Mobile apps against food waste: Are consumers willing to use them? A survey research on Italian consumers

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ABSTRACT

This paper is aimed at analyzing the consumers' willingness to use mobile apps that claim to contribute to mitigating the food waste problem. We study the extent to which such willingness is influenced by three factors related to the consumers' willingness to use mobile apps in general (perceived usefulness, perceived ease of use, and perceived risks) and three factors related to the consumer behavior against food waste (food neophobia, moral attitude, and knowledge about food conservation). A survey was conducted on 283 Italian consumers. Results show that perceived usefulness and perceived ease of use positively affect the willingness to use mobile apps against food waste, while perceived risks by potential users negatively impact such willingness. However, none of the three consumer-related factors has been proved to be significant. The results of this paper offer managerial implications to developers, related to how to advertise the app and how to improve the app functionality, in order to enhance the consumers' willingness to use.

1. Introduction

According to the recent estimates of the Food and Agriculture Organization of United Nations (FAO), nearly 690 million people – which correspond to 8.9% of the world population – are hungry, close to 750 million are exposed to severe levels of food insecurity, and two billion people in the world do not have regular access to sufficient food (FAO, 2020). Nevertheless, over 1.3 billion tons of food are annually wasted at the global level (FAO, 2011). Apart from the social and ethical perspectives, food waste has strong consequences from the environmental point of view (Abeliotis et al., 2015; Ananno et al., 2021): the environmental impact of food waste is quantified as 8% of global greenhouse gas (GHG) emissions, 20% of freshwater consumption, and 30% of global agricultural land use (FAO, 2018, 2013). Furthermore, from the economic perspective, the value of food waste is quantified at over 1.000 billion dollars per year (FAO, 2014). Food waste is a crucial problem nowadays and, within the context of the circular economy, mitigating this problem is a priority (e.g., de Souza et al., 2021; Kumari et al., 2022; Mabe et al., 2022; Teigiserova et al., 2020).

The food can be lost across all the stages of the supply chain, i.e.,

primary production, processing and manufacturing, distribution, and household consumption (e.g., Amicarelli et al., 2021; Aschemann-Witzel et al., 2022; Jeswani et al., 2021; Wang et al., 2022). This paper focuses on the food waste produced by the food service industry, which is actually not negligible.[1] For instance, Filimonau et al. (2022) highlighted how restaurants in Uzbekistan can produce yearly up to 30 tons of food waste each, due to the overproduction of meals. Similarly, Leverenz et al. (2021) estimated that German hotels can produce up to 9 kg of food waste per day.

Recently, several mobile apps that claim to contribute to the mitigation of the food waste problem in this sector (hereafter, apps against food waste) have been developed and are currently available to be downloaded and used by consumers (e.g., Hanson and Ahmadi, 2022). These apps are aimed at highlighting supermarkets, food shops, and restaurants where consumers can get the surplus food these businesses are unlikely to sell until the end of the day – which has a high chance to be thrown out – at lower prices than market ones.[2] For instance, in Italy the app X[3] is available since 2019 and counts for more than 10.000 shops where to pick up food. Each shop can make one or more food boxes available every day, whose content is hidden to potential consumers.

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[1] Readers interested to deepen the food waste issue produced by food service industry are referred to the recent review by Dhir et al. (2020).
[2] https://www.foodrecoverynetwork.org/blog/2019/8/27/6-apps-for-reducing-food-waste
[3] The real name of the app is hidden in this paper.

Each box can be bought at around one-third of the original price of the food inside. Via the mobile app, consumers can become aware of the shops available to sell food boxes and buy one or more boxes. Then, users must pick up the box from the correspondent shop in a specific time range, indicated by the food shop. Similar apps are available in other countries. Several studies in the literature recognize these apps as a useful tool to mitigate food waste in the food service sector (e.g., Filimonau et al., 2020; Vo-Thanh et al., 2021). Furthermore, a recent paper by Apostolidis et al. (2021) highlights that apps against food waste can support sustainable value co-creation for consumers, calling for further research on these apps.

In this context, this paper contributes to the literature on sustainable behavior (Davis et al., 2021; Milfont and Markowitz, 2016), in particular the field related to encouraging consumer behavior change towards sustainability (Jones et al., 2017; White et al., 2019), by addressing the consumers' willingness to use mobile apps against food waste. In the literature, several studies have been conducted aimed at highlighting the factors able to affect the willingness to download and use mobile apps (e.g., Harris et al., 2016; Hur et al., 2017; Kang, 2014). However, to the best of our knowledge, there are no studies that specifically investigate the willingness of consumers towards the use of apps against food waste. In this regard, understanding which factors drive such a willingness could help the further development and adoption of these apps, in turn contributing to further mitigating the food waste problem.

This paper contributes to filling this research gap by investigating the willingness of Italian consumers towards the use of mobile apps against food waste – in particular, in this paper we refer to apps against food waste that work similarly to the app X. Specifically, the paper addresses the following research question: *What are the determinants of the willingness to download and use mobile apps against food waste*? To answer this question, first a literature review study was conducted, aimed at investigating (1) the factors impacting the willingness to install and use mobile apps in general and (2) the factors affecting consumer behavior against food waste. Then, based on the literature review results, a survey among Italian consumers was designed and conducted between November 2020 and March 2021 on a sample of Italian consumers.

The paper is organized as follows. Section 2 presents the hypotheses development. Section 3 concerns the methodology and data collection. Section 4 presents the data analysis and results. Section 5 develops the discussion and implications. Section 6 concludes the paper.

2. Literature review and hypotheses development

This section is divided into two subsections. Section 2.1 addresses the factors affecting the willingness to install and use mobile apps. To identify these factors, we have relied on the theory of Consumers' Decision-Making Process (Engel et al., 1968) and the Technology Acceptance Model (Davis, 1989). According to the former, during the purchasing decision process, consumers consider perceived risks and benefits related to that purchase. According to the latter, the attitude towards using a (new) technology primarily depends on its perceived usefulness and the perceived ease of use. Based on the above-mentioned theories, three factors have been hypothesized able to affect the willingness to use apps against food waste: (1) perceived utility (addressed in Section 2.1.1), (2) perceived ease of use (Section 2.1.2), and (3) perceived risks (Section 2.1.3). Section 2.2 addresses three factors affecting consumer behavior against food waste, which are hypothesized able to affect the willingness to use apps against food waste: (1) food neophobia (addressed in Section 2.2.1), (2) moral attitude (Section 2.2.2), and (3) knowledge of food conservation (Section 2.2.3). Fig. 1 displays the theoretical model investigated in this study, whose hypotheses will be developed in the next subsections.

2.1. Factors related to the willingness to download and use mobile apps

2.1.1. Perceived utility

The perceived utility of a mobile app is defined as the extent to which consumers believe to try advantage from using that app (Venkatesh et al., 2003). It is widely demonstrated that the perceived utility is one of the strongest drivers of downloading mobile applications, since it is a representative factor of the utilitarian benefits provided to consumers (Diaz et al., 2021; Harris et al., 2016; Huang and Chueh, 2022; Wang et al., 2013; Xu et al., 2015). Accordingly, the more useful a person perceives the mobile app, the greater the value he/she expects to receive by downloading and using it and, therefore, the higher the willingness to download the app will be, ceteris paribus.

Based on these considerations, we hypothesize that:

H1. The higher the apps against food waste are perceived as useful by potential users, the higher the willingness to download and use them will be, ceteris paribus.

2.1.2. Perceived ease of use

Perceived ease of use is defined as "the degree to which the prospective user expects the target system to be free of effort" (Davis et al., 1989, p. 985). A wide literature exists on the positive relationship between the perceived ease of use related to a given technology and the willingness to adopt that technology (Davis, 1989; Davis et al., 1989; Venkatesh et al., 2003). Ease of use is recognized as a strong factor affecting the willingness to download and use mobile apps (Huang and Chueh, 2022; Hur et al., 2017; Kang, 2014; Leong et al., 2021).

Based on these considerations, we hypothesize that:

H2. The higher the apps against food waste are perceived as easy to use by potential users, the higher the willingness to download and use them will be, ceteris paribus.

2.1.3. Perceived risks

Perceived risk is defined as "the customer's subjective expectation of suffering a loss in pursuit of a desired outcome" (Warkentin et al., 2002, p. 160). Risks might involve different perspectives, for instance financial, performance, physical, psychological, social, time, and opportunity cost risks (Jacoby and Kaplan, 1972). Concerning the online environment, the perceived risks have been widely studied for online transactions in the e-commerce context. Here, consumers might perceive two main risks: exposure of personal information (e.g., credit card information might be stolen) and financial risk (e.g., transaction duplicated due to unintended double-clicking the purchase button, which results in a net loss of money to the consumer) (Kim et al., 2008). All in all, the literature highlights that these perceived risks hinder the consumers' willingness to buy products online (Aghekyan-Simonian et al., 2012; Chang and Wu, 2012).

In the case of mobile apps, the main risk is related to a lack of behavioral control that includes security and privacy risk (Harris et al., 2016). From the security perspective, users might be afraid that the mobile app contains malware, able to steal sensitive information contained in the smartphone without permission from the user (Wang et al., 2019). From the privacy risk, users can be afraid that the mobile app requires access to sensitive information, e.g., routes and locations visited (if the app requires geolocalization permissions), thus monitoring some aspects of the users' behavior. Several studies in the literature (Al-Natour et al., 2020; Chin et al., 2018; Gu et al., 2017; Huang and Chueh, 2022; Keith et al., 2013; Xu et al., 2015) highlight the negative effect played by perceived risks on the willingness to download mobile apps.

Based on these considerations, we hypothesize that:

H3. The higher the perceived risk of potential users related to the ability of apps against food waste to collect information of users, the lower the willingness to download and use them will be, ceteris paribus.
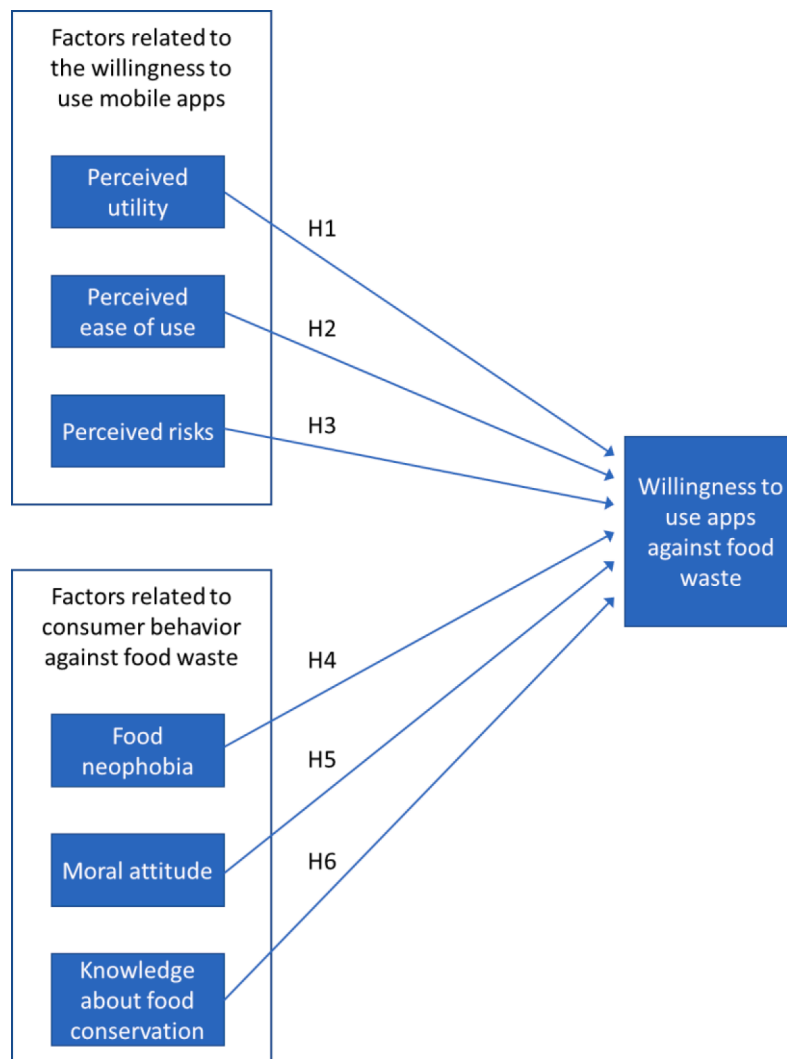
Fig. 1. Theoretical model investigated in this study.

2.2. Factors related to consumer behavior against food waste

2.2.1. Food neophobia

Food neophobia is defined as the "reluctance to eat and/or avoidance of novel foods" (Pliner and Hobden, 1992). A large body of research suggests that food-neophobic persons are hesitant to try or buy unfamiliar foods products (Bäckström et al., 2004; Coderoni and Perito, 2020; Henriques et al., 2009). Accordingly, people with low levels of food neophobia consume a wider range of food products compared to food-neophobic persons.

To the best of our knowledge, there are no previous studies that investigate the impact of food neophobia on the willingness to use apps against food waste. Nevertheless, food neophobia could impact the willingness to use apps against food waste that work similarly to the app X. Accordingly, the fact that people do not know in advance which specific food is contained in the box bought via the app – indeed, consumers might know in advance which kind of food is sold by a specific shop (e.g., consumers buying online a box sold by a bakery expect to find bakery products in the box) but they do not know in advance which specific products they will find in the box till they have opened it – might hamper consumers with a high level of food neophobia to use the app. Further, consumers can use the app X to order food boxes from supermarkets: in this specific case, having a clear expectation on which kind of food they are going to receive can be hard. Indeed, in their study conducted on a similar app, Vo-Thanh et al. (2021) highlighted that the

majority of users interviewed by them wish to have information on the food contained in the box in advance, which would reduce the risk of throwing away part of them, for instance because of allergies.

Based on these considerations, we hypothesize that:

H4. The higher the food neophobia level of potential app users, the lower the willingness to download and use apps against food waste will be, ceteris paribus.

2.2.2. Moral attitude

Several studies highlighted that people might experience negative feelings when they waste food (Richter, 2017; Stefan et al., 2013). In this regard, consumers' moral values regarding food waste play an important role in determining their food waste behavior (Aydin and Yildirim, 2021). In fact, the individual moral attitude induces feelings of discomfort as a result of wasting food (Stefan et al., 2013). Accordingly, a negative relationship between strong moral attitudes and food waste behavior is found in the literature (Aydin and Yildirim, 2021; McCarthy and Liu, 2017).

People with a strong moral attitude against wasting food waste, who feel a responsibility to avoid wasting food and conserve resources (Graham-Rowe et al., 2015; McCarthy and Liu, 2017), could be more willing to use mobile apps against food waste.

Based on these considerations, we hypothesize that:

H5. The higher the moral attitude towards food waste of potential app

users, the higher the willingness to download and use apps against food waste will be, ceteris paribus.

2.2.3. Knowledge about food conservation

Knowledge about food conservation is defined as "the consumers' extent of information on preserving the nutritional value of food and avoiding hazardous food effects while storing and preparing food" (Aydin and Yildirim, 2021, p. 3). The literature has shown that people who have high knowledge about the appropriate conditions to store food produce less waste (Bravi et al., 2019; Farr-Wharton et al., 2014). Food boxes bought via apps against food waste might contain food with a short expiration date or fresh products, which need to be consumed in a short time or conserved properly. Consumers without appropriate knowledge about how to conserve food might be reluctant to use apps against food waste, being afraid not to be able to eat the whole food, causing further food waste.

Based on these considerations, we hypothesize that:

H6. The higher the knowledge about food conservation of potential app users, the higher the willingness to download and use mobile apps against food waste will be, ceteris paribus

3. Methodology and data collection

Primary data to test the hypotheses developed in Section 2 was collected through a survey of Italian consumers. To conduct the survey, a questionnaire was developed. The questionnaire is divided into three parts.

First, respondents were asked whether they currently use apps against food waste that work similarly to the app X. Since the aim of this research is to investigate the willingness to use mobile apps against food waste, only for people answering *no* the questionnaire continued with the second part. For people answering *yes*, the questionnaire ended.

In the second part of the survey, the following constructs were measured with multiple-item scales: (1) perceived utility with five items (out of six items, from Xu et al., 2015); (2) perceived ease of use with five items (out of fourteen items, from Davis, 1989); (3) perceived privacy risks with six items (from Xu et al., 2015); (4) food neophobia with five items (out of ten items, from Ritchey et al., 2003); (5) moral attitude with three items (out of four, from Visschers et al., 2016); and (6) knowledge of food conservation with four items (Aydin and Yildirim, 2021). For each construct, a five-point Likert scale (from 1="strongly disagree" to 5="strongly agree") was used to assess the statements. The willingness to install and use mobile apps against food waste was measured through a specific question, assessed through a five-point Likert scale (from 1="strongly disagree" to 5="strongly agree").

The third part of the survey was aimed at collecting socio-demographic information of respondents: gender (a dummy variable codified as 0 for male and 1 for female) (Dangelico et al., 2021) and age (from 1="18–24″ to 6="over 65″) (de Marchi et al., 2020).

Before collecting data, a pre-test phase was conducted on a sample of 20 consumers, aimed at checking whether the questions were clear enough to respondents. Few changes have been done after this phase, in order to enhance the sake of clarity of some questions. During the pre-test phase, we also assessed that about 5 to 10 min were required to complete the questionnaire.

A convenience sampling was used, as common in consumer behavior studies (e.g., Butt et al., 2017; D'Agostin et al., 2020; de Medeiros et al., 2021; Han et al., 2019; Najmi et al., 2021; Talha et al., 2020; Wei et al., 2021). The final version of the survey was distributed online, through instant messaging clients and social networks between November 2020 and March 2021. All the questions were mandatory: without having provided an answer to one question, respondents were disallowed to continue to the next questions. Hence, respondents could finally submit the questionnaire only if they had replied to all the questions. This resulted in no missing values in the dataset. The total number of collected responses was 283.

4. Data analysis and results

This Section is divided into two subsections. Section 4.1 presents the socio-demographic characteristics of the sample and the descriptive analysis of the responses provided. Section 4.2 concerns the statistical analyses conducted.

4.1. Descriptive analysis

Table 1 displays the socio-demographic characteristics of the sample. 41% of the respondents are male and 59% are female. The sample is mostly made of people under 35.

Table 2 displays the responses for each scale of the questionnaire. The apps against food waste are perceived as useful by over 40% of respondents and as easy to use by more than 50% of respondents. Around 50% of respondents do not have particular concerns about the risks of using these mobile apps. The majority of the sample is made by people with low levels of food neophobia, a high moral attitude, and a good knowledge of food conservation.

4.2. The statistical analyses

Several analyses were performed using the IBM SPSS Statistics 27 data analysis package.

First, a series of factor analyses was conducted, using the principal component method, according to Dangelico et al. (2021).

Results of the factor analysis on items referred to perceived utility show one factor with eigenvalue greater than one, accounting for 74.78% of the variance (K-M-O statistic 0.827; Bartlett's statistic 1058.76, significance <0.001). Results of the factor analysis on items referred to perceived ease of use show one factor with eigenvalue greater than one, accounting for 82.63% of the variance (K-M-O statistic 0.882; Bartlett's statistic 1458.38, significance <0.001). Results of the factor analysis on items referred to perceived risks show one factor with eigenvalue greater than one, accounting for 82.99% of the variance (K-M-O statistic 0.865; Bartlett's statistic 2079.86, significance <0.001). Results of the factor analysis on items referred to food neophobia show one factor with eigenvalue greater than one, accounting for 59.20% of the variance (K-M-O statistic 0.798; Bartlett's statistic 547.89, significance <0.001). Results of the factor analysis on items referred to moral attitude show one factor with eigenvalue greater than one, accounting for 70.89% of the variance (K-M-O statistic 0.709; Bartlett's statistic 253.40, significance <0.001). Results of the factor analysis on items referred to knowledge of food conservation show one factor with eigenvalue greater than one, accounting for 73.54% of the variance (K-M-O statistic 0.808; Bartlett's statistic 606.03, significance <0.001).

Table 3 displays (1) Cronbach's alpha, Average Variance Extracted (AVE), and Composite Reliability (CR) for each factor and (2) mean, standard deviation, and factor loading for each item. All factor loadings exceed the value of 0.50, being the lowest 0.646. CR and Cronbach's

Table 1
Socio-demographic characteristics of the sample.

	Frequency (percentage)
Gender	
Male	116 (41%)
Female	167 (59%)
Age	
18–24	53 (18.7%)
25–34	119 (42%)
35–44	30 (10.6%)
45–54	25 (8.8%)
55–65	41 (14.5%)
over 65	15 (5.3%)

Table 2
Scales and percentage of responses for each category of answers (1= "strongly disagree", 2= "disagree", 3= "neither agree nor disagree", 4= "agree", 5= "strongly agree").

	Source	Item	1	2	3	4	5
Perceived utility	Xu et al. (2015)	The application would help me be more effective	3.9%	3.9%	38.2%	47.7%	6.4%
		The application would help me be more productive	3.9%	11.3%	38.5%	41.3%	4.9%
		The application would help me to save time	4.9%	12.7%	43.8%	33.9%	4.6%
		The application would make it easier to do it	4.9%	9.5%	47.7%	32.9%	4.9%
		The application would be useful to me	4.2%	4.6%	34.3%	47.3%	9.5%
Perceived easy of use	Davis (1989)	I would find the app easy to use	3.5%	6.0%	33.2%	45.9%	11.3%
		I would not find it cumbersome to use the app	2.8%	5.3%	29.7%	47.7%	14.5%
		My interaction with the app would be easy for me to understand	1.1%	5.7%	32.5%	49.8%	11.0%
		Interacting with the app would not require mental effort	1.8%	4.2%	36.0%	46.3%	11.7%
		I would find it easy to get the app to do what I want to do	2.5%	4.9%	31.4%	48.4%	12.7%
Perceived risks	Xu et al. (2015)	The application may disclose my personal information to others	18.7%	35.7%	29%	14.1%	2.5%
		The application may share my personal information to others	17.7%	33.6%	29.7%	17%	2.1%
		The application may track my habits of mobile phone use	14.8%	26.1%	35%	20.1%	3.9%
		The application may collect and use my personal information in an unintended way	15.5%	30.7%	33.6%	17%	3.2%
		The application may cause me to lose control over my privacy	19.1%	35.7%	33.6%	10.6%	1.1%
		The application may lead to a loss of my privacy without my knowledge	19.4%	33.6%	32.2%	12%	2.8%
Food neophobia	Ritchey et al. (2003)	I am afraid to eat things I have never had before	25.4%	40.6%	23.7%	8.8%	1.4%
		If I don't know what a food is, I won't try it	18%	30.4%	21.6%	26.5%	3.5%
		I don't trust new foods	23.3%	42%	24%	9.9%	7%
		I am not very particular about the foods I eat	34.3%	38.9%	12.4%	11.3%	3.2%
		I am constantly sampling new and different foods	13.8%	29.7%	29.3%	21.9%	5.3%
Moral attitude	Visschers et al. (2016)	It is contrary to my principles when I have to discard food	1.4%	1.4%	4.6%	30%	62.5%
		I feel obliged not to waste any food	1.4%	2.1%	7.8%	33.2%	55.5%
		I have been raised to believe that food should not be wasted and I still live according to this principle	1.4%	1.4%	7.4%	28.3%	61.5%
Knowledge of food conservation	Aydin and Yildirim (2021)	I am informed about how to defrost food without losing its nutritional value	2.8%	23.7%	22.6%	39.2%	11.7%
		I am informed about when to throw away food to prevent food poisoning	1.8%	8.5%	15.5%	52.3%	21.9%
		I am informed about proper time periods different food types can be retained in the freezer	3.2%	25.8%	26.5%	34.6%	13.1%
		I am informed about how to reheat food to avoid hazardous effects	2.8%	17.3%	25.1%	40.6%	14.1%

alpha are above the recommended cut-off value of 0.70 for all constructs, being the lowest 0.798 and 0.786, respectively. For all constructs, AVE is above 0.50, being the lowest 0.592. Thus, all constructs show evidence of good convergent validity and reliability (Alhosseini Almodarresi et al., 2019; Fornell and Larcker, 1981; Gleim et al., 2013; Hair et al., 2006). Table 4 displays the correlation matrix. Discriminant validity was tested following Fornell and Larcker (1981). There is evidence of discriminant validity among all the constructs, since for each construct the square root of the AVE is higher than the correlation coefficient between that construct and other constructs,

In order to test the research hypotheses, an ordinary least squares regression analysis was performed. The socio-demographic variables were included as controls. Table 5 displays the results of the regression analysis.

As shown in the table, perceived utility (β=0.569, p<0.001) and perceived ease of use (β=0.110, p<0.001) have a positive and significant effect on the willingness to use apps against food waste. Hence, H1 and H2 are supported. Alternatively, perceived risks (β=−0.087, p<0.1) have a negative and significant effect on the willingness to use apps against food waste. Hence H3 is supported. Food neophobia, Moral attitude, and Knowledge about food conservation are found to be not significant. Hence, H4, H5, and H6 are not supported. Concerning the control variables, age (β=−0.082, p<0.1) negatively affects the willingness to use apps against food waste.

5. Discussion and implications

The results show that three out of six factors considered in the theoretical model investigated affect the willingness to use mobile apps against food waste.

In particular, all the three factors related to the consumers' perception of the apps against food waste (i.e., perceived utility, perceived ease of use, and perceived risks) have been proven to be significant.

The perceived risk related to privacy issues has been proven a barrier that hampers the download and use of mobile apps against food waste. Consumers afraid that these apps can collect and track personal information or personal habits in an unintended way, and even share this data with others – leading to a loss of control on the privacy – are less willing to use them. Accordingly, several studies in the literature highlight that perceived privacy risk negatively influences the perceived security of mobile apps (e.g., Balapour et al., 2020; Johnson et al., 2018). Hence, this result is consistent with the study by Kim et al. (2008), which highlights that consumers having privacy concerns are less willing to use online channels to buy products, and with several other studies (e.g., Gu et al., 2017; Harris et al., 2016; Trivedi et al., 2022) highlighting that consumers concerned about privacy issues are less prone to download and use mobile apps. In order to offset users' privacy concerns, Xu et al. (2015) suggest that app developers should emphasize their privacy policies and make them publicly known. Consistently, Gu et al. (2017) suggest that app developers clearly explain which data are collected through the app usage, as well as the purpose and data protection practice, to users. Based on the results of this paper, together with the implications highlighted by previous studies, we suggest that the developers of mobile apps against food waste put efforts into clarifying, to the potential users, which data the app collects, as well as that such data collection is not dangerous for the mobile device and does not punch the user's privacy.

Concerning the other factors related to the consumers' perceptions, the perceived utility and the perceived ease of use positively affect the willingness to download and use apps against food waste. These results are consistent with other studies in the literature (Harris et al., 2016; Huang and Chueh, 2022; Hur et al., 2017; Xu et al., 2015).

Regarding the perceived utility, Akdim et al. (2022) highlight that developers should be careful in understanding the needs of potential users, in order to align the incentives by fulfilling the users' expectations. Moreover, Xu et al. (2015) and Leong et al. (2021) suggest that

Table 3

Scales with Cronbach's alpha, AVE, and CR for each construct and mean, standard deviation, and factor loading for each item.

Construct	Cronbach's alpha	AVE	CR	Item	Mean	Standard deviation	Factor loadings
Perceived utility	0.915	0.748	0.892	The application would help me be more effective	3.49	0.831	0.885
				The application would help me be more productive	3.32	0.883	0.849
				The application would help me to save time	3.20	0.899	0.839
				The application would make it easier to do it	3.23	0.876	0.880
				The application would be useful to me	3.53	0.888	0.870
Perceived ease of use	0.946	0.826	0.917	I would find the app easy to use	3.55	0.899	0.840
				I would not find it cumbersome to use the app	3.66	0.891	0.907
				My interaction with the app would be easy for me to understand	3.64	0.793	0.922
				Interacting with the app would not require mental effort	3.62	0.814	0.933
				I would find it easy to get the app to do what I want to do	3.64	0.857	0.939
Perceived risks	0.959	0.83	0.967	The application may disclose my personal information to others	2.46	1.028	0.914
				The application may share my personal information to others	2.52	1.036	0.928
				The application may track my habits of mobile phone use	2.72	1.067	0.889
				The application may collect and use my personal information in an unintended way	2.61	1.040	0.901
				The application may cause me to lose control over my privacy	2.39	0.948	0.908
				The application may lead to a loss of my privacy without my knowledge	2.45	1.025	0.925
Food neophobia	0.816	0.592	0.882	I am afraid to eat things I have never had before	2.20	0.967	0.854
				If I don't know what a food is, I won't try it	2.67	1.152	0.745
				I don't trust new foods	2.23	0.941	0.869
				I am not very particular about the foods I eat [(*)]	2.10	1.095	0.709
				I am constantly sampling new and different foods [(*)]	2.75	1.106	0.646
Moral attitude	0.794	0.709	0.88	It is contrary to my principles when I have to discard food	4.51	0.774	0.845
				I feel obliged not to waste any food	4.39	0.833	0.848
				I have been raised to believe that food should not be wasted and I still live according to this principle	4.47	0.809	0.833
Knowledge of food conservation	0.880	0.735	0.917	I am informed about how to defrost food without losing its nutritional value	3.33	1.050	0.842
				I am informed about when to throw away food to prevent food poisoning	3.84	0.922	0.818
				I am informed about proper time periods different food types can be retained in the freezer	3.32	1.061	0.895
				I am informed about how to reheat food to avoid hazardous effects	3.46	1.025	0.873

[(*)] = reverse coded.

Table 4

Correlation matrix (square root of the AVE of constructs in bold, as elements of the main diagonal).

	Perceived utility	Perceived ease of use	Perceived risks	Food neophobia	Moral attitude	Perceived easy of use
Perceived utility	**0.865**					
Perceived ease of use	0.341***	**0.973**				
Perceived risks	−0.180***	−0.165***	**0.979**			
Food neophobia	−0.101	−0.203***	0.225***	**0.903**		
Moral attitude	0.027	0.044	0.084	−0.050	**0.891**	
Perceived easy of use	−0.014	0.048	0.113	−0.054	0.120**	**0.938**

** $p < 0.05$;.

*** $p < 0.01$.

app developers stress the benefits of app utility in their marketing campaigns, aimed at creating awareness among potential users.

Regarding the perceived ease of use, several studies highlight that this is a key variable that positively affects the users' continuance intention of the mobile app (e.g., Akdim et al., 2022; Kang, 2014). Consistently, Huang and Chueh (2022) highlight that the perceived ease of use can be much affected by the graphical interfaces; hence, they suggest to simplify the graphical interfaces, thus making them user-friendly as much as possible, aimed at further enhancing the ease of use. Moreover, Akdim et al. (2022) suggest that developers provide technical assistance that clearly shows their users how to operate the mobile app.

According to the results of this paper, we can suggest that developers of apps against food waste focus their marketing campaigns to advertise which are the benefits that users can achieve from the adoption of the app, as well as to enhance as much as possible the ease of use of the app. For instance, the app developers could ask that users upload short videos where they show how to use the app, reporting their personal experience in this regard. Similarly, the developers should push users to upload their reviews of the app. Both these actions could be awarded with coupons or vouchers, aimed at encouraging users to provide their contributions. In this regard, the positive effect played by rewarding programs is recognized by the literature (e.g., Huang and Chueh, 2022). Furthermore, the graphic interface of the app should be optimized to

Table 5
Regression results.

Variables		Regression coefficients
Socio-demographic variables	Gender	0.013
	Age	-0.082*
Factors related to the willingness to use mobile apps	Perceived utility	0.569***
	Perceived ease of use	0.110***
	Perceived risks	-0.087*
Factors related to the consumer behavior against food waste	Food neophobia	-0.036
	Knowledge about food conservation	-0.065
	Moral attitude	0.009
	F	28.90***
	R^2	0.676
	Adj R^2	0.442

* $p<0.10$;.
*** $p< 0.01$.

enhance the ease of use.

Alternatively, none of the three consumer-related factors has been proven to be significant.

Regarding the food neophobia, to the best of our knowledge this is the first study that investigates the impact it plays on the willingness to use mobile apps against food waste. Indeed, in recent years the literature has focused on measuring the food neophobia (Damsbo-Svendsen et al., 2017), investigating the factors impacting on the individual food neophobia (Lafraire et al., 2016), as well as on investigating the consumers' willingness to try novel foods, such as waste-to-value products (Cattaneo et al., 2019; Coderoni and Perito, 2021, 2020), nutrition-modified and functional products (Bimbo et al., 2017), and 3D printed products (Manstan and McSweeney, 2020). Hence, this study provides a novel contribution to the literature on food neophobia and its impact on the consumers' purchasing choices. Regarding the specific results, the sample considered in this study is characterized by low levels of food neophobia – on average, the 80% of respondents have negatively replied to questions aimed at measuring the food neophobia. In this regard, Rabadán and Bernabéu (2021) highlighted that the levels of food neophobia are tending to fall in the last ten years, perhaps thanks to the increased number of restaurants serving foods from foreign countries worldwide, which has resulted in greater exposure of consumers to different ingredients and foods, as well as to the reduction in the cost of these meals. Accordingly, the results of this paper support the idea that consumers do not consider the lack of knowledge about what they are going to find in the fill box as a barrier towards the usage of mobile apps against food waste. Nevertheless, although consumers do not know in advance which specific food is contained in the box they have bought, they have at least some expectations on the kind of food they are going to find (e.g., bakery products in a box bought from a bakery). Such an issue could have mitigated the role of food neophobia on the consumer behavior.

Differently from what was hypothesized, moral attitude and knowledge of food conservation were found not to affect the consumers' willingness to use apps against food waste. Regarding the effect of moral attitude, perhaps this factor only influences consumers to reduce their own food waste, without driving them to contribute reducing the food waste of others – as mobile apps against food waste do. The unsignificant effect of knowledge of food conservation might depend on how consumers manage the food taken via these mobile apps. Perhaps consumers prefer eating this food asap, without freezing it. These results call for future investigation about how consumers use mobile apps against food waste.

All in all, the above-mentioned results might suggest that the main drivers to use mobile apps against food waste are not related to ethical factors (e.g., the willingness to contribute to saving food that otherwise would be wasted) but rather to personal utility (e.g., the chance to save time thanks to using the app) – according to the factors above-discussed.

Regarding the socioeconomic factors, age was found to negatively affect the willingness to use mobile apps against food waste. Hence, developers should devote their efforts – in terms, for instance, of marketing campaigns, as well as the development of the graphical interface – to younger users. Nevertheless, different marketing campaigns should be designed for different categories of consumers, according to their age.

Some *ad-hoc* considerations should be deserved for the sample used for the analysis. We recognize that our sample is not representative of the overall Italian population because overestimates the share of young people (over 35) while underestimates the share of those over 65. Nevertheless, for a better comparison, we should consider the characteristics of the Italian digital population. According to the National Institute of Statistics (ISTAT), over 80% of people under 40 use internet every day, while such a percentage decreases to around 68% for 45–55 y.o. and to around 25% for people over 65.[4] Furthermore, the share of online buyers purchasing via smartphone in Italy in 2021 was equal to 85% of 18–34 y.o., 76% of 35–55 y.o., and 56% of over 55.[5] Hence, the average age of the Italian digital population is recognized to be lower than the average age of the overall Italian population. Therefore, we might assume the bias introduced by our non-representative sample is mitigated.

6. Conclusions

This paper investigates the factors impacting the consumers' willingness to use mobile apps that claim a positive contribution towards reducing the amounts of food waste by food shops. Results have shown that the main factors contributing to the willingness to use these apps are the perceived utility and the perceived ease of use. Alternatively, the perceived risks related to the privacy were found to negatively affect the willingness to use these apps. Results have also shown that food neophobia, moral attitude, and knowledge of food conservations seem not to affect the consumer's willingness to use these apps. Given these results, future research should be devoted to investigate which factors are in turn able to affect the consumers' perception of utility, ease of use, and risks related to mobile apps against food waste, with the aim to further spread their usage.

All in all, some limitations must be acknowledged. First, data come from a convenience sample. Although the use of convenience sampling is common in consumer behavior studies (e.g., Butt et al., 2017; D'Agostin et al., 2020; de Medeiros et al., 2021; Han et al., 2019; Lin and Chen, 2006; Mohd Suki and Mohd Suki, 2019; Talha et al., 2020; Wei et al., 2021), such a sampling technique might not ensure the sample is fully representative of the overall population. Thus, caution should be considered when generalizing the results. In this regard, further research could be devoted to enlarging the sample size, in order to use a more representative sample of the whole population. Second, the study is related to a specific category of mobile apps. Different perceptions can exist related to specific mobile apps that, although having similar aims, are characterized by different functions. Moreover, the research is focused only on Italian consumers. Further research can therefore be conducted in other countries, in order to investigate the impact of the country-specific cultural factors on the outcome of this study. Future research can be also aimed at exploring whether different clusters of consumers, characterized by different socio-demographic features, have different willingness to use mobile apps against food waste, as well as whether such willingness is driven by different factors. Indeed, Hur et al. (2017) highlight that millennials and mature consumers can have different behaviors in this sense. Future studies can be also address the role of perceived product availability, which is related to the consumer's

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[4] "Share of the population using the internet everyday in Italy in 2021, by age and gender", accessed via www.statista.com.
[5] "Share of online buyers purchasing via smartphone in Italy in 2021", accessed via www.statista.com.

effortlessness in finding and buying the product (e.g., Vermeir and Verbeke, 2008). The literature highlights that perceived product availability might play a positive role on the willingness to buy the product (e.g., Chakraborty et al., 2022): accordingly, the unavailability of product can prevent consumers from buying it (e.g., Tran et al., 2022). Concerning mobile apps against food waste, consumers living/working in an area poorly served by shops offering food boxes via the mobile apps would face a higher distance to reach shops where to buy food boxes; this issue could reduce the perceived product availability, thus potentially reducing the consumers' willingness to adopt the app. However, *ad-hoc* investigation is required.

These further studies would provide useful managerial implications, in particular related to how design marketing campaigns differentiated per clusters of potential users, even in different countries. Finally, this paper highlights which factors affect the willingness to use mobile apps against food waste and therefore focuses on respondents who currently do not use these apps. Future research could be devoted to studying the behavior of the current app users, in order to highlight the factors driving the app usage over time.

CRediT authorship contribution statement

Luca Fraccascia: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Alberto Nastasi:** Conceptualization, Formal analysis, Writing – review & editing.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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