

# Predicting restaurants' surplus food platform continuance: Insights from the combined use of PLS-SEM and NCA and predictive model comparisons<sup>☆</sup>

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## ABSTRACT

Surplus or anti-food waste platforms have emerged as opportunities for restaurants to sell their daily surplus food. However, restaurants' commitment to these platforms often diminishes over time, which can result in discontinuance. Hence, it is necessary to explain and predict restaurant surplus food platform continuance intentions. For this purpose, we propose a model that integrates the technology acceptance model (TAM) and self-determination theory. We assessed our model by jointly applying partial least squares structural equation modeling (PLS-SEM) and necessary condition analysis (NCA) to analyze data from 214 restaurants using surplus food platforms. The findings indicate that perceived ease of use, economic motivation, and environmental motivation are significant determinants of and necessary conditions for continuance intention. Moreover, model comparisons using BIC, Akaike weights, and CVPAT highlighted that our model's predictive accuracy was higher than that of alternative models based solely on the TAM.

## 1. Introduction

Mitigating food waste and its environmental, social, and economic impacts is a global priority (FAO, 2023; UNEP, 2021). Specifically, the Sustainable Development Goal (SDG) 12.3 of the United Nations' 2030 Agenda for Sustainable Development aims to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" by 2030 (United Nations, 2015, p. 27). The foodservice industry is deemed responsible for 26% of the 931 million tons of annual food waste worldwide (UNEP, 2021). However, it is also progressively implementing new practices to mitigate food waste production (Arun et al., 2021; Baloglu et al., 2022; Eičaitė et al., 2022; Filimonau et al., 2023). In particular, restaurants are increasingly embracing food waste management initiatives to reduce their large volumes of daily food waste (Cantele and Cassia, 2020; Ng and Sia, 2023).

Among the many strategies available for restaurants to reduce food waste (Filimonau et al., 2022; Vizzoto et al., 2021), selling excess food through surplus food (or anti-food waste) digital platforms is gaining popularity (Cane and Parra, 2020; Fuentes et al., 2021; Somlai, 2022).

These platforms enable restaurants to transform "trash into cash" as they can reach deal-prone consumers interested in purchasing surplus perishable food at significantly discounted prices (Amaral and Orsato, 2023; de Visser-Amundson et al., 2023; Luo et al., 2024). The use of surplus food platforms is desirable because they facilitate the redistribution of food leftovers for human consumption, which is a priority when food waste cannot be prevented (Kirmani et al., 2023; Parsa et al., 2023).

However, after an initial period of interest, restaurants often decrease or entirely discontinue their use of surplus food platforms (Amaral and Orsato, 2023; Mazzucchelli et al., 2021). Hence, platforms try to keep restaurants motivated by continuously creating value, such as by providing them with relevant benefits and minimizing usage complexity and costs (Amaral and Orsato, 2023). In response, restaurants continue to upload their surplus food offerings to digital platforms, which increases the number of consumers subscribing to the platforms, thereby activating a virtuous circle (Mullick et al., 2021).

Prior exploratory research suggested that extrinsic or instrumental motivations, namely, the search for additional revenue from selling perishables and lowering waste disposal costs, play a primary role in

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motivating businesses to use surplus food platforms (Amaral and Orsato, 2023; Martin-Rios et al., 2018). In addition, previous research reported that businesses' adoption of behaviors against food waste was also driven by environmental motivations, that is, intrinsic motives reflecting the willingness to increase environmental sustainability (Islam et al., 2023). However, the available research neither studied the motives for restaurants' continued usage of anti-food waste platforms nor distinguished between necessary and desirable motivations for usage continuance.

This study aims to fill this gap in the literature by proposing a model that combines the technology acceptance model (TAM, Davis, 1989) with self-determination theory (SDT, Deci and Ryan, 1985). Drawing on this theoretical background and a detailed literature review of previous studies on restaurants' green behaviors, our model suggests that three factors explain and predict the usage continuance intention of surplus food platforms, with attitude as a mediator: economic motivation (Baloglu et al., 2022; Filimonau et al., 2022; Paulraj et al., 2017), environmental motivation (Karatepe et al., 2021; Paulraj et al., 2017; Sharma et al., 2022), and perceived ease of use (Amaral and Orsato, 2023; Venkatesh et al., 2003). To substantiate our arguments, we assessed the proposed model through partial least squares structural equation modeling (PLS-SEM) and some of its recent advancements (Cheah et al., 2024; Hair et al., 2022, 2024; Sarstedt and Liu, 2023). Recently, PLS-SEM has received significant interest in marketing and management (Guenther et al., 2023; Magno et al., 2022; Sarstedt et al., 2022) and in many other disciplines (Cheah et al., 2023). Its causal-predictive nature and recent methodological extensions make PLS-SEM particularly useful for performing in-depth predictive model assessments (Hair et al., 2022). Specifically, we evaluated our model through the combined use of PLS-SEM and necessary condition analysis (NCA, Richter et al., 2020). This combined approach is useful for understanding the significance and relevance of the proposed antecedents as significant determinants (should-have factors) and necessary conditions (must-have factors) for the outcome (Richter et al., 2023). Our analysis was strengthened by comparing the proposed model with alternative models based solely on the traditional TAM. This procedure allowed us to evaluate whether the proposed model, which integrates the TAM's tenets and intrinsic motivations, better approximates the data generation process and has a higher predictive power than alternative models based solely on the TAM (Hair et al., 2022). The model was assessed using data from 214 restaurants that used Too Good To Go, one of the most popular digital platforms against food waste (Cane and Parra, 2020; Hellemans et al., 2022).

The results of this study contribute to advancing our theoretical understanding of the factors predicting restaurant usage continuance intention for surplus food platforms. The comparative analysis allowed us to assess whether the proposed model had a higher predictive accuracy for such intentions than the alternative TAM-based models. The findings also provide clear managerial insights as the application of PLS-SEM and NCA enabled the distinction between "should-have" and "must-have" factors (Dul, 2022; Dul et al., 2023). This study highlights whether economic motivation, environmental motivation, and perceived ease of use are necessary conditions for continuance intention—that is, whether each factor must reach a certain necessary level to have continuance intention. Such evidence can guide surplus food platform owners in designing their platforms to better meet restaurant needs.

## 2. Literature review and research model

### 2.1. Overview and background

Firms' decisions to embrace technological green innovation or eco-innovation in the foodservice context are explained by the expected environmental and economic benefits (Luu, 2022; Sharma et al., 2020) and the ease of using them in daily business routines (Martin-Rios et al.,

2018). Hence, for foodservice businesses, the adoption of green technological innovations needs to enhance profitability by reducing costs and/or increasing revenues while mitigating the negative environmental impacts of daily activities (Kim et al., 2018). Simultaneously, green innovations must be easy to implement in terms of cost and effort (Gonzalez et al., 2022). Surplus food platforms are a type of technological green innovation, and restaurant managers' motivations for using them are complex and not limited to economic gains or ease of use (Amaral and Orsato, 2023).

Based on these premises, this study proposes a model that draws on the integration of the TAM with SDT to explain and predict restaurants' continuance intentions toward surplus food platforms. The TAM suggests that the attitude towards a technology (such as a technological platform), and thus the continuance intention, depend on both its perceived usefulness and ease of use (Davis, 1989). Specifically, perceived usefulness reflects the extrinsic (or instrumental) benefits a user can derive from using technology (Davis et al., 1992; Venkatesh et al., 2003). However, the TAM overlooks intrinsic benefits (Gilal et al., 2019). Hence, this study combines TAM with SDT to consider the effects of intrinsic motivation (Ryan and Deci, 2000a). The resulting model includes three predictors (perceived ease of use, economic motivation, and environmental motivation) and enables a comprehensive understanding of restaurants' continuance intentions toward surplus food platforms. The main tenets of the two theories (TAM and SDT) and the proposed hypotheses are detailed in the following sections.

### 2.2. Models and theories

#### 2.2.1. Technology acceptance model

Davis (1989) proposed TAM to explain and predict a person's decision to accept technologies. Since its introduction, the TAM has undergone several refinements and extensions. However, the core tenets of the theory are well established: a technology's perceived usefulness and ease of use influence a person's attitude toward the technology and, in turn, their intention to adopt and use it (Marangunic and Granić, 2015). Perceived usefulness indicates "the degree to which a person believes that using a particular system would enhance his or her job performance," while perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). As highlighted by Davis et al. (1992), technology adoption research considers perceived usefulness to be synonymous with extrinsic motivation. Consequently, extrinsic motivation is routinely measured using the TAM scale of perceived usefulness (Venkatesh et al., 2003). Thus, perceived usefulness indicates an individual's motivation to use a technology because it is instrumental in obtaining tangible benefits such as job performance improvements or money (Davis et al., 1992).

As shown by the recent extensive review by Yan et al. (2021), TAM is the most frequently adopted theory to study the continuance intention of online technologies, including platforms. The TAM has been extensively applied to understand technology use by organizations, such as social media (Siamagka et al., 2015). For example, the TAM has been successfully applied to explain the use of digital marketing by small business owners and managers (Ritz et al., 2019). Similarly, the TAM has been applied to understand the adoption of digital technologies by out-of-home advertising firm owners and top managers (Cho et al., 2022). Marketing executives' intentions to adopt digital platforms in their organizations have also been studied through the TAM (Swani, 2021).

#### 2.2.2. Self-determination theory

The SDT was formally introduced by Deci and Ryan in the 1980s and currently encompasses six mini-theories (Deci and Ryan, 1985; Ryan and Deci, 2022). In this study, we specifically draw on the cognitive evaluation mini-theory (Deci and Ryan, 1980; Ryan and Deci, 2022), which highlights the intrinsic and extrinsic motivations of human

behavior (Deci and Ryan, 1985; Gagné and Deci, 2014). SDT argues that the motivations that move people to act can be intrinsic or extrinsic (Deci and Ryan, 1985). Specifically, “*extrinsic motivation* refers to the performance of an activity to attain some separable outcome and, thus, contrasts with *intrinsic motivation*, which refers to doing an activity for the inherent satisfaction of the activity itself” (Ryan and Deci, 2000b, p. 71).

Insights from other SDT mini-theories indicate that the satisfaction of a person’s internal needs favors long-term changes in that person’s behavior (Ryan and Deci, 2000b). By contrast, extrinsic motivations encourage short-term behaviors, which means that a person will discontinue a specific behavior in the absence of external pressure, such as rewards (Nicolau et al., 2022; Rigby and Ryan, 2018; Ryan and Deci, 2000a). Over the years, SDT has proven to be effective in explaining a wide range of human behaviors, including technology adoption and sustainable behaviors (Ryan and Deci, 2022; Wang et al., 2024). Notably, SDT has shown accuracy in predicting surplus food platform acceptance among consumers (Cassia and Magno, 2024).

### 2.3. Hypotheses

Perceived ease of use, defined as the freedom from efforts and costs of using a technology such as a platform (Amaral and Orsato, 2023), plays a primary role in explaining and predicting technology continuance intention, as confirmed by extensive evidence (Yan et al., 2021). Firms are often unwilling to embrace green innovations because of their complexity, which implies additional costs (Paulraj et al., 2017). Restaurant managers are often hesitant to use digital services because of the perceived technological effort required (Vo-Thanh et al., 2022). In the foodservice industry, firms’ intentions to use anti-food waste innovations are weakened by the expected time required to integrate these innovations into daily business activities (Martin-Rios et al., 2018). The negative impact of perceived complexity and the need for easy-to-use digital services have been highlighted in relation to surplus food platforms (Amaral and Orsato, 2023). Specifically, restaurants may be discouraged by the perception of the time required to post offerings on the platforms (Mullick et al., 2021). Consistent with several previous applications of the TAM (e.g., Kulviwat et al., 2007; Lim and Zhang, 2022) and meta-analyses of other established motivation theories (e.g., Sheppard et al., 1988), we suggest that attitude acts as a mediator. In other words, perceived antecedents shape people’s attitudes and, in turn, their behaviors. Therefore, we hypothesized the following:

**H1a.** Perceived ease of use positively influences continuance intention.

**H1b.** The relationship between perceived ease of use and continuance intention is fully mediated by attitude.

Both the SDT and TAM support the argument that a person is motivated to adopt and use a certain technology when it is instrumental in achieving some kind of external advantage or reward. SDT labels this construct as “*extrinsic motivation*” (Deci and Ryan, 1985), while TAM indicates it as “*perceived usefulness*” (Davis, 1989). Nonetheless, when comparing TAM with other models of user acceptance of technology, Davis and colleagues (Davis et al., 1992) treat perceived usefulness as synonymous with extrinsic motivation and explain that “*extrinsic motivation is operationalized using the same items as perceived usefulness from TAM*” (Venkatesh et al., 2003, p. 448). Hence, in our study, we considered perceived usefulness to overlap with extrinsic motivation. Specifically, consistent with previous studies on restaurants’ green and anti-food waste behaviors (Amaral and Orsato, 2023; Baloglu et al., 2022; Filimonau et al., 2022), extrinsic motivation is defined as the economic benefits that a restaurant can gain from using surplus food platforms. Bui and Filimonau’s (2021) literature review of the triple bottom line of the sustainability of commercial foodservices reported that most businesses engage in anti-food waste initiatives for economic

reasons. Similarly, Baloglu et al. (2022) found that cost reduction and financial benefits from increased customer satisfaction were the most important motivations for restaurants’ green behavior. The fundamental role of economic motivation has consistently emerged from research on food waste conducted among foodservice business managers (Martin-Rios et al., 2018). Anti-food waste practices can help foodservice businesses reduce the costs of excess prepared food because of the impossibility of accurately forecasting food demand levels (Shroff et al., 2022). Filimonau et al. (2022) noted that foodservice businesses’ intention to reduce food waste is driven by the expectation of increasing their competitive advantage and economic performance. In addition to the immediate economic benefits related to cost savings, restaurants aim to achieve long-term economic benefits from reputational gains (Cho and Yoo, 2021). Generally, economic motivations are the main motivations for business users to participate in surplus food platforms (Amaral and Orsato, 2023). Moreover, restaurants’ decisions to use new technologies are primarily driven by expectations of tangible benefits such as increased efficiency and higher financial performance, together with brand image gains (Vo-Thanh et al., 2022). Therefore, recalling the mediating role of attitude, as explained above, we hypothesize the following:

**H2a.** Economic motivation positively influences continuance intention.

**H2b.** The relationship between economic motivation and continuance intention is fully mediated by attitude.

Firms are motivated to adopt green behaviors not only by instrumental motives but also by the intrinsic belief that they are “the right thing to do” (Paulraj et al., 2017). Specifically, consistent with previous research, we conceptualized environmental motivation as the intrinsic benefits related to the moral concern for the environment that a restaurant can achieve from using surplus food platforms (Karatepe et al., 2021; Sharma et al., 2022). The sense of purpose internalized by an organization acts as an intrinsic motivation to drive the pursuit of environmental sustainability goals (Karatepe et al., 2021). Restaurant ethical standards have a positive impact on green passion within an organization and, in turn, on the adoption of pro-environmental behaviors (Cho and Yoo, 2021). Baloglu et al. (2022) found that willingness to mitigate environmental impacts is highly important (albeit less important than economic benefits) in explaining restaurant managers’ motivations to introduce green practices. Similarly, Shin and Cho (2023) reported a significant relationship between restaurant managers’ environmental cognition and green practice adoption. When environmental awareness is not interiorized, foodservice managers experience environmental apathy, which has negative effects on their attitudes toward mitigating food waste (Filimonau et al., 2022). Hence, food waste reduction is an economic and ethical challenge for restaurants (Obuobi et al., 2022; Sharma et al., 2022). Moreover, intrinsic motivation is fundamental in explaining a person’s sustained motivation to engage in a certain behavior (Ryan and Deci, 2000a). The belief in a “*moral duty*” to protect the environment drives persistence in green behaviors (Paulraj et al., 2017; Talwar et al., 2022). Specifically, previous research suggests that reasons beyond economic benefits, such as reducing environmental impacts, are the basis of firms’ continued commitment to surplus food platforms (Amaral and Orsato, 2023). Hence, there is substantial evidence to hypothesize that environmental motivation has a positive impact on restaurants’ continued use of surplus food platforms. Therefore, considering the mediating role of attitude, we hypothesize the following:

**H3a.** Environmental motivation positively influences continuance intention.

**H3b.** The relationship between environmental motivation and continuance intention is fully mediated by attitude.

NCA assumes that if a certain factor X is necessary for an outcome Y,

then X must be present to have Y, meaning that Y will be absent if X is absent, and X will be present if Y is present (Dul et al., 2023; Richter and Hauff, 2022). Therefore, environmental motivation, economic motivation, and perceived ease of use are necessary conditions if they are required to have continuance intention. In addition, the lack of a necessary factor cannot be alleviated by other factors (Richter and Hauff, 2022). Research has examined the TAM and some of its extensions using necessity logic and concluded that usefulness, ease of use, and intrinsic motivation (labeled as emotional value) are necessary conditions for technology adoption intention and use (Richter et al., 2020, 2023). However, existing research has not specifically assessed whether environmental motivation, economic motivation, and perceived ease of use are must-have factors or merely should-have factors for restaurants' continuance intention of green innovations in general or surplus food platforms in particular. Nonetheless, there is evidence that economic and environmental motives are required for consumers' continued use of surplus food platforms (Cassia and Magno, 2024). In the broader context of technologies supporting more sustainable uses of resources, Leong et al. (2024) found that perceived usefulness and perceived ease of use were must-have factors for the adoption of sharing economy mobile applications. Moreover, these insights are further supported by studies suggesting that utilitarian and intrinsic benefits are needed for the adoption and continuation of pro-environmental behaviors (Mazzucchelli et al., 2021; Onel and Mukherjee, 2017). Research on firms' green initiatives supports the argument that expected positive economic returns (i.e., economic motivations) are necessary for their continued implementation of those initiatives (Amaral and Orsato, 2023). Other studies (e.g., Paulraj et al., 2017) argue that green initiatives are pursued over time by firms only if they are moved by moral motivations (i.e., environmental motivations). Given the absence of detailed empirical evidence on the necessity of the antecedents considered in our model, we hypothesized that they are all necessary conditions for continuance intention.

**H4.** Perceived ease of use is a necessary condition for continuance intention.

**H5.** Economic motivation is a necessary condition for continuance intention.

**H6.** Environmental motivation is a necessary condition for continuance intention.

The proposed conceptual model and the suggested hypotheses are shown in Fig. 1.

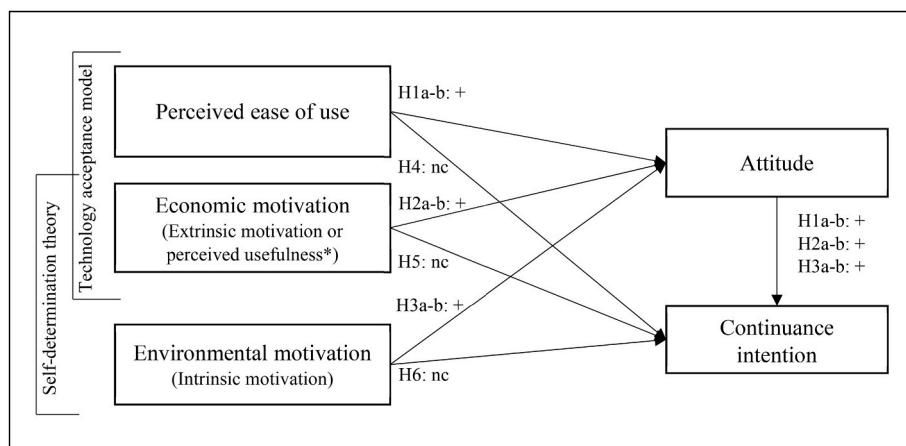
### 3. Methods

#### 3.1. Context and data collection

This study adopted a cross-sectional design and collected data from a sample of Italian restaurants using Too Good To Go, a leading digital platform against food waste (Cane and Parra, 2020; Vo-Thanh et al., 2021). Too Good To Go is a B Corp that gives restaurants and other retailers the opportunity to sell their perishable surplus food to customers in the neighborhood at the end of the day. Restaurants post what are called "surprise bags" on the platform, and customers can purchase them at one-third of the original price and collect them at a specific pickup time (<https://www.toogoodtogo.com/en-gb/user>). According to Too Good To Go, the platform has more than "75 million registered users and 134,000 active business partners across 17 countries," including Italy (Too Good To Go, 2023).

To compile a list of restaurants in Italy that actively use this platform, we employed the following procedure. We downloaded the Too Good To Go app and for 12 consecutive weeks in Spring (2023), rotating weekdays and times of day, we consulted all available surprise bags from all types of restaurants, including pizzerias, in 30 of the largest Italian cities. This manual approach was necessary to collect data, as the app only shows user bags available within a radius of 30 km from the location entered by the user. For each restaurant identified through this procedure, we looked for contact details, that is, either an email address found on the restaurant's website (when available) or a Facebook account. This process returned 468 restaurants. Each restaurant was then sent an email or message with an overview of our research and an invitation to complete an online questionnaire. Two reminders were sent to each restaurant one and two weeks after the original invitation.

This procedure yielded 222 completed questionnaires, of which 8 were discarded because of suspicious response patterns (Hair et al., 2022), resulting in a final sample of 214 restaurants. According to Kock and Hadaya's (2018) inverse square root method for evaluating the sample size in PLS-SEM, our sample exceeded the requirement to detect path coefficients of 0.11 or higher (significance level: 5%; statistical power: 80%). Moreover, even if comprehensive statistics on the population of Italian restaurants using Too Good To Go are not available, the procedure followed to compile the sampling list and the significant response rate (45.72%) suggest that the final sample accurately reflects the entire population. The questionnaires contained no missing data because responses were mandatory for all questions. The responses from restaurants that completed the questionnaire after receiving the reminders were compared with early responses along with several variables, and no statistically significant differences emerged (Armstrong



**Fig. 1.** Research model and hypotheses.

\* TAM includes the construct "perceived usefulness," while SDT includes the construct "extrinsic motivation." However, technology adoption research usually considers "perceived usefulness" as synonymous with "extrinsic motivation" (see for example Davis et al., 1992).

and Overton, 1977).

### 3.2. Scales and data analysis

Multi-item scales were used to measure the model’s latent constructs, drawing on existing instruments and making minor adaptations to better fit the context of this study. Consistent with the original scales used in this study, all the constructs were specified as reflective. Environmental and economic motivations were measured using four items based on Paulraj et al. (2017). Four items from Venkatesh and Davis (2000) were used to measure the perceived ease of use. Attitudes were assessed on the basis of three items from Venkatesh et al. (2003). Continuance intention was measured using two items developed by Bhattacherjee (2001). Respondents indicated their level of disagreement or agreement with each item on a seven-point Likert scale. Table 1 presents the items and their descriptive statistics. All values of kurtosis and skewness were between -2 and 2, with only one item with a slightly higher kurtosis (2.024), indicating a normal distribution for all items (Hair et al., 2022).

The data analysis relied on the combined application of PLS-SEM and NCA (Richter et al., 2020) and predictive model comparisons (Hair et al., 2022). PLS-SEM was selected because of its ability to evaluate both the explanatory and predictive power of the proposed model (Sarstedt et al., 2023). We used a maximum number of iterations of 3,

000, a stop criterion of  $10^{-7}$ , and the path weighting scheme as the settings to execute the PLS-SEM algorithm. In addition, bootstrapping with 10,000 subsamples was performed to evaluate the significance of the structural model relationships using percentile bootstrapping to build confidence intervals (Sarstedt et al., 2023). Moreover, we used the cross-validated predictive ability test (CVPAT) with ten folds and ten repetitions to analyze our model’s out-of-sample predictive accuracy for continuance intention (Sharma et al., 2023). The PLS-SEM model assessment is based on sufficiency, or additive logic. It clarifies the extent to which higher levels of predictors result in higher levels of the outcome (Richter and Hauff, 2022). By contrast, NCA is rooted in necessity logic and determines whether the studied antecedents act as necessary conditions or bottlenecks for the outcome (Dul, 2022; Richter and Hauff, 2022). The NCA was executed using unstandardized latent variable scores extracted from the PLS-SEM results. We selected the ceiling regression-free disposal hull (CR-FDH) line because the data were continuous (Richter et al., 2023). The necessity of the antecedents was assessed based on the effect sizes and their significance using NCA’s approximate permutation test with 10,000 permutations and a significance level of 0.05 (Dul, 2020). Before running the NCA, an outlier analysis was performed using NCA software 3.3.3, following the guidelines outlined by Dul (2021). The findings highlighted a few outliers for perceived ease of use (Fig. 2), economic motivation (Fig. 3), and

**Table 1**  
Items, descriptive statistics, and outer loadings.

Construct	Item	Mean <sup>a</sup>	Std. dev.	Kurtosis	Skewness	Outer loading	Cronbach's alpha	Rho_A	Composite reliability	Average variance extracted (AVE)
<b>Perceived ease of use (Venkatesh and Davis, 2000)</b>	Our interaction with the Too Good To Go platform is clear and understandable	4.271	1.630	-0.769	-0.092	0.789	0.728	0.734	0.830	0.551
	Interacting with the Too Good To Go platform does not require a lot of time	4.206	1.645	-0.856	-0.048	0.791				
	We find the Too Good To Go platform to be easy to use	3.841	1.786	-0.875	0.146	0.722				
	We find it easy to post and sell surprise bags on the Too Good To Go platform	5.897	1.456	1.558	-1.439	0.659				
<b>Economic motivation (Paulraj et al., 2017)</b>	We engage in the Too Good To Go platform ...						0.768	0.775	0.852	0.590
	To increase revenues and reduce costs	5.724	1.269	1.783	-1.195	0.722				
	For short-term profitability	4.495	1.693	-0.589	-0.353	0.728				
	To improve long-term profitability	5.327	1.490	0.820	-0.976	0.839				
<b>Environmental motivation (Paulraj et al., 2017)</b>	To gain positive publicity	4.397	1.758	-0.755	-0.210	0.778	0.919	0.931	0.943	0.805
	We engage in the Too Good To Go platform ...									
	Because we feel responsibility to the environment	5.346	1.604	-0.034	-0.810	0.862				
	Because of genuine concern for the environment	5.734	1.456	1.185	-1.265	0.923				
	Because we feel that saving the environment is a mission for us	5.664	1.434	1.117	-1.204	0.901				
<b>Attitude (Venkatesh et al., 2003)</b>	Because it is the right thing to do	5.364	1.564	0.259	-0.894	0.902				
	Using the Too Good To Go platform is a good idea	5.645	1.306	1.577	-1.182	0.908	0.892	0.894	0.933	0.823
	Using the Too Good To Go platform is interesting	5.364	1.404	-0.009	-0.741	0.893				
	We like working with the Too Good To Go platform	5.822	1.352	2.024	-1.478	0.919				
<b>Continuance intention (Bhattacherjee, 2001)</b>	We intend to continue using the Too Good To Go platform rather than discontinue its use	5.107	1.706	0.031	-0.863	0.970	0.938	0.938	0.970	0.942
	Our intentions are to continue using the Too Good To Go platform than use any alternative means	5.271	1.705	0.300	-1.001	0.971				

<sup>a</sup> For all items: seven-point Likert scale (1 = completely disagree; 7 = completely agree); observed minimum = 1 and observed maximum = 7.

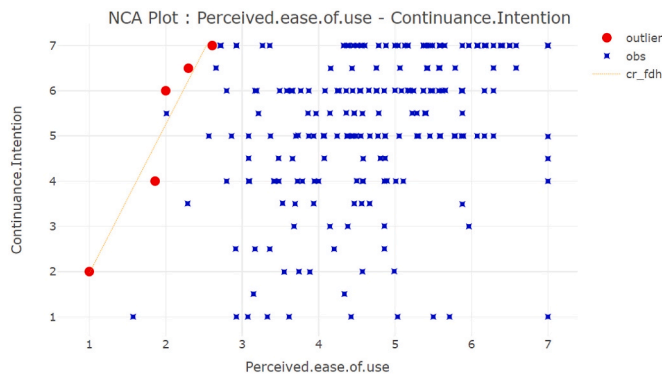


Fig. 2. Outlier analysis for perceived ease of use (CR-FDH).

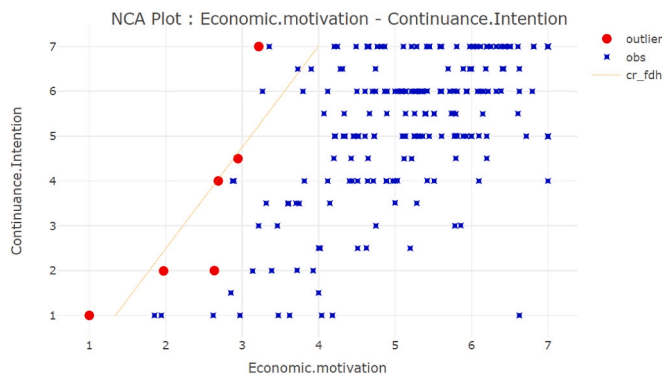


Fig. 3. Outlier analysis for economic motivation (CR-FDH).

environmental motivation (Fig. 4). These outliers affected the extension of the ceiling zone and/or slope, thus strengthening or mitigating the effect sizes, as listed in Table 2. After careful examination, we concluded that these outliers were not related to sampling or measurement issues and were retained in the analysis (Dul, 2021).

Finally, for model comparisons, we applied the following selection criteria: CVPAT (Sharma et al., 2023), Bayesian information criterion (BIC, Sharma et al., 2021), and Akaike weights (Rigdon et al., 2023). Among these criteria, we gave priority to the CVPAT because our study focused on prediction-oriented model comparisons (Hair et al., 2022). Data were analyzed using SmartPLS 4 (Ringle et al., 2022).

## 4. Findings

### 4.1. Measurement model evaluation

The latent variables' measurement models were examined following

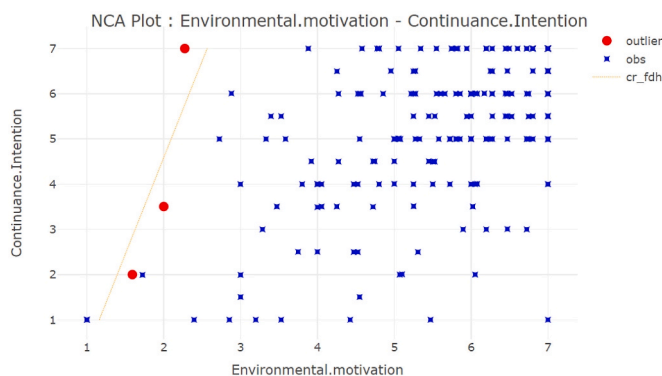


Fig. 4. Outlier analysis for environmental motivation (CR-FDH).

the appropriate criteria for reflective models (Hair et al., 2019). As reported in Table 1, the outer loadings were larger than the suggested minimum level of 0.708 (except for one outer loading of 0.659), thereby proving indicator reliability (Hair et al., 2022). Moreover, all constructs showed Cronbach's alpha, composite reliability  $\rho_c$ , and consistent reliability coefficient  $\rho_A$  greater than 0.70 (Hair et al., 2022), as reported in Table 1. The table also shows that the average variance extracted (AVE) for each construct was higher than 0.50, confirming convergent validity (Sarstedt et al., 2019). Discriminant validity was analyzed through heterotrait–monotrait (HTMT) ratios of correlations, which should not exceed 0.90 (Ringle et al., 2023). Table 3 indicates that all HTMT values were below 0.90, and the upper bounds of the 95% bootstrap confidence interval (one-sided) were within the 0.90 threshold, with only one value slightly higher than 0.90. Therefore, we concluded that discriminant validity had been established (Sarstedt et al., 2023).

### 4.2. Structural model evaluation and NCA

The structural model evaluation followed the established procedures in PLS-SEM (Hair et al., 2022). First, inspection of the variance inflation factor values showed that none exceeded the maximum acceptable level of three, confirming that collinearity had no substantial effect on the structural model estimates (Sarstedt et al., 2023). Then, we analyzed the path coefficients (Table 4). The estimations indicated that perceived ease of use, economic motivation, and environmental motivation had positive effects on continuance intention and that these effects were fully mediated by attitude, thereby supporting H1a-b, H2a-b, and H3a-b. The next step involved examining the explanatory power of the model. The coefficients of determination ( $R^2$ ) were 0.623 for attitude and 0.576 for continuance intention, the main target construct.

To assess the predictive power of the model, we used the PLS<sub>predict</sub> algorithm (Sharma et al., 2021) and CVPAT (Lienggaard et al., 2021). Analysis of both the target construct (continuance intention) and the overall model revealed predictive validity. For both the continuance intention and the overall model, the PLS-SEM predictions showed a significantly lower average loss than the naïve indicator-average prediction benchmark (Table 5). They also highlighted a lower average loss compared with the linear model prediction benchmark, although this difference was not statistically significant.

NCA was executed by extracting construct scores from the PLS-SEM estimations (Table 6). Analysis using CR-FDH (Table 7) revealed high levels of accuracy, calculated as the number of cases on or below the ceiling line divided by the total number of cases, well beyond a benchmark of 95% (Dul, 2020; Richter et al., 2023). The effect sizes  $d$  for perceived ease of use, economic motivation, and environmental motivation were all significant and above 0.1, which is the minimum level suggested for detecting relevant necessary conditions (Dul, 2021). According to Dul's (2016) guidelines, the magnitude of all these effects could be described as medium since they are in the 0.1–0.3 range.

The bottleneck table for continuance intention shows the levels of the conditions required for a specific level of the outcome (Table 8). We adopted the 75th percentile as the criterion for identifying high levels of continuance intention (Richter et al., 2021). To achieve high levels of continuance intention, perceived ease of use, economic motivation, and environmental motivation should achieve minimum levels of 2.075, 3.331, and 2.214, respectively, on a seven-point scale. Therefore, even if perceived ease of use and environmental motivation are significant necessary conditions (Table 7), they only need to reach low levels (slightly above two on a seven-point scale) to achieve high continuance intention.

### 4.3. Model comparisons

In the model comparison analysis, we compared our proposed model with two alternative models based on the original TAM (Davis, 1986) and a version of the TAM with attitude as a full mediator. The original

**Table 2**  
Analysis of outliers (CR-FDH).

Variables	Outliers	Original effect size	New effect size <sup>a</sup>	Absolute difference <sup>b</sup>	Relative difference <sup>b</sup>	Ceiling zone outlier	Scope outlier
Perceived ease of use–continuance intention	213	0.11	0.06	−0.04	−39.4	•	•
	130	0.11	0.10	−0.01	−8.3	•	
	146	0.11	0.11	0.00	4.2	•	
	80	0.11	0.11	0.00	4.1	•	
	69	0.11	0.11	0.00	2.4	•	
Economic motivation–continuance intention	125	0.28	0.17	−0.11	−40.0	•	•
	213	0.28	0.25	−0.03	−10.8	•	
	88	0.28	0.28	0.01	2.3	•	
	6	0.28	0.27	−0.01	−2.0	•	
	80	0.28	0.27	0.00	−1.5	•	
Environmental motivation–continuance intention	186	0.28	0.28	0.00	−0.9	•	
	150	0.14	0.22	0.07	51.7	•	
	16	0.14	0.13	−0.02	−11.7	•	
	213	0.14	0.15	0.01	4.3	•	

<sup>a</sup> After outlier removal.

<sup>b</sup> Difference between the effects with and without the outlier.

**Table 3**  
Discriminant validity (HTMT values).

	1	2	3	4	5
<b>1. Perceived ease of use</b>	–				
<b>2. Economic motivation</b>	0.364 [0.233; 0.536]	–			
<b>3. Environmental motivation</b>	0.318 [0.203; 0.460]	0.803 [0.723; 0.871]	–		
<b>4. Attitude</b>	0.445 [0.287; 0.603]	0.870 [0.802; 0.928]	0.768 [0.678; 0.841]	–	
<b>5. Continuance intention</b>	0.369 [0.226; 0.509]	0.689 [0.576; 0.783]	0.627 [0.517; 0.723]	0.829 [0.740; 0.900]	–

TAM included a direct effect from perceived usefulness to intention because “if affect is not fully activated when deciding whether to use a particular system, one’s attitude would not be expected to completely capture the impact of performance considerations on one’s intention” (Davis et al., 1989, p. 986). Thus, attitude was modeled as a partial mediator. However, findings on the significance of this direct effect have been mixed, so TAM without this effect (that is, modeling attitude as a full mediator) is well established in the literature (Marangunić and Granić, 2015).

To execute model comparisons, we evaluated the values for the BIC (Sharma et al., 2021) and Akaike weights (Rigdon et al., 2023). For predictive model comparisons, we first assessed that all models met all relevant measurement and structural assessment criteria (Hair et al., 2019) and performed better (i.e., had a lower average loss) than the IA benchmark (Sharma et al., 2023). We then compared the models for predictive accuracy of the target construct continuance intention (using  $CVPAT_{compare}^{construct}$ ). The outcomes of the comparison between the proposed model and the alternative model based on the original TAM (M1 and M2, respectively) are summarized in Table 9 and indicate that all the criteria favor M1. The results of the comparison between the proposed model and the alternative model based on the TAM with full mediation (M1 and M3, respectively) also favor M1 (Table 10). In this case, while the relative likelihoods of M1 and M3 were very similar (51.0% and 49.0%, respectively), CVPAT clearly favored M1. Given that this study focuses on a prediction-oriented model comparison, we concluded that M1 was to be preferred to M2 and M3.

**Table 4**  
Structural model estimates.

Effects	Path coefficient	p-value	95% two-tailed confidence intervals	f <sup>2</sup> effect size
Perceived ease of use → Attitude	0.138	0.003**	[0.058; 0.240]	0.046
Perceived ease of use → Continuance intention	0.038	0.469	[-0.06; 0.148]	0.003
Economic motivation → Attitude	0.437	0.000**	[0.317; 0.552]	0.266
Economic motivation → Continuance intention	0.045	0.581	[-0.106; 0.21]	0.002
Environmental motivation → Attitude	0.368	0.000**	[0.230; 0.491]	0.191
Environmental motivation → Continuance intention	0.092	0.174	[-0.038; 0.227]	0.009
Attitude → Continuance intention	0.647	0.000**	[0.450; 0.813]	0.374
<b>Specific indirect effects</b>				
Perceived ease of use → Attitude → Continuance intention	0.089	0.004**	[0.037; 0.159]	
Economic motivation → Attitude → Continuance intention	0.283	0.000**	[0.169; 0.402]	
Environmental motivation → Attitude → Continuance intention	0.238	0.000**	[0.133; 0.345]	
<b>Total effects</b>				
Perceived ease of use → Continuance intention	0.128	0.029*	[0.022; 0.251]	
Economic motivation → Continuance intention	0.327	0.000**	[0.171; 0.476]	
Environmental motivation → Continuance intention	0.330	0.000**	[0.164; 0.484]	

\*p < 0.05; \*\*p < 0.01.

**Table 5**  
Predictive model evaluation: CVPAT.

Benchmark <sup>a</sup>	Level of analysis	Average loss difference	p-value
$CVPAT_{benchmark\_IA}^{construct}$	Continuance intention	−1.114	0.000
$CVPAT_{benchmark\_IA}^{overall}$	Overall model	−1.000	0.000
$CVPAT_{benchmark\_LM}^{construct}$	Continuance intention	−0.094	0.251
$CVPAT_{benchmark\_LM}^{overall}$	Overall model	−0.036	0.415

<sup>a</sup> IA = indicator–average; LM = linear model.

**Table 6**  
Construct scores (PLS-SEM estimations).

Construct	Mean value	Std. dev.	Obs. Min.	Obs. Max.
Perceived ease of use	4.636	1.181	1.000	7.000
Economic motivation	5.110	1.163	1.000	7.000
Environmental motivation	5.537	1.357	1.000	7.000
Attitude	5.620	1.227	1.000	7.000
Continuance intention	5.190	1.655	1.000	7.000

**Table 7**  
Results of NCA for the outcome “continuance intention”.

Construct	Effect size (CR-FDH)	Accuracy	p-value
Perceived ease of use	0.107	98.131	0.009
Economic motivation	0.278	97.664	0.000
Environmental motivation	0.144	98.131	0.000
Attitude <sup>a</sup>	0.389	97.664	0.000

<sup>a</sup> While the focus was on perceived ease of use, economic motivation, and environmental motivation, attitude was added to ensure completeness.

## 5. Implications and conclusions

### 5.1. Discussion of the results

The use of PLS-SEM and its advanced tools shed light on the accuracy of the proposed model in predicting restaurants’ continuance intention of surplus food platforms. The model comparisons showed that while the proposed model, alternative model based on the original TAM, and alternative model based on TAM’s later versions all had predictive validity, the proposed model had a significantly lower prediction error. Based on our prediction-oriented model comparisons using the CVPAT, we concluded that our model was superior to alternative TAM-based models in terms of predictive accuracy.

In addition, the combined use of PLS-SEM and NCA enabled an in-depth examination of the three exogenous constructs—perceived ease of use, economic motivation, and environmental motivation—as should-have and must-have factors. The PLS-SEM results confirm that the three constructs are significant determinants of continuance intention, with attitude as a mediator. Therefore, an increase in each of these three constructs increases the continuance intention. In addition, the NCA results indicate that the three constructs are significant and necessary conditions for continuance intention. However, examination of the bottleneck tables showed that high continuance intention was attained, notwithstanding relatively low levels of perceived ease of use and environmental motivation.

### 5.2. Theoretical implications

The results of this study make several contributions to the extant

**Table 8**  
Bottleneck table for continuance intention.

Continuance intention (percentile)	Continuance intention (values)	Perceived ease of use	Economic motivation	Environmental motivation	Attitude
0.00%	1.0	NN <sup>a</sup>	1.342	1.16	1.249
10.00%	1.6	NN <sup>a</sup>	1.607	1.301	1.666
20.00%	2.2	1.072	1.873	1.441	2.082
30.00%	2.8	1.254	2.138	1.582	2.499
40.00%	3.4	1.437	2.403	1.722	2.916
50.00%	4.0	1.619	2.668	1.863	3.332
60.00%	4.6	1.801	2.934	2.003	3.749
70.00%	5.2	1.984	3.199	2.144	4.166
75.00%	5.5	2.075	3.331	2.214	4.374
80.00%	5.8	2.166	3.464	2.284	4.582
90.00%	6.4	2.349	3.729	2.425	4.999
100.00%	7.0	2.531	3.994	2.565	5.416

<sup>a</sup> NN = Not necessary.

literature. By addressing the prediction of the continuance intention of surplus food platforms, this study fills two major gaps. First, previous studies have focused on explanations but not on the prediction of these behaviors (e.g., Filimonau et al., 2022). The application of the PLS-SEM toolbox enabled us to perform a causal-predictive assessment of the model (Hair et al., 2022; Sarstedt et al., 2023) and draw well-substantiated conclusions regarding the accuracy of the model in predicting restaurants’ continuance intention. Second, our analysis focused on the continuance intention of surplus food platforms, which is of paramount importance, as behaviors to reduce food waste need to be continued over time to generate substantial results (Mullick et al., 2021). Therefore, our study complements previous knowledge, which was largely limited to the adoption stage and cross-sectional descriptions of these behaviors (Baloglu et al., 2022). Previous studies were not useful in understanding the discontinuance of food surplus platforms, which was highlighted in recent research (Mazzucchelli et al., 2021).

Regarding the antecedents of restaurants’ continuance intention for surplus food platforms, this study provides additional theoretical contributions by integrating the TAM with SDT. TAM is a general model of technology use based solely on extrinsic factors (perceived ease of use and usefulness). Hence, it overlooks the intrinsic moral motivation to contribute to environmental sustainability, which is increasingly central to foodservice businesses (Sharma et al., 2022). The findings of this study confirm that, by acknowledging intrinsic (environmental) motivation as an antecedent, our model achieves a higher predictive accuracy than TAM-based alternative models for the continuance intention of surplus food platforms. Moreover, through the combined use of PLS-SEM and NCA (Richter et al., 2023), our analysis provides evidence that, similar to extrinsic motivation, intrinsic motivation is both a significant determinant and a necessary condition for continuance intention. Finally, the integration of the TAM with SDT proposed in our study may prove valuable in predicting other responsible behaviors and innovation implementation beyond the use of surplus food platforms (Le Bot et al., 2022; Qi et al., 2022; Saari et al., 2024).

### 5.3. Methodological implications

This study applied the PLS-SEM toolbox to execute prediction-oriented model evaluation (Hair et al., 2022, 2024). Specifically, we illustrated how the CVPAT can be applied to assess the predictive accuracy of the proposed model and compare it with alternative models. Regarding model comparisons, consistent with Hair et al. (2022), we suggest that the information provided by CVPAT (i.e., the statistical significance of the average loss difference between the two models) should guide model selection when the main focus is on prediction. For example, when we compared M1 and M3, the BIC and Akaike weights did not clearly favor one model over the other (e.g., Akaike weights were 51.0% and 49.0%, respectively). In this case, the CVPAT provided strong evidence of the better predictive accuracy of M1, which was then



**Table 9**

Model comparison: M1 versus M2<sup>a</sup> for the target construct “continuance intention”.

Model	Path model	BIC	Akaike weights	CVPAT
M1 <sup>a</sup>		-173.732	0.875	Average loss difference (M1 – M2): 0.807 p < 0.001
M2 <sup>a</sup>		-169.841	0.125	

<sup>a</sup> M1 = model proposed in this study; M2 = alternative model based on the original TAM with partial mediation. In M1, the effects of the exogenous variables were fully mediated by attitude; thus, there were no direct effects of the exogenous variables on continuance intention.

**Table 10**

Model comparison: M1 versus M3<sup>a</sup> for the target construct “continuance intention”.

Model	Path model	BIC	Akaike weights	CVPAT
M1 <sup>a</sup>		-173.732	0.510	Average loss difference (M1 – M2): 0.807 p < 0.001
M3 <sup>a</sup>		-173.653	0.490	

<sup>a</sup> M1 = model proposed in this study; M3 = alternative model based on the TAM with full mediation. In M1, the effects of the exogenous variables were fully mediated by attitude; thus, there were no direct effects of the exogenous variables on continuance intention.

preferred.

The combined application of PLS-SEM and NCA enabled a detailed analysis of the proposed antecedents as should-have and must-have factors. We suggest that NCA is useful in cases where the focus of the study is to integrate an established model (such as the TAM) with new antecedents. The joint evaluation of PLS-SEM and NCA results can provide a nuanced understanding of newly added antecedents as both should-have and must-have factors. However, consistent with recent studies (Dul et al., 2023; Hauff et al., 2024; Richter et al., 2023), we recommend an in-depth interpretation of NCA outcomes. In particular, bottleneck tables may indicate that for some necessary antecedents, even if their effects are statistically significant, low levels are sufficient to have the outcomes, as in the case of environmental motivation in this study. The interpretation of these findings should properly reflect the actual relevance of the assessed conditions.

#### 5.4. Managerial implications

The findings provide actionable insights for platform owners to keep restaurants committed to using surplus food platforms over time. Restaurants are driven by economic and environmental motivations, as well as perceived ease of use. Therefore, platforms should be designed to emphasize the economic benefits that restaurants can gain from their continued use. For example, the availability of updated metrics reflecting the positive impacts on the restaurant's margins may keep restaurateurs committed to using the platform. Platforms should also appeal to environmental motivation, emphasizing that restaurants can reduce the environmental impact of food waste by continuously using the platform. Finally, platforms should be easy to use, meaning that managing sales through them should require little time and effort and should be easy to integrate into restaurants' daily routines.

Platform owners may increase restaurants' continuance intentions by investing in each of the three aforementioned factors: economic motivation, environmental motivation, and perceived ease of use. However, the findings of this study indicate that economic motivation has the highest effect on continuance intention and needs to reach a higher level than the other two factors to result in high continuance intention. Therefore, guaranteeing economic benefits to restaurants that use these platforms should be a priority for platform owners.

#### 5.5. Limitations and future research

The results presented in this study are based on a limited sample of restaurants in Italy that use only one specific food surplus platform, Too Good To Go. Further research is recommended to replicate our work in other contexts and better understand the generalizability of our findings (Adler et al., 2023). Moreover, looking beyond food waste management, the model suggested in this study can be used to evaluate the continuance intention of other green and sustainable behaviors. In addition, this study strongly emphasized the benefits that the application of recent PLS-SEM methodological advancements can offer in terms of predicting outcomes but did not specifically focus on heterogeneity in data structures. Future research could address this weakness by performing moderator or multigroup analyses considering variables such as restaurant managers' predispositions to green behaviors (Arruda Filho and Brito, 2017). Finally, further research could enrich our analysis by applying several PLS-SEM extensions, ranging from importance-performance map analysis (IPMA, Hair et al., 2024; Ringle and Sarstedt, 2016) and combined importance-performance map analysis (cIPMA, Hauff et al., 2024) to the combination of PLS-SEM with machine learning algorithms (Richter and Tudoran, 2024).

#### CRedit authorship contribution statement

**Francesca Magno:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Formal analysis, Data

curation, Conceptualization. **Fabio Cassia:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization.

#### Declaration of competing interest

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

Data will be made available on request.

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