategies. Through these tools, DT is expected to reduce guest and workers interactions and empower restaurants cleanliness (Shin and Kang, 2020). In this context, scholars have shown that – during the post-pandemic era – customers' risk perception should be considered one of the main barriers to the re-start of food service activities since it influences the purchase decision-making process (e.g. Dedeoğlu and Boğan, 2021; Leung and Cai, 2021).

Consequently, reducing customers' retention to go to the restaurant has become the new priority for the RS. Indeed, “due to the risks associated with the possibility of contracting the virus, the mitigation of customers' perceived risk also requires attention” (Min *et al.*, 2021, p. 2). Therefore, in the wake of its relevance, scholars have started to investigate risk perception in the RS – both from a customers and workers' perspective – to assess the levels of risk perception and the actions implemented to manage it during the post-pandemic (e.g. Roberts *et al.*, 2020; Min *et al.*, 2021; Yan *et al.*, 2021). In particular, academics have shown that high levels of perceived risk determine the reduction of customers' intention to visit restaurants (e.g. Song *et al.*, 2021; Forouzi *et al.*, 2021). At the same time, other scholars have started to investigate the use of DT for RS recovery during the pandemic (e.g. Shin and Kang, 2020; Demaitre, 2020; Hoque *et al.*, 2020). More specifically, Shin and Kang (2020) have explored how the use of DT could reduce the risk perception of the virus among customers and workers in the hospitality sector (i.e. hotels and restaurants within the hotels). They have highlighted that these technologies could impact food safety and hygiene practices. However, despite scholars have investigated separately the impact of DT on risk perception and the impact of risk perception on the intention to go to the restaurant, the relationship between the

use of DT and the customers' risk perception and its consequential effect on customers' intention to go to the restaurant remains still unexplored.

Starting from this background, adopting a theoretical framework based on the integration of the theory of planned behaviour (TPB) and the perceived risk theory (PRT), this paper aims to answer the following research question:

- RQ1.* To what extent do digital technologies support restaurants in managing risk perception and enticing customers to go to restaurants during the Covid-19 pandemic?
- RQ2.* How the Covid-19 pandemic has affected customers' perception of digital technologies?

To answer the research questions, a survey on a customers' resident in Italy has been carried out with the intent to explore:

- (1) The potential mediating role of customers' risk perception in the relationship between DT and customers' intention to go to the restaurant;
- (2) The potential mediating role of expected interactions and expected cleanliness in the relationship between DT and customers' risk perceptions and
- (3) The potential moderating role of the COVID-19 pandemic in the relationship between DT and (a) expected interactions; (b) expected cleanliness and (c) customers' risk perceptions.

This paper is divided into seven sections. After the introduction, the second section presents the literature review focused on service innovation in the restaurant sector. Moreover, prior research on customers' risk perception during the COVID-19 is provided. The third section develops the theoretical framework and the research hypotheses. The fourth section describes the research methodology. In the fifth section, the results are presented. The sixth section presents the managerial discussion. Lastly, the main conclusions, limitations and managerial implications of the study are discussed.

2. Literature review

2.1 Service innovation and digital technologies in the restaurant sector

Over the years, the idea that firms can achieve sustainable and competitive advantages through the innovation of products and services has been widely recognised (Xin *et al.*, 2006; Lee *et al.*, 2010; Maglio, 2017). In turn, companies have started to commit to SI, and scholars have increased their attention towards this issue (Ciasullo, 2018; Helkkula *et al.*, 2018; Mele and Russo Spina, 2018). Accordingly, the body of literature on SI has significantly grown (Lush and Nambisan, 2015; Edvardsson *et al.*, 2018). Scholars have adopted many assumptions about SI over time. Coombs and Miles (2000) have classified SI research into three distinct approaches: assimilation, demarcation and synthesis. The assimilation approach focuses on the impact of DT as the main driver of service innovation (Gallouj, 2002; Toivonen and Tuominen, 2009). Therefore, according to the assimilation perspective, existing theories on product innovation should also analyse SI research without adaptation (e.g. Evangelista, 2000; Miozzo and Soete, 2001). On the contrary, the demarcation approach argues that SI essentially differs from product innovation (Coombs and Miles, 2000), requiring the development of new specific-service theories for its investigation (Drejer, 2004; Tether, 2005). The synthesis approach – overcoming both the assimilation and the demarcation perspectives – suggests that theories on SI should provide an integrated perspective that combines innovation in manufacturing and services, including both

technological and non-technological innovations (Coombs and Miles, 2000; Gallouj and Savona, 2009; Wittel *et al.*, 2016).

Although these perspectives contributed to the development of the literature on SI, a more holistic approach to investigating this topic was required. From this perspective, service-dominant (S-D) logic emerged as the most useful answer to this theoretical need (Vargo and Lusch, 2004, 2008, Lusch and Vargo, 2014). S-D logic is a theoretical view applied to management research, together with economics and society (Vargo and Lush, 2004, 2006). According to S-D logic, the exchange of goods and money lie down on a service-for-service exchange (Pels *et al.*, 2014). In this light, scholars have provided broader definitions of service innovation from an S-D logic perspective (Edvardsson and Tronvoll, 2013). One of the most recognised concept definitions describes SI as “the re-bundling of diverse resources that create novel resources that are beneficial (i.e. value experiencing) to some actors in a given context; this involves a network of actors, including the beneficiary (e.g. the customer)” (Lusch and Nambisan, 2015, p. 161). Therefore, following this approach, SI comprehends three elements of S-D logic: (1) the service ecosystem; (2) service platforms and (3) value co-creation (Barile and Saviano, 2010; Gröonroos and Ravald, 2011; Polese *et al.*, 2015; Frey *et al.*, 2019). The service ecosystem includes all the actors involved in the service’s activities that proactively participate in the value co-creation process (Polese *et al.*, 2011; Vargo and Lusch, 2017). The service platform comprises tangible and intangible resources that facilitate service exchange, providing an organisational structure for resources (Lush and Nambisan, 2015). The last element of SI is the value co-creation linked to the ability of social and economic actors to integrate resources of service ecosystems and service platforms in order to collectively create value (Barile and Polese, 2010; Lush and Nambisan, 2015; Rajala *et al.*, 2016; Polese *et al.*, 2019).

A recent stream of research has begun to recognise the impact of DT on SI (Lush and Nambisan, 2015; Kaartemo and Helkkula, 2018). Therefore, DT have become a pivotal component of value creation in service systems (Maglio and Spohrer, 2008; Nambisan *et al.*, 2017). A lot of enabling technologies – such as the fifth-generation mobile network (5G), radio frequency identification (RFID), artificial intelligence (AI), mobile devices and smartphones, wearables, applications or apps (along with application programming interfaces), cryptocurrency and blockchain – support firms in enhancing services, customer engagement and expectation (Helkkula *et al.*, 2018). From an S-D logic perspective, DT acquire a different role, according to the ability of the technology to lead service innovation (Gummesson, 2012; Kindstrom *et al.*, 2013; Frey *et al.*, 2019). Thus, DT should be analysed in the double role of “operand” and “operant” resources (Nambisan, 2013; Lusch and Nambisan, 2015). On the one hand, actors use operand resources to gain support. Accordingly, operand resources – which are generally tangible and static (e.g. natural resources) – should be considered enablers or facilitators of SI (Nambisan, 2013). On the other hand, operant resources are used to act with other resources in order to produce beneficial effects. Therefore, operant resources are seen as initiators or actors of SI (Akaka and Vargo, 2014; Lush and Nambisan, 2015). Different to operand resources, operant resources are intangible and dynamic (e.g. knowledge, skills). These characteristics make operant resources more difficult to transfer and, thereby, a source of competitive advantage (Capon and Glazer, 1987).

The pandemic has fostered SI dynamics, using DT as an instrument for organisational survival and resilience (Heinonen and Strandvik, 2021; Mele *et al.*, 2020). In this “imposed service innovation” (Heinonen and Strandvik, 2021), DT have supported the restaurant sector in creating new business models and services to survive. In addition, restaurants and hotels have started to use DT to implement risk-reduction strategies (Shin and Kang, 2020). Mitchell (1999) defines a risk-reduction strategy as a process that attempts to decrease the perceived risk of purchasing a product or service. Therefore, a level of perceived risk higher than the acceptable level leads consumers to adopt a risk-reduction strategy in the decision-making

process (Gemünden, 1985; Pappas, 2016). Accordingly, DT can reduce interactions between customers and employees, transforming the restaurant sector (RS) from traditional “high-touch and low-tech” service experiences into “low-touch and high-tech” service experiences (Bitner *et al.*, 2000; Shin *et al.*, 2019; Shin and Kang, 2020). Moreover, DT can implement advanced cleaning systems to enhance the cleanliness and safety of restaurant surfaces (Xenex, 2020). Therefore, in the pandemic scenario, DT for enhancing cleanliness and reducing interactions can influence perceived risk and the resulting behavioural intention to go to restaurants (Shin and Kang, 2020).

From this background, understanding the impact of risk perception on customers’ behaviour becomes crucial for answering the research questions.

2.2 Prior research on risk perception in the restaurant sector during COVID-19

“Risk perception is defined as assessing potential dangers that may represent a threat to an individual’s health or well-being” (Hakim *et al.*, 2021, p. 2). Several empirical studies investigating risk perception have been conducted in various sectors, such as banking (e.g. Skvarciany and Jurevičienė, 2017), online banking (e.g. Namahoot and Laohavichien, 2018; Kaur and Arora, 2021; Usman and Antika, 2021), e-commerce (e.g. Yen, 2010; Lee and Stoel, 2014; Thakur and Srivastava, 2015; Li and Yuan, 2018), tourism (e.g. Liu-Lastres *et al.*, 2019; ElShafei, 2020), food service (e.g. Wen and Kwon, 2017; Hwang and Choe, 2020), retail (e.g. Mitchell and Harris, 2005; Tsai *et al.*, 2008; Walsh *et al.*, 2017), agri-food (e.g. Lacey *et al.*, 2009; Sarwar and Saeed, 2013) and healthcare (e.g. Ghaderi *et al.*, 2019). These studies mainly focus on determinants that affect risk perception, such as socioeconomic factors (*inter alia* gender, religion, education, age, etc. (e.g. Huynh, 2020), as well as media exposure (e.g. social networks and TV news; Oh *et al.*, 2015)). These studies were all conducted before the pandemic. As COVID-19 has spread globally, a growing need to investigate risk perceptions has emerged (Song *et al.*, 2021).

In adverse events, people make decisions instinctively according to their perceived risk (Slovic, 1987). Therefore, the level of risk perception should produce two opposite behaviours. On the one hand, people with low-risk perceptions may exhibit a negative attitude towards compliance with safety guidelines and preventive measures imposed by governments (Hakim *et al.*, 2021). On the other hand, people with a high-risk perception may slow down the global economy’s recovery by avoiding behaviours considered usual before the pandemic. Due to the relevance of risk perception in shaping behaviours, its investigation has become essential in understanding customers’ decision-making.

In keeping with these arguments, scholars have begun to investigate risk perception during COVID-19 (e.g. Cori *et al.*, 2020; Dryhurst *et al.*, 2020; Neuburger and Egger, 2021). In this scenario, research on risk perception in the RS – which is proving to be one of the hardest hit by the pandemic due to the high risk of contamination – is progressively increasing, with both customer and worker risk perspectives being investigated (Yang *et al.*, 2020). The majority of studies retrieved in the literature focus on customers’ risk perception (e.g. Foroudi *et al.*, 2021; Min *et al.*, 2021; Song *et al.*, 2021; Villace-Molinero *et al.*, 2021; Yost and Cheng, 2021). In particular, Villace-Molinero *et al.* (2021) have demonstrated that customers’ risk perception has changed since the COVID-19 pandemic. Accordingly, Sung and King (2021) have shown that media reporting has positively influenced risk perceptions during the outbreak. Other scholars have demonstrated that perceived risk affects customers’ purchase intention (e.g. Leung and Cai, 2021; Pham Minh and Mai, 2021). Meanwhile, another stream of literature has turned attention towards the endeavour that the RS has to make to achieve and maintain customers’ trust in authorities and restaurateurs to recover quickly from the shock (e.g. Dedeoğlu and Boğan, 2021; Foroudi *et al.*, 2021; Hakim *et al.*, 2021; Yost and Cheng, 2021). At the same time, other researchers have explored workers’ risk perception

(e.g. Roberts *et al.*, 2020; Asefa *et al.*, 2020; Yan *et al.*, 2021). Roberts *et al.* (2020) have shown that workers perceived a moderately higher risk of contracting the virus than customers. However, Asefa *et al.* (2020) demonstrated that workers' risk perception was positively associated with age, knowledge about the virus and preventive behaviours. Moreover, the pandemic has also strongly impacted workers' mental health. In this line, Yan *et al.* (2021) have shown that job satisfaction reduces the link between workers' risk perception and their potential depressive symptoms. Lastly, Wut *et al.* (2021) have investigated the risk perception of both customers and workers in order to understand how crisis-management practices have been implemented in the RS.

Despite the fact that the literature on this issue in the RS during and post the COVID-19 pandemic (when there were no restrictions/lockdowns) is growing, research on the role of DT in managing risk perception is still scant. Table 1 provides the main results of the literature review.

3. Theoretical framework and hypotheses development

The present research was developed following an approach that integrates two behavioural theories, that is the theory of planned behaviour and perceived risk theory. Rahmafitria *et al.* (2021) suggest that these theories might be considered complementary in underpinning customers' behaviour. Accordingly, several studies have employed a theoretical framework that combines the TPB and PRT (e.g. Liao *et al.*, 2010; Rahmafitria *et al.*, 2021).

The TPB is a popular and extensively validated framework employed in a variety of instances of human behaviour. According to Ajzen (1985, 1991), behavioural intentions are established by attitude, subjective norms and perceived behavioural control. Attitude "refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question" (Ajzen, 1991, p. 188). It is described as the appearance of beliefs due to certain actions (Liao *et al.*, 2010). As a result, if a person is certain of an action's positive or negative effects, they will take a specific attitude. Subjective norms are linked to social factors that enclose the perceived social pressure to undertake, or not, a specific behaviour (Vesci and Botti, 2019). In particular, the subjective norm is a subjective belief according to which behaviours depend on others' opinions or judgements (Ajzen, 1991; Yuzhanin and Fisher, 2016). Lastly, perceived behavioural control refers to a customer's perception of their ability to fulfil a specific action. Perceived behavioural control reflects past experience with the conduct's performance and expected impediments that could prevent the behaviour (Kiriakidis, 2017).

The literature suggests that the TPB may be useful in explaining customers' behaviour in a pandemic scenario (e.g. Prati *et al.*, 2011; Rahmafitria *et al.*, 2021). During the COVID-19 outbreak, the TPB may be adopted to explain the effects of attitude, perceived behavioural control and subjective norms to comply with protocols and measures affecting customer intentions to go to restaurants (CIR) (Rahmafitria *et al.*, 2021). The pandemic has triggered perceived risks for restaurant customers, impacting their purchase behaviour (Foroudi *et al.*, 2021). Indeed, when someone perceives a high risk of contracting the virus, they will avoid going to the restaurant. Therefore, when investigating customers' decision-making, it appears to be essential to take into account their perceived risks. Perceived risk is associated with perceived uncertainty (Bauer, 1960; Rehman *et al.*, 2020). A higher level of uncertainty makes customers feel a higher level of risk. Scholars have widely adopted PRT to investigate consumer decision-making behaviours (Buratti and Allowood, 2019). Recently, a growing number of studies have started to explore the impact of risk perception in the hospitality industry (e.g. Lepp and Gibson, 2003; Adam, 2015). Perceived risk has been measured as a multi-dimensional construct (Liao *et al.*, 2010). Researchers have identified different risk dimensions to explain customers' purchase behavioural intentions in the hospitality industry. For example, Adam (2015) has categorised perceived risk into six dimensions; that is political

Authors	Type of paper	Main purpose of the paper	Investigated actor	Risk's dimensions	Main findings
Roberts <i>et al.</i> (2020)	Empirical	To assess the impacts of Covid-19 on restaurants workers	Workers	Perceived risk of contracting, getting ill from, or dying from the virus	Workers perceived a moderately higher risk of contracting the virus
Song <i>et al.</i> (2021)	Empirical	How the prudential behaviours of restaurant customers during Covid-19 are moulded by exposure to media reporting	Customers	Level of threat, Fear, perceived danger	Consumer risk perceptions were positively influenced by media reporting of virus
Villace-Molinero <i>et al.</i> (2021)	Empirical	It explores the new risk scenario in the hospitality industry during the pandemic	Customers	Probability of contagious and level of threat	Customers' risk perception has changed after the Covid-19 crisis
Wut <i>et al.</i> (2021)	Review	To understand how crisis management practices have been implemented in the industry	All actors	–	Research is mainly focused on crisis management
Yan <i>et al.</i> (2021)	Empirical	To investigate when hospitality workers' risk perception impacts potential depressive symptoms	Workers	Possibility of contracting the virus, Fear of health damage, Perception of Covid compared to other respiratory diseases	Job satisfaction reduces the link between workers' risk perception and their potential depressive symptoms
Yost and Cheng (2021)	Empirical	To delineate the role of loyalty, trust, and transparency in restaurants after the pandemic	Customers	Affective motivation and taste for accuracy	Fostering transparency enhance customers' trust, and restaurants quickly recover from the shock
Pham Minh and Ngoc Mai (2021)	Empirical	To explore the relationship between perceived risk and customers' booking intention in the hospitality sector	Customers	Perceived risk before and after the pandemic	Perceived risk hurts customers' booking intention

Table 1.
Literature review
framework

(continued)

Authors	Type of paper	Main purpose of the paper	Investigated actor	Risk's dimensions	Main findings
Leung and Cai (2021)	Empirical	To investigate the effects of perceived risk on customers' intention to use food delivery apps during the Covid-19	Customers	Experience intentions, anxiety, perceived Fear, perceived danger	Perceived risk hurts purchase intention
Min <i>et al.</i> (2021)	Empirical	To examine the extent to which risk perception moderates the formation of restaurant repatronage intention during the pandemic	Customers	Perceived vulnerability	The findings partially support the moderation effect of perceived vulnerability to the virus
Hakim <i>et al.</i> (2021)	Empirical	To investigate how consumers' intention to visit restaurants during the pandemic is affected by trust and risk perception	Customers	Perceived safety and restaurant brand	Consumers' trust in a restaurant, disease denial and health surveillance trust predict intention to visit a restaurant during the pandemic
Foroudi <i>et al.</i> (2021)	Empirical	To explore how Covid-19 customer's perception impacts their future desire towards visiting restaurants	Customers	Quality, psychological, health, financial, environmental, time-loss, social risk	The hospitality sector is based on trust from their customers. The continuous uncertainty restaurant business needs the enhancement of localization strategies, practices and performance.
Dedeođlu and Bođan (2021)	Empirical	To unveil how customers intend to visit exclusive restaurants and investigate the moderating role of risk perceptions of the virus and trust in authorities in establishing relationships in Istanbul	Customers	Impact of the virus on visiting in tensions, anxiety, Government's role in reducing the risk of contagious	Consumers' Covid –19 risk perception and their trust in authorities moderate the relationship between some motivational factors and visit intention

(continued)

Table 1.

Authors	Type of paper	Main purpose of the paper	Investigated actor	Risk's dimensions	Main findings
Choe et al. (2021)		To explore if perceived risk negatively affects the image and if the image positively affects intentions to use food delivery services	Customers	Financial, time, privacy, performance and psychological risks	The explosion of the virus positively moderates the relationship between performance risk and image.
Byrd et al. (2021)	Empirical	To explore consumers' Covid-19 risk perceptions in restaurants in the US	Customers	level of concern about contracting the virus from various sources	Consumers were more worried about contracting the virus from restaurant food and its packaging rather than from food in general
Asefa et al. (2020)	Empirical	To assess Covid-19 risk perception among waiters in Ethiopia	Workers	Perceived susceptibility, perceived severity	The risk perception was positively associated with age, knowledge and preventive behaviours

Table 1.

risk, financial risk, socio-psychological risk, environmental risk, expectation risk and physical risk. Moreover, [Bentley and Page \(2008\)](#) have highlighted the importance of health risks in hospitality research. After the SARS pandemic, the Asian tsunami and the twin towers terrorist attack, many researchers started to investigate health and safety risk perception (e.g. [Yang and Nair, 2014](#)). The COVID-19 outbreak has generated an increasing degree of risk from a multi-dimensional perspective, especially in the RS. Thus, understanding and managing customer risk perception is a key point for RS survival.

Therefore, it has emerged that the integration of the TPB and PRT permits a deeper insight into the research objectives on which the conceptual model described in [Figure 1](#) is built.

In the pandemic context, the TPB could be used as an alternative to interpreting the effect of attitude, perceived behavioural control and external influences in compliance with Covid-19 protocols on the customers' intention to go to the restaurant. Other studies in the outbreak scenario have attempted to enlarge the TPB (e.g. [Agarwal, 2014](#); [Myers and Goodwin, 2012](#); [Ho et al., 2013](#)). However, to the best of our knowledge, no research has expanded the TPB involving risk perception factors (i.e. socio-psychological, security, privacy, hygienic, environmental and health risk), integrating the PRT. Thus, TPB has never been used to explain the relationship between the impact of DT on risk perception and the intention of customers to visit restaurants. Accordingly, this background leaves a gap on which our study is built, aiming to provide a theoretical novelty.

3.1 Expected interactions and expected cleanliness

DT are expected to underpin the RS in three different domains: physical, cognitive and social ([Gomes de Freitas and Stedefeldt, 2020](#)). More specifically, DT may empower the services'

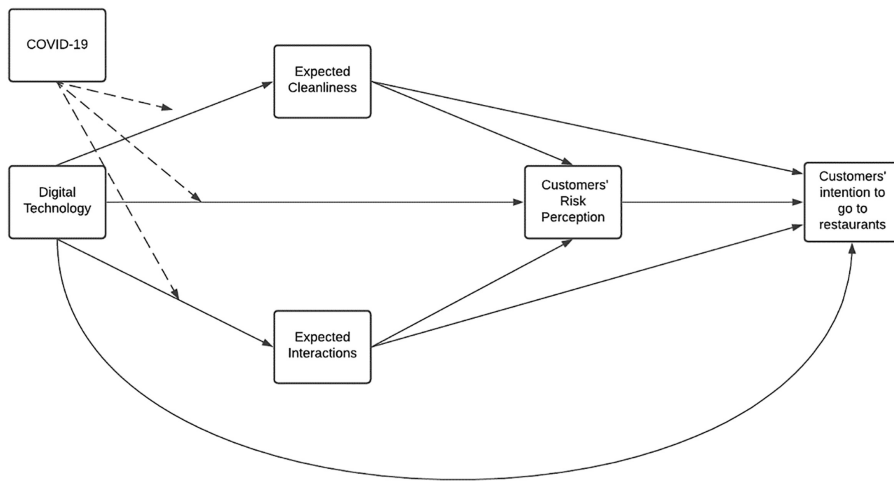


Figure 1.
Conceptual model

infrastructures (i.e. physical domain), support the sector in understanding customers' and workers' perceptions and beliefs (i.e. cognitive domain) and, lastly, enhance social support to co-create resilient strategies (i.e. social domain; Galanakis, 2020).

Scholars have demonstrated that DT may help the RS manage health and safety issues (Esposito *et al.*, 2021). Accordingly, Albert and Hayes (2003) and Hoque *et al.* (2020) have shown that robots and other DT have allowed restaurants to facilitate physical distancing practices. Furthermore, scholars have contended that DT have also been implemented to boost delivery practices and food preparation hygiene (e.g. Demaitre, 2020; Meisenzahl, 2020). In this light, DT may support restaurants in achieving logistical and disinfection tasks and giving COVID-19 information to people, minimising the fear of the virus (Meisenzahl, 2020).

Previous research on risk perception during the pandemic in the RS has mainly explored cultural, socio-psychological and demographic factors (e.g. Choe *et al.*, 2021; Foroudi *et al.*, 2021; Hakim *et al.*, 2021). External sources of perceived health risks during the outbreak have been investigated only in the more extensive hospitality industry. In particular, Zeng *et al.* (2020) have demonstrated that DT may reduce customers' perceived health risks. Furthermore, Shin and Kang (2020) have explored how DT have been used in the hospitality sector as a risk-reduction strategy to manage booking intentions during the pandemic. They have shown that risk perception is interconnected with the level of expected interactions and expected cleanliness. Moreover, before the pandemic, Nicholls (2010) highlighted that the implementation of technology-mediated systems may enhance physical distancing and reduce the opportunity for interactions.

Therefore, the following hypotheses aim to investigate how the use of DT may affect expected interactions and the consequent relationship between risk perception and customers' intention to go to restaurants.

Accordingly, the following hypotheses are developed:

- H1a.* There is a positive relationship between DT use in restaurants and the reduction of expected interactions among customers and workers during the COVID-19 pandemic.
- H1b.* There is a positive relationship between the reduced level of expected interactions and the reduction of customers' risk perception in restaurants during the COVID-19 pandemic.

H1c. The expected interactions mediate the relationship between DT and customers' risk perception.

During the COVID-19 pandemic, the perception of cleanliness has played a crucial role in restaurants. The RS needs to guarantee a higher level of cleanliness to attract customers (Shin and Kang, 2020). Guests are greatly interested in restaurant cleaning quality (Wang and Hung, 2015). Indeed, the literature has shown that cleanliness impacts service quality (Barber *et al.*, 2011), customer satisfaction (Liu and Jang, 2009), security (Amblee, 2015) and perceived risk (Shin and Kang, 2020). In this light, the implementation of DT to cleaning systems can enhance the cleanliness perception, resulting in a lower level of customers' risk perception (Shin and Kang, 2020; Esposito *et al.*, 2021).

Thus, the following hypotheses are proposed:

H2a. There is a positive relationship between DT and the level of expected cleanliness in restaurants during the COVID-19 pandemic.

H2b. There is a positive relationship between expected cleanliness and the reduction of customers' risk perception in restaurants during the COVID-19 pandemic.

H2c. The level of expected cleanliness mediates the relationship between DT and customers' risk perception.

Through the theoretical lens of PRT and the TPB, perceived risk represents a pivotal factor in interpreting how consumers make decisions. The theoretical framework adopted in the present paper has hinted at the role of attitude, subjective norms and perceived behavioural control –concerning the use of DT – in determining customers' decision-making under uncertainty (Rahmafritria *et al.*, 2021). In the context of this research, consumers are likely to evaluate risks according to the cleanliness and interactions level perception during the pandemic, which impacts their intention to go to restaurants.

Accordingly, the following hypotheses are developed:

H3a. There is a positive relationship between the use of DT in restaurants and the reduction of customers' risk perception during the COVID-19 pandemic.

H3b. There is a positive relationship between reducing customers' risk perception and their intention to go to restaurants during the COVID-19 pandemic.

H3c. There is a positive relationship between the use of DT and customers' intention to go to restaurants during the COVID-19 pandemic.

H3d. There is a positive relationship between the level of expected cleanliness and customers' intention to go to restaurants during the COVID-19 pandemic.

H3e. There is a positive relationship between the reduced level of expected interactions and customers' intention to go to restaurants during the COVID-19 pandemic.

The conceptual model depicted in Figure 1 shows the existent interconnections among the constructs already discussed. In keeping with these arguments, we assume the existence of mediation relationships between the variables.

Accordingly, the following hypotheses are developed:

H4a. The reduction of customers' risk perception mediates the relationship between DT and customers' intention to go to restaurants.

H4b. Customers' risk perception mediates the relationship between expected cleanliness and customers' intention to go to restaurants.

H4c. Customers' risk perception mediates the relationship between expected interactions and customers' intention to go to restaurants.

3.2 *The potential moderating role of COVID-19*

Starting from the previous hypotheses – which assume a relationship between the use of DT and (1) the level of expected interactions; (2) the level of expected cleanliness and (3) the level of customers' risk perception – the present paper also aims to investigate if the COVID-19 outbreak has impacted on these relationships. Moreover, it attempts to explore which relationship is most affected by the pandemic.

Accordingly, the following hypotheses are proposed:

H5a. The COVID-19 pandemic has moderated the relationship between DT and the level of expected cleanliness.

H5b. The COVID-19 pandemic has moderated the relationship between DT and customers' risk perception levels.

H5c. The COVID-19 pandemic has moderated the relationship between DT and the level of expected interactions.

4. Research methodology

4.1 *Data collection and coding process*

This paper aims to analyse whether and to what extent the use of DT in the RS during the COVID-19 pandemic has affected customers' risk perception, considering the level of expected interactions and expected cleanliness. The research attempts to investigate how these factors should influence customers' intention to go to restaurants. Moreover, the potential moderating role of COVID-19 on the relationship between the use of DT and the indirect effects of customer risk perception (CRP), expected cleanliness (EC) and expected interactions (EI) are explored. To this end, an exploratory study of a quantitative nature was carried out by underpinning multiple regression analyses to test the research hypotheses. Data were collected from a sample of customers resident in Italy. According to the literature analysis, a questionnaire was built to analyse which of these dimensions have more impact on CIR. Furthermore, we attempt to explore which indirect effect is more influenced by COVID-19. The questionnaire comprised 33 questions, including personal data and closed-ended questions using a five-point Likert scale (Matell and Jacoby, 1971; Ciasullo *et al.*, 2021).

The questionnaire's reliability and usability were checked with a pre-test by three researchers. A random sampling from the mailing list of three restaurants – located in the north, centre and south of Italy – was performed. Restaurants were chosen from the Gambero Rosso gastronomic guidebook 2021. The restaurants were selected according to the following criteria. The researchers have chosen one restaurant for the north of Italy, one restaurant for the south and one restaurant for the centre of Italy to explore customers' perceptions all over the Italian country and avoid biases related to the location. Moreover, the researchers have preferred restaurants located in big cities where tourism is also active (i.e. Milan, Rome and Naples). In this way, researchers have ensured that the customers potentially come from all Italian regions despite the restaurants being located in specific cities.

Furthermore, the researchers have selected the size of the restaurant as another criterion to skim the number of restaurants. It has been checked if the restaurants that have fitted the selection criteria have a website with a newsletter section. This choice is justified because authors are sure that the restauranters have a mailing list and the permission to send an e-mail to their customers.

Three restaurants were contacted – one for each geographical location – to ask if they wanted to collaborate in the research. Restaurants that showed availability for the study were selected. The total number of e-mails collected from the three restaurants was 1980. Accordingly, the population size (N) was composed of 1980 customers. The sample size (n), calculated with the formula for finite population, was considered sufficiently representative (i.e. confidence interval: 2.09; confidence level: 95%). [Table 2](#) provides a detailed description of the sampling process.

The questionnaire was disseminated using a computer-assisted web interview (CAWI) technique ([Bartosik-Purgat, 2018](#)). Customers were invited by e-mail to take part in the research in May 2021. To avoid cross-cultural methodological questions – as all the interviewees were Italian speaking ([Smaldone et al., 2020](#)) – the survey was developed in the Italian language and then translated into English. The questionnaire comprised six sections. [Section 1](#) concisely described the purpose of the study. [Section 2](#) comprised 12 questions on customers' attitudes towards DT, their perceived behavioural control and the external influences that lead customers to use DT during the pandemic. [Section 3](#) contained six questions on customers' risk perception when DT are implemented in restaurants. [Section 4](#) contained six questions regarding the level of cleanliness and interactions expected by restaurant customers. [Section 5](#) comprised five questions relating to customers' willingness to return to restaurants and their perception of DT during the COVID-19 pandemic. Lastly, four questions' personal data section ([Section 6](#)) was administrated. Respondents stated their perceived risk or the level of agreement for each item or sentence (i.e. 1 = least/strongly disagree; 5 = maximum/strongly agree). Each construct was built using multiple indicators adapted from the literature (e.g. [Li et al., 2020](#); [Nardi et al., 2020](#); [Shin and Kang, 2020](#); [Amin et al., 2021](#); [Foroudi et al., 2021](#); [Zhong et al., 2021](#)). The items developed in each section have been adapted from previous studies developed in different contexts and rephrased according to our research scenario. Only items linked to the "Digital technologies" section and "Customers' risk perception" section have been taken verbatim from previous studies since they have developed according to the TPB and PRT. Moreover, some new items were developed to fulfil the information needs to answer the research questions. [Table 3](#) shows the coding framework designed.

4.2 Data analysis and empirical model

This research applied multiple regression analysis implementing the ordinary least square (OLS) model to test the research hypotheses. OLS is a multivariate statistical method used to describe the linear dependence of the outcome variable from one or more predictor variables ([Tripepi et al., 2008](#)). According to the conceptual model described in [Figure 1](#), SPSS 23.0 software was used to test the hypotheses. A normality test (i.e. skewness and kurtosis) was performed for each variable. Moreover, to evaluate potential multicollinearity problems, the variance inflation factor (VIF) was tested. In order to avoid possible heteroscedasticity problems, a White test was performed. Furthermore, a Durbin–Watson test – to detect probable autocorrelation in the residuals – was carried out.

Furthermore, in order to address the common method bias, an estimator bias was analysed through the standard error methodology ([Ippolito et al., 2020](#)). The estimators' values retrieved from the test were 0.000 for all the dimensions analysed. Although the model

Table 2.
Sampling process

Sent questionnaires	Response rate	Non-response rate	Response bias
1980	1,050 (53.03%)	900 (45.45%)	30 (1.51%)

Construct	Attributes	Levels	Measure	Source
Digital technologies	Attitude	(1) Usefulness	5-point Likert scale	Mishra <i>et al.</i> (2014)
		(2) Valuable	5-point Likert scale	Zhong <i>et al.</i> (2021)
		(3) Security	5-point Likert scale	
		(4) Attractiveness	5-point Likert scale	
	Subjective norms	(1) Influence of colleagues	5-point Likert scale	Mishra <i>et al.</i> (2014), Zhong <i>et al.</i> (2021)
		(2) Influence of relatives	5-point Likert scale	
		(3) Influence of friends	5-point Likert scale	
		(4) Influence of media	5-point Likert scale	
		(5) Influence of regulations and society	5-point Likert scale	
	Perceived Behavioral Control	(1) Accessibility	5-point Likert scale	Clayton and Griffith (2008), Amin <i>et al.</i> (2021)
(2) Efficiency		5-point Likert scale		
(3) Ability		5-point Likert scale		
Customers' risk perception	Risk perception	(1) Socio-psychological risk	5-point Likert scale	Choi <i>et al.</i> (2013), Thakur and Srivastava (2015), Foroudi <i>et al.</i> (2021)
		(2) Security risk	5-point Likert scale	Thakur and Srivastava (2015), Li <i>et al.</i> (2020)
		(3) Privacy risk	5-point Likert scale	Thakur and Srivastava (2015), Li <i>et al.</i> (2020)
		(4) Hygienic risk	5-point Likert scale	Choi <i>et al.</i> (2013), Li <i>et al.</i> (2020), Foroudi <i>et al.</i> (2021)
		(5) Environmental risk	5-point Likert scale	Li <i>et al.</i> (2020), Nardi <i>et al.</i> (2020)
		(6) Health risk	5-point Likert scale	Choi <i>et al.</i> (2013), Foroudi <i>et al.</i> (2021)

(continued)

Table 3.
Coding framework

Construct	Attributes	Levels	Measure	Source
Expected interactions	Level of interactions	(1) Interaction with workers	5-point Likert scale	Shin and Kang (2020), Kim <i>et al.</i> (2021)
		(2) Interaction with customers	5-point Likert scale	
Expected cleanliness	Level of cleanliness	(1) Surfaces cleanliness	5-point Likert scale	Shin and Kang (2020)
		(2) Local environments	5-point Likert scale	Shin and Kang (2020)
		(3) Dishes and towels	5-point Likert scale	Kim <i>et al.</i> (2021)
		(4) Air	5-point Likert scale	Chang <i>et al.</i> (2021)
Customer's behaviour	Future desire	(1) Willingness in the near future	5-point Likert scale	Foroudi <i>et al.</i> (2021)
		(2) Willingness after the vaccination campaign	5-point Likert scale	
Covid-19	Lockdown restriction	(1) Impact of Covid-19 on customers' risk perception	5-point Likert scale	Lee <i>et al.</i> (2012), Foroudi <i>et al.</i> (2021)
		(2) Impact of Covid-19 on expected cleanliness via IT	5-point Likert scale	
		(3) Impact of Covid-19 on expected interactions via IT	5-point Likert scale	

Table 3.

seems to have a not completely good consistency, our model could not be explained by other dimensions since there is an impossibility of choosing different dimensions to describe the conceptual model according to the literature framework. Moreover, considering that we work on about 30.450 modalities (29 questions per 1,050 answers), a need for complex computation emerges. Hence, the estimators could be considered acceptable for this study (Smaldone *et al.*, 2020). Lastly, before testing the conceptual model, the maximum shared squared variance (MSV) and the average variance extracted (AVE) were estimated to define discriminant validity and validate the constructs. The results show an AVE of 0.36 is higher than the value of MSV of 0.20. Accordingly, the discriminant validity is set.

To test the mediating role of the variables expected cleanliness, expected interactions and customers' risk perception in the relationship between DT and customers' intention to go to restaurants, the following empirical model was developed:

$$CIR = \gamma_0 + \gamma_1(DT) + \gamma_2(CRP) + \gamma_3(EC) + \gamma_4(EI) + \varepsilon_i,$$

where C_int_to_go is the variable customers' intention to go to restaurants, γ_0 is the constant, $\gamma_1, \gamma_2, \gamma_3$ and γ_4 are the coefficients of the explanatory variables (DT; CRP; EI and EC) and ε_i is the error.

Moreover, an additional analysis was performed to analyse if COVID-19 has influenced customers' perceptions. A moderation analysis for each effect between DT and the dependent variables expected cleanliness, expected interactions and customers' risk perception was carried out, based on the following equations:

$$EC = \gamma_0 + \gamma_1(DT) + \gamma_2(\text{Covid_EC}) + \gamma_3(DT * \text{Covid_EC}) + \varepsilon_i$$

$$EI = \gamma_0 + \gamma_1(DT) + \gamma_2(\text{Covid_EI}) + \gamma_3(DT * \text{Covid_EI}) + \varepsilon_i$$

$$CRP = \gamma_0 + \gamma_1(DT) + \gamma_2(\text{Covid_CRP}) + \gamma_3(DT * \text{Covid_CRP}) + \varepsilon_i,$$

where DT * Covid_EC, DT * Covid_EI and DT * Covid_CRP represent the interactions between the respective independent variables. These relationships were tested according to the bootstrapping technique (Awang *et al.*, 2015) since this method allows the researchers to test the model holistically, providing better performance compared to the other possible analytical approach (e.g. casual steps) (Nevitt and Hancock, 2001).

5. Results and discussion

This section presents the main findings. The descriptive results and the results of the dependency model are shown. Moreover, the results of the moderation analysis are displayed.

5.1 Descriptive results

Descriptive statistics are presented in Table 4. Of the respondents, 48.52% were female, and 47.57% were male, while 3.80% did not provide this information. The average age of the interviewees was 48 years. Moreover, it is shown that the largest number of respondents had a high school diploma (i.e. 35.24%) and a bachelor's degree or master's degree (i.e. 53.34%).

The concentration of interviewees for the survey is shown in Figure 2. Demographic statistics for the sample are described in the legend. The largest portion of respondents came from Campania (i.e. 190), Lazio (i.e. 200) and Lombardy (i.e. 3,030). The regions with less aggregation were Veneto (i.e. 3), Molise (i.e. 1), Liguria (i.e. 5) and Marche (i.e. 5). Sardinia and Sicily did not present answers. Table 5 presents the standardised factor loading. All the variables are considered acceptable since the skewness and kurtosis values are, in all cases, lower than 2.

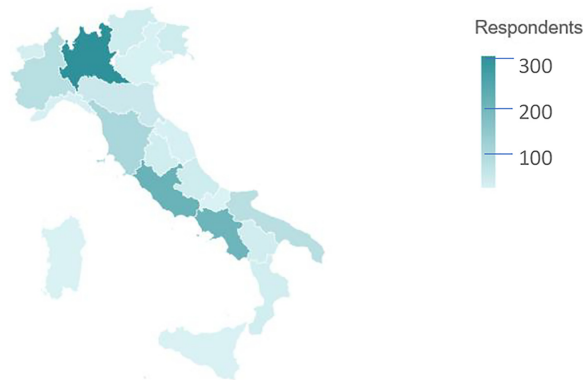
5.2 Correlation matrix and fit indices

In order to evaluate the goodness-of-fit of the model, the correlation matrixes for the latent construct and fit indices were computed. Table 6 shows the Pearson correlation matrix of the

Descriptors		Frequency	Percentage
Gender	Male	500	47.57%
	Female	510	48.52%
	Not defined	40	3.80%
Age	Average age	48	
	Min	15	
	Max	83	
Educational qualification	No educational qualification	0	0.00%
	Elementary education	10	0.95%
	Secondary school diploma	50	4.76%
	High school diploma	370	35.24%
	Bachelor's degree/master's degree	560	53.34%
	Post-graduate master/doctoral degree	60	5.71%

Table 4.
Sample profile

Figure 2.
Concentration map of
the sampled
respondents



variables. No multicollinearity problems were retrieved since the correlation values are lower than the threshold (i.e. 0.8). Table 7 provides the fit indices. Significant correlations were found between (1) DT and CRP; (2) EI and CRP and (3) EI and CRP. The VIF (in all cases lower than 2.625) suggests no multicollinearity problems (Miceli *et al.*, 2014). To avoid heteroscedasticity problems, a White test was carried out. The resulting p -value (19.038) was not significant. As a consequence, no robust standard errors were retrieved. Moreover, a strong causal relationship between the dimensions analysed is granted by an R coefficient equal to 0.782 (Emerson, 2015).

As shown in Table 7, the R -squared coefficients – calculated to assess the variability level among data – show a good variability explanation (i.e. R square: 0.776 and adjusted R square: 0.719). Furthermore, the standard error was 0.870. The analysis suggests that our model has a good explanation of all the variables. Moreover, Table 7 presents the White test results and the Durbin–Watson test. The White test retrieved a non-significant p -value (i.e. 19.038), suggesting no heteroskedasticity problems. In addition, the value obtained from the Durbin–Watson test (i.e. 1.841) reveals that there is no autocorrelation among the residuals.

5.3 Results of the dependency models

The results of the dependency models are presented in Table 8. Model 1 shows the results that test the relationship between DT and expected cleanliness (H2a). Model 2 tests the relationship between DT and expected interactions (H1a). Model 3 represents the results that test the impact of DT on the level of customers' risk perception (H1b, H2b, H3a). Lastly, Model 4 provides the results regarding the impact of DT on customers' intention to go to restaurants (H3b, H3c, H3d, H3e). All the models are statistically significant, with a p -value lower than 0.01. Moreover, the coefficient of determination for each model is between 0 and 1 (Model 1- $R^2 = 0.4321$; Model 2- $R^2 = 0.5202$; Model 3- $R^2 = 0.7104$; Model 4- $R^2 = 0.2783$). These values suggest that the regression models provide adequate explanatory power.

The impact of DT on the level of expected cleanliness (Model 1) and expected interactions (Model 2) is, in both cases, positive and significant (i.e. Model 1 = 0.7819, Model 2 = 0.8675). In line with previous studies (i.e. Shin and Kang, 2020; Zeng *et al.*, 2020), the relationship between expected cleanliness and customers' risk perception is positive and significant (i.e. 0.3203). Similarly, the relationship between the variable expected interactions and customers' risk perception shows a positive and significant coefficient (i.e. 0.5731). Results from the OLS confirm that customers perceive a lower level of expected interactions and a higher level of expected cleanliness when DT are implemented in restaurants (Esposito *et al.*, 2021).

Description	Mean	Std. Deviation	Skewness	Kurtosis
<i>Attitude</i>				
Usefulness	4.22	1.061	1.066	-1.358
Valuable	3.92	1.202	-0.496	-0.811
Security	3.95	1.041	0.152	-0.830
Attractiveness	4.06	1.142	0.091	-1.008
<i>Subjective norms</i>				
Influence of colleagues	3.23	1.373	-0.975	-0.260
Influence of relatives	2.93	1.362	-1.041	0.166
Influence of friends	3.39	1.321	-0.925	-0.371
Influence of media	3.23	1.371	-1.073	-0.261
Influence of regulations and society	3.33	1.312	-0.958	-0.278
<i>Perceived behavioral control</i>				
Accessibility	3.66	1.022	-0.328	-0.401
Efficiency	3.73	1.083	-0.706	-0.480
Ability	3.52	1.091	-0.775	-0.261
<i>Risk perception</i>				
Socio-psychological risk	2.49	1.354	-0.908	0.437
Security risk	3.12	1.282	-1.002	-0.151
Privacy risk	2.74	1.531	-1.380	0.278
Hygienic risk	3.57	1.402	-0.891	-0.609
Environmental risk	3.28	1.401	-1.257	-0.145
Health risk	2.90	1.333	-1.104	0.102
<i>Level of expected interactions</i>				
Interaction with workers	3.25	1.375	-1.060	-0.337
Interaction with customers	3.30	1.304	-0.967	-0.292
<i>Level of expected cleanliness</i>				
Surfaces cleanliness	3.4	1.402	-1.156	-0.359
Local environments	3.30	1.431	-1.180	-0.310
Dishes and towels	3.12	1.343	-1.072	-0.037
Air	3.24	1.401	-1.241	-0.154
<i>Future desire</i>				
Willingness in the near future	4.05	1.051	-0.231	-0.807
Willingness after the vaccination campaign	3.07	1.422	-1.247	-0.015
<i>Lockdown restrictions</i>				
Impact of Covid-19 on customers' risk perception	2.87	1.333	-0.964	0.130
Impact of Covid-19 on expected cleanliness via IT	2.94	1.422	-1.215	0.122
Impact of Covid-19 on expected interactions via IT	2.99	1.381	-1.199	-0.004

Table 5. Descriptive statistics and normality tests of the constructs in the model

	Mean	SD	1	2	3	4	5	6	7	8
1. DT	0.874	3.633	1							
2. CRP	3.020	1.104	0.729	1						
3. EI	3.281	1.233	0.602	0.686	1					
4. EC	3.269	1.209	0.570	0.551	0.542	1				
5. C_BEHAV	3.566	3.566	0.451	0.429	0.415	0.418	1			
6. Covid_CRP	2.876	1.329	0.502	0.448	0.492	0.586	0.423	1		
7. Covid_EC	2.942	1.420	0.594	0.588	0.478	0.662	0.343	0.819	1	
8. Covid_EI	2.990	1.384	0.451	0.432	0.582	0.453	0.428	0.649	0.673	1

Table 6. Correlation matrix for latent construct

The results are in line with previous literature, such as the work of Demaitre (2020), demonstrating that DT represent the only way to cope with CIR and fear of being exposed to the virus. Accordingly, our findings suggest that the use of DT positively impacts reducing customers' risk perception, confirming Shin and Kang's (2020) results in the hotel industry field. Moreover, Models 1, 2 and 3 show positive and strong significant relationships among the DT variable and the independent variables customers' risk perception, expected interactions and expected cleanliness, confirming the following hypotheses: H1a, H2a, H1b, H2b and H3a. These findings are in agreement with Esposito *et al.* (2021), who conducted a study on the impact of information and communication technologies on EC, EI and safety perception in the restaurant industry during the pandemic. Furthermore, Table 8 highlights that risk perception significantly impacts customers' intention to go to restaurants. These findings are in line with the theoretical framework adopted, according to which the perceived risks impact customers' purchase behaviours (Rahmafitria *et al.*, 2021).

In order to test the mediation hypotheses (i.e. H1c, H2c, H4a, H4b and H4c), both the direct and indirect effects were analysed. Table 9 shows the direct and indirect influences of dependent and independent variables. Path A shows that both the relationship DT→EC ($a = 0.7819, p < 0.001$) and EC→C_int_to_go ($b = 0.2361, p < 0.001$) are significant and positive. The indirect effect of DT on customers' intention to go to restaurants through expected cleanliness is significant ($a*b = 0.2723$, bootstrap CI [0.0584, 0.15376]). The direct effect is significant even after controlling for the mediator ($c' = 0.2024, p < 0.001$). The total effect of DT is significant and positive ($c = 0.2024, p < 0.001$) and is equal to $(a*b) + c' = 0.2723 + 0.2024 = 0.4747$. In keeping with this explanation, expected cleanliness significantly mediates the effects of DT on customers' intention to go to restaurants.

The same argument should also be provided for paths B, C, D, E and F. More specifically, Table 9 shows that all the direct and indirect effects coefficients are positive and significant. As a result, expected interactions significantly mediate the effects of DT on customers' intention to go to restaurants. Moreover, customers' risk perception significantly mediates the effects of DT on customers' intention to go to restaurants. Lastly, the indirect effects of DT on customers' intention to go to restaurants through customers' risk perception and (1) expected cleanliness and (2) expected interactions are both positive and significant.

Table 7.
Fit indices

<i>R</i>	<i>R</i> square	Adjusted <i>R</i> square	Std. Error	White test (<i>p</i> -value)	Durbin–Watson
0.782	0.776	0.719	0.870	19.038	1.841

Table 8.
Multiple regression
analysis results

Independent variables	Dependent variable			
	Model 1 (EC)	Model 2 (EI)	Model 3 (CRP)	Model 4 (C_int_to_go)
DT	0.7819***	0.8675***	0.7352***	0.2024***
EC	–	–	0.3203***	0.2361***
EI	–	–	0.5731***	0.2457***
CRP	–	–	–	0.0689**
<i>R</i> ²	0.3243	0.3650	0.7104	0.2783
<i>F</i>	503.785***	603.272***	562.532***	96.411***

Note(s): **p* < 0.10 ***p* < 0.05 ****p* < 0.01

Table 9. Direct and indirect effects of Digital Technology on Customers' intention to go to restaurants

Effect	Path	Coefficient
Direct	A	DT → EC
Direct		EC → CIR
Indirect		DT → EC → CIR
Direct	B	DT → EI
Direct		EI → CIR
Indirect		DT → EI → CIR
Direct	C	DT → CRP
Direct		CRP → CIR
Indirect		DT → CRP → CIR
Direct	D	DT → CIR
Indirect	E	DT → EC → CRP → CIR
Indirect	F	DT → EI → CRP → CIR

Note(s): * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

6. Discussion and implications

The analysis results show that risk perception largely influences Italian customers' intention to visit restaurants. This confirms that, within the pandemic and post-pandemic context, restauranters have been called upon to adopt strategies and implement measures to manage risk perception (Foroudi *et al.*, 2021; Rahmafitria *et al.*, 2021). In line with our expectations, the regression results show that CRP is influenced by the level of expected cleanliness and the level of expected interactions, confirming previous studies in the hospitality industry (e.g. Nicholls, 2010; Shin and Kang, 2020). However, in order to manage customers' perceptions concerning expected cleanliness and expected interactions, our findings show that the implementation of DT may be considered an efficient tool for this purpose (Demaitre, 2020; Hoque *et al.*, 2020). Moreover, our findings show that the implementation of DT has a significant and positive impact on the level of CRP in the Italian context. More specifically, the mediation analysis results highlight that the use of DT determines a lower level of expected interaction and a lower level of expected cleanliness and leads to a lower level of perceived risk, resulting in higher levels of customers' intention to go to restaurants. These results extend the previous literature on CRP during the COVID-19 pandemic, which did not investigate how to manage risk perception for restaurants' recovery (Byrd *et al.*, 2021; Choe *et al.*, 2021; Hakim *et al.*, 2021).

In addition, these empirical shreds of evidence confirm the PRT and TPB arguments. Accordingly, customers' subjective norms, attitude and behavioural control explain customers' compliance with the use of DT in a context characterised by uncertainty. In this scenario, the impact of DT on perceived risks unveils recovery strategies for the sector. This peculiar relationship between DT and CRP, in turn, stimulates customers in returning to restaurants, overcoming their fear of being exposed to the virus. However, the considerable effect of perceived risk on customers' intention to go to restaurants in the post-pandemic scenario may suggest that full RS recovery could take several years because more customers will be unwilling to go to restaurants due to the fear of contracting the virus. Accordingly, risk perception is likely to be one of the most relevant elements in understanding the customer decision-making process in foodservice research. From this perspective, the implementation of DT may be considered useful to manage risk perception and positively affect customers' decision-making processes.

Consistent with previous studies (Roberts *et al.*, 2020; Villacé-Molinero *et al.*, 2021), CRP increased during the COVID-19 outbreak. Our results show that the pandemic has empowered the relationships between the use of DT and the dependent variables customers' risk perception, expected interactions and expected cleanliness. Accordingly, during the

outbreak, customers' perceptions have been more influenced by the use of DT, as suggested by [Esposito et al. \(2021\)](#). However, our findings highlight that COVID-19 impacts customers' risk perception more than the effects of the other examined variables.

In keeping with these arguments, the use of DT emerges as a beneficial form of service innovation to manage the re-start of the RS ([Mele et al., 2020](#)). From a S-D logic perspective ([Lusch and Nambisan, 2015](#)), DT create a novel value in terms of safety perception for customers in the RS. This kind of service innovation involves not only customers but also all the actors of the restaurant supply chain. As a result, DT should be considered service infrastructures that allow the RS to have value co-creation processes for restaurant survival ([Nambisan, 2013](#); [Vargo and Lusch, 2017](#)). From this perspective, the massive disruption generated by the pandemic has acted as an efficient catalyst for innovation ([Heinonen and Strandvik, 2021](#)). Thus, in a context characterised by uncertainties, the disruptive forces of change have to be considered through a strategic lens, with DT as drivers for SI.

This research provides several implications. From a theoretical perspective, this study contributes to developing the integrated framework of PRT and the TPB by highlighting the pivotal role of DT in perceived risks and their impact on customers' decision-making processes. Indeed, as highlighted by the literature review, previous research on customers' risk perception has predominantly focused on other industrial sectors. Therefore, there is still a need to explore how restaurant customers perceive risks and how they impact customers' intention to go to restaurants. Accordingly, this research aims to fill this gap by highlighting the critical impact of risk perception on customers' behavioural intention during the pandemic. Moreover, this study displays that service innovation based on DT can be a strategic vehicle for restaurant risk management to reduce customers' risk perception. Furthermore, this research analysed the perceived risk in both pandemic and post-pandemic scenarios to investigate if COVID-19 has affected the perceived risk mechanism. This article enlarged the context of DT innovation research. While previous research on technology innovation has focused on adopting DT from a managerial or employee perspective, this research attempts to explore the role of innovation in reducing the perceived risks from a customer perspective. In addition, our results also suggest that the restaurant sector needs several years before the full business recovery since customers, in conditions of uncertainty, will be reluctant to go to restaurants. Accordingly, this reflection suggests that safety and health risks could be considered pivotal elements in understanding the customer decision-making processes in hospitality studies.

This study also provides practical implications for managers and RS operators. Due to the pandemic, "imposed service innovation" has forced restaurants to adopt measures in order to provide safety for customers. Importantly, DT as tools for service innovation has a pioneering role in the changing process that the foodservice sector will go through in the years after the COVID-19 outbreak. Accordingly, restaurants need to implement DT in their working practices to enhance cleanliness levels and social distancing. Moreover, adopting advanced cleaning systems to disinfect rooms and all high-touch surfaces is fundamental for reducing perceived risks. Restaurants need to demonstrate to their customers, using social media and all their communication channels, that integrating DT can provide a higher level of safety and ensure social distancing. Managers have to reduce interactions among customers and workers using technologies and, at the same time, enhance the cleanliness level through the use of advanced cleaning technologies. This – in turn – will reduce the perception of health risk since customers have developed a greater sensitivity to social distancing and cleaning measures that persists even after the pandemic period, impacting the choice of restaurants. However, despite the implementation of DT providing several advantages for restaurateurs, these technology-mediated services present also as many trials. Among them, the loss of employment and the increase in operating costs linked to technology investment could be considered the most relevant.

Notwithstanding these disadvantages, our findings revealed the pivotal role of DT in attracting customers. Accordingly, the implementation of DT in restaurants could be seen as a long-term investment. Moreover, the loss of employment could be managed by reallocating workers – following training and education courses – into new positions for DT implementation and management.

7. Conclusions

As stated in the previous sections, this research aimed to investigate the supportive role of DT in the foodservice field during the COVID-19 pandemic and how this affected customers' risk perception and consequential decision-making behaviours both in the pandemic and in the post-pandemic period. This study has conducted quantitative analysis on a sample of customers resident in Italy, showing that the implementation of DT leads restaurants to adopt measures that can balance the need to preserve health safety and reduce customers' risk perception to enhance their willingness to go to restaurants.

Despite the multiple benefits of implementing DT in the post-pandemic period, several challenges may be considered. In particular, the adoption of these technologies requires high costs for restaurant owners. However, considering the pivotal role played by DT in attracting customers during the pandemic, these investments are essential for restaurants' survival. Furthermore, informing stakeholders about the risk-reduction strategies implemented is essential to orient customers' decision-making behaviours. Lastly, policymakers might rely on our findings to establish guidelines, standards and regulations to support the RS during the reopening process.

This research is not without limitations, which can represent useful suggestions for further investigations. First, the study is based on a sample of customers resident in Italy. Scholars can implement the same analytical framework in other geographical contexts. Second, the analysis was carried out using an OLS model investigating the linear effect of each variable on the dependent variable. Considering the existing interconnections among the examined dimensions, an analysis based on a structural equation model may explore further relationships among latent variables. Third, the research investigates DT in general without exploring each technology's effectiveness in reducing customers' risk perception. Further research could analyse the specific impact of each innovation tool on risk perception. Fourth, the present paper is focused on customers. However, from an S-D logic perspective, all the actors of the "foodservice-scape" have a pivotal role in co-creating value for the system (Polese *et al.*, 2019). Accordingly, scholars may replicate this analysis to investigate the role of DT in reducing the risk perception of other actors in the supply chain. Fifth, this study was conducted at the beginning of the vaccination campaign in Italy. Future research may compare our findings with the results provided at the end of the vaccination journey. Lastly, considering the strategic role of UN Sustainable Development Goals in addressing the worldwide downturn, it would be interesting to explore if DT should be used as tools for the sustainable recovery of the RS (Ciasullo and Troisi, 2013; Ciasullo *et al.*, 2017; Esposito *et al.*, 2020).

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