



Saving food surplus and developing new business models: Exploring the potential of 'Too Good To Go' at territorial level using web-scraped data

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ABSTRACT

Food surplus, fit for consumption, is often excluded from the consumption loop for commercial reasons, leading to wasted food, nutrients, resources, and costs. Digital innovations with diverse business models aim to combat this through food redistribution. However, it is critical to assess their effectiveness from stakeholder and consumer perspectives, meanwhile, new research focuses on the value of these business models.

This study employs web scraping technology to collect multi-dimensional data from two Italian cities on *Too Good To Go*. The analysis results confirm its positive contribution to food surplus redistribution with economic benefits, despite a weaker presence of certain food establishment types and a lack of social motivation among consumers. Furthermore, strong business-customer relationships can be established when businesses commit to reducing food waste and effectively communicate with their customers using the platform.

1. Introduction

In Europe, 42 % of food produced is wasted at the consumption stage [35]. Reducing consumer food waste (FW) and promoting sustainable consumption are pivotal to achieving a sustainable food system, as outlined by the United Nations Sustainable Development Goals (SDGs). To tackle these challenges, extensive research has been conducted on consumer food waste, particularly focusing on the quantification of FW and the identification of consumer waste behaviors. Concurrently, the advent of digital technologies and the rapid development of sharing economy models have catalyzed the creation of numerous internet-based platforms, including web platforms and mobile applications, offering innovative solutions to address this issue [15,16].

Digital technologies address food waste in various forms at different stages of the food value chain. Cane and Parra [18] differentiate food surplus from food waste. Unlike food waste, which results from improper storage, processing errors, poor demand forecasting, and similar issues, surplus food products meet health and traceability standards and are fit for human consumption. However, they are often excluded from the food value chain and fail to reach consumers primarily due to commercial reasons.

Food redistribution, a core pillar of the circular economy, underpins the concept of rescuing surplus food. Traditionally, surplus food is donated to non-profit organizations such as food banks and social

supermarkets. Recent trends, driven by digital innovations, have expanded these connections to include more businesses and individuals, facilitating better management of food surplus. These innovations provide additional economic benefits, offering good bargains or free distribution.

Within the scope of business-to-individual relationships, current digital innovations operate predominantly at a local level, where surplus food often circulates between businesses and customers or among community members [15].

One important and original example of food-sharing innovations is *Too Good To Go* (TGTG), which is the main research focus of this paper. TGTG is described as a solution to "save delicious food and fight food waste" by engaging individuals, while simultaneously benefiting local businesses [34]. As a free-to-use platform, TGTG establishes a B2C marketplace for food redistribution, hence surplus food waste reduction, where surplus food is listed as meal boxes on the platform and sold at discounted prices. Case studies have been conducted to evaluate the value of TGTG as a social business, highlighting its success as evidenced by market adoption [8,10,25,32]. To our best knowledge, most of these studies adopted a conceptual or qualitative approach and primary data were collected via surveys.

A research gap exists due to the rapid changes in consumer food acquisition methods and the development of various innovations aimed at promoting sustainable food consumption, including technology-based

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solutions and new business models. The effectiveness of these innovations in mitigating food waste needs to be assessed from the perspectives of both stakeholders and consumers [5]. Comparative research is lacking, particularly in terms of understanding the unobserved heterogeneity across different countries or regions [17]. This territorial variation is crucial for the success of managerial policies and strategies. Furthermore, alternative data sources, empowered by big data technologies, may provide new insights.

This paper contributes to the existing literature by examining the effectiveness of food waste mitigation using primary data collected through web scraping technology on TGTG. In addition to quantifying the amount of food saved, the diversity of the collected data allows for an exploration of the motivations and user patterns of businesses and consumers at the territorial level. To this end, it enables performance evaluation from both business and consumer perspectives, as well as the assessment of the new business model for economic and social sustainability.

The paper is structured as follows. Firstly, [Section 2](#) presents a literature review focusing on food surplus and food-sharing models, followed by the identification of the research gap, the big data technology employed, and the contribution of this work. [Section 3](#) provides the background of the case study, TGTG, as well as a summary of recent literature regarding it. [Section 4](#) details the data collection and methodology. [Section 5](#) provides the analytical results, while [Section 6](#) extends the discussion and managerial implications. Finally, [Section 7](#) concludes with the limitations of this study and directions for future research.

2. Literature review

2.1. Food surplus – one aspect of food waste

Cane and Parra [18] sought to disentangle the concepts of food "loss," "waste," and "surplus" through a theoretical and empirical analysis of data from Spain and Italy. Surplus food, which is fit for consumption, is excluded from the consumption loop primarily for commercial reasons. Like food loss and food waste, food surplus can occur at any stage from agricultural production to food distribution phases.

In the research scope of this paper, we focus on the food surplus in the final consumption phase. Pandey et al. [29] conducted an explanatory survey in Danish canteens to examine the intentions and actions related to purchasing surplus meals. Their findings underscore the fundamental influence of social, behavioural, and personal factors on consumer decisions. Furthermore, they highlighted the significant impact of surplus food reduction, not only in terms of rescuing food and nutrients but also in recovering inputs and costs such as energy, water, land, and fertilizers.

2.2. Food-sharing – one popular mitigation for food surplus reduction

Food redistribution, which is fundamental to reducing food surplus, has been implemented through various food-sharing models. Michelini et al. [15] proposed a conceptual framework categorizing these models into "sharing for money," "sharing for charity," and "sharing for the community." While food surplus has traditionally been managed through "sharing for charity" models, such as food banks and social supermarkets, it is increasingly being incorporated into "sharing for money" (market-based and profit-driven) and "sharing for the community" (consumer-to-consumer) models, facilitated by a broader network of digital platforms.

Puram and Gurumurthy [24] provided a summary of food surplus sharing: surplus food is either donated for free or sold at significant discounts, depending on the model. Donors, such as producers, distributors, restaurants, and households, post details of their surplus food – such as near-expiry items or leftovers that are still suitable for consumption – on digital platforms. Recipients, who may be non-profit

organizations or individual consumers, then request and collect these items directly or through volunteers who handle collection and distribution.

In recent years, extensive academic research has focused on the two primary roles in food-sharing models: donors and recipients. These studies identify shared perceived values among users, such as food security, self-efficacy, environmental and social well-being, and reputational benefits [23]. However, motivations and intentions for using food-sharing platforms vary across different models and regions.

In the UK, users are primarily motivated by economic and environmental justice, which puts social pressure on consumers and businesses by the fact that food waste contributes to approximately 3 % of UK greenhouse gas emissions and costs consumers £12 billion per year, rather than social responsibility [12]. Conversely, a study of French consumers highlights the emotional value of using these platforms, such as the belief in saving the planet, alongside social values like fighting food waste and gaining a sense of social responsibility, as well as functional values like economic benefits [33]. Research in Italy shows a strong focus on the quality, quantity, and variety of products offered on food-sharing platforms, with consumers also seeking new experiences and surprises [26]. In Thailand, environmental concerns coupled with perceived playfulness are the main driving forces for consumers [22]. Among Japanese consumers, the aversion to throwing away food is widely acknowledged; however, there is no significant connection between environmental issues and food waste [4]. These findings suggest that while the overarching goal of reducing food waste is shared, the specific motivations and values driving platform usage differ significantly by region.

Academic literature on various food-sharing models with digital innovations, particularly "sharing for money" models, is relatively scarce [15]. [Table 1](#) presents a summary of literature published in the last 10 years regarding digital innovative platforms with food-sharing models. Significant attention has been given to the conceptual aspects, rather than application aspects, of food-sharing models; however, there is limited literature assessing specific types of food-sharing models adopted by the existing digital platforms. Research on the motivations and drivers of using sharing-for-community applications, such as OLIO, dominates this niche.

2.3. Research gap

According to Puram and Gurumurthy [24], the literature on food-sharing is predominantly focused on developed countries. Data sources and collection methods are mainly secondary and conducted through interviews, although both quantitative and qualitative approaches have been employed. This focus compromises the measurement of actual food waste reduction, specifically the effectiveness of food waste mitigation, as highlighted by Michelini et al. [15]. During our review of the literature on TGTG, this phenomenon becomes even more pronounced. The research appears to be predominantly at a conceptual or explanatory stage, with a primary academic focus on social business and marketing rather than the effectiveness evaluation of waste reduction. Additionally, Michelini et al. [15] identified several research gaps and future research directions for food-sharing platforms, including performance evaluation in terms of business sustainability, particularly for sharing-for-money models, assessments to bridge the gap between users' motivations and actions, the examination of opportunistic behaviors in surplus food-sharing services, and the exploration of food-sharing services in resource-constrained or less densely populated areas.

Table 1

Summary of the literature on digital innovative platforms with food-sharing models (2014–2024).

Article	Year	Country	Research target	Food-sharing model investigated	Digital application	Methodology	Key results
[7]	2019	The Netherlands	Performance evaluation	Sharing for money	Thuisafgehaald ("Picked up from home")	qualitative	A clear social element in this meal sharing platform that distinguishes it from more mainstream economic transactions.
[12]	2020	UK	Social configurations of the users	Sharing for community	OLIO	qualitative	Donor-recipient reciprocity and balance are rare, but genuinely novel social relations have formed between organizations and consumers.
[3]	2021	Italy	Drivers of usage	Sharing for community	OLIO	mixed	Consumer familiarity, perception of environmental, social responsibility, and community social support enhance consumer behavioral response on the platform.
[36]	2021	China	Drivers of usage	Sharing for money	Anonymous	experiment	Platform-level buyer protection insurance (PPI) significantly increases buyer spending and seller revenue in sharing economy.
[13]	2021	UK	User pattern	Sharing for community	OLIO	quantitative	Volunteers engaged much more in driving growth of the app.
[22]	2023	Thailand	Drivers of usage	Sharing for money	Yindii	mixed	Environmental concern and perceived playfulness are the primary construct influencing consumers' purchase intention towards food surplus (on food surplus sharing platform).
[32]	2023	UK	Performance evaluation	Sharing for community	OLIO	quantitative	Rebound effects could limit the potential to achieve meaningful reductions in environmental burdens through sharing. Rebound effects should be incorporated in environmental assessments of the digital sharing economy.
[31]	2023	UK	Performance evaluation (under pandemic)	Sharing for community	OLIO	quantitative	The growth in digital food sharing relates to lifestyle changes potentially triggered by the pandemic, rather than the rise of food insecurity in pandemic.
[9]	2024	Germany	Drivers of usage	Sharing for money	Not mentioned	mixed	Intrinsic motives (desire to explore new food) have a stronger influence than extrinsic motives (perceived economic benefits and sustainable motives).
[19]	2024	Italy	Drivers of usage, performance evaluation	Sharing for money	TGTG	quantitative (System Dynamics simulation model)	TGTG is a successful food sharing platform in terms of adoption by users, however, the performance regarding its potential to reduce food waste can still improve to a large context.

3. The case study: *Too Good To Go*

As stated by TGTG,¹ “*Too Good To Go is a certified B Corp social impact company, on a mission to inspire and empower everyone to fight food waste together*”. Founded in 2016, in Copenhagen to fight food waste, the company has achieved significant milestones in reducing food waste, saving over 300 million meals and preventing the equivalent of 810,000 tons of CO₂ emissions with 90 million registered users and 155,000 business partners across 17 countries in Europe and North America. Nowadays, the company offers various business solutions tailored to food retail (including grocery, FMCGs, and wholesale), food service, and catering sectors, focusing on managing surplus food and reducing food waste. One of the most well-known tools for reducing surplus food waste is TGTG’s B2C marketplace, where surplus food is listed as Meal Boxes (MBs) on the platform and sold at discounted prices – a win-win-win business model for people, profit and the planet.

Due to its rapid market growth and notable achievements, TGTG has garnered scholarly attention, particularly in Europe [8,10,25,32]. Table 2 provides a comparative summary of the literature on TGTG.² However, there is a significant lack of empirical data assessing actual food waste reduction while the market-based platform generates commercial value. Specifically, questions arise regarding how effectively the

platform helps businesses optimize operations and manage surplus food, and how it engages consumers.

4. Data and methodology

4.1. Web scraping technology and big data

Web scraping has increasingly been adopted as a method for extracting "big data" by institutions, academics, and businesses. It serves various functions, including providing alternative data sources, validating data and models, forecasting and "nowcasting," and measuring the effectiveness of activities and events [1,6,23]. This technique has shown its utility in price statistics, effectively overcoming challenges related to data accessibility and reliability [2,11].

Big data, defined most commonly nowadays [25] refers to the 4 Vs: Volume, Velocity, Variety, and Veracity, which summarize a large amount of data with impressive diversity and quality that increases fast and is difficult or even impossible to handle by traditional methods. Regarding TGTG, this experimental analysis was conducted based on scraping data from a single platform with a smaller geo-focus and shorter period [20], which might be less qualified for the facets of big data - velocity and variety [25]. However, data obtained through web scraping by hour captures real-time offerings and transactions on the platform, thus offering primary and authentic consumption data associated with businesses and consumers. The heterogeneity of the food offerings shows among business users. Therefore, this method holds promise for evaluating the overall performance and the effectiveness of food waste reduction initiatives.

¹ <https://www.toogoodtogo.com/>

² The literature was gathered by searching for journal articles using the keyword "Too Good To Go" on Scopus. A manual screening process was then employed to select articles relevant to the topic.

Table 2

Comparative summary of the literature on TGTG.

Year	Article	Research Location	Research Target	Theoretical Background or Conceptual Framework	Methodology	Data	Main Results
2021	[33]	Paris, France	TGTG providers and users (Restaurant manager, customer)	Technology affordance theory and Service-Dominant Logic with customer value proposition and value-in-use	Qualitative	Secondary data (TGTG Press Kit), Primary data (Semi-structured Interview)	Social, functional, and emotional values are the success factors for TGTG to accomplish its social missions (food waste and CO2 emissions reduction) and allowing the access to quality food at an affordable price.
2022	[26]	Italy	Consumer	/	Qualitative & Content analysis (FB group posts)	Primary (Survey, FB groups)	The initiative of TGTG is successful in Italy. However, users seem to place more emphasis on saving money and the quality of food than combating food waste. Trust and relationship are established via the preparation of the box and the businesses' commitment to be aligned with TGTG initiatives.
2024	[10]	/	/	/	Conceptual	/	TGTG, a market-based platform, can address the inefficiencies and shortcomings of the Coase Theorem within the realm of food waste by facilitating negotiation, reducing information asymmetries, and addressing environmental costs, however, drawbacks such as greenwashing and diverted investment on other technologies exist.
2024	[8]	Italy	Consumer	Self-determination theory	Quantitative (PLS-SEM, NCA)	Primary (Survey)	Intrinsic (green altruism, hedonic motivation) and extrinsic (utilitarian benefits) motivations were necessary for the attitudes and intentions to adopt or continue to use anti-food waste apps. However, not all intrinsic motivations were relevant necessary conditions (e.g. green altruism for non-users).

4.2. The (big) data collection process and web-scraping specifications

For this research, we set up a regular scraping program to capture data on TGTG leveraging the open-source *tgtg-python* library.³ The program took hourly snapshots, recovering information about all outlets offering MBs within 10 km from an arbitrary place in the centres of two Italian cities, Viterbo and Perugia.

The selection of Viterbo and Perugia as case studies was made in accordance with the research plan developed within the H2020 LOW-INFOOD project. Task 5.6 of the project involved the assessment of impacts and solutions for food waste in the catering and out-of-home consumption phase. Consequently, this task entailed the monitoring of restaurants, takeaways and delivery services in the two cities of Viterbo and Perugia. Furthermore, this paper assesses the dissemination, efficacy and commercial potential of TGTG app in both cities.

The data collection process run for approximately three months (November 2022 to February 2023). Following data collection, we conducted data cleaning and processing to remove inconsistencies and erroneous information.

Our dataset comprised 122,932 observations for Viterbo from 14 November 2022 to 20 January 2023 (67 days) and 155,616 observations for Perugia from 14 November 2022 to 6 January 2023 (53 days). Key information recorded at each snapshot included:

- i) whether the MB was available for sale (True or False);
- ii) number of MBs listed for sale;
- iii) cut-off time for the last ordering by each shop;
- iv) pickup starting and ending time by each shop;
- v) sold-out date and time, if applicable.

Among the variables, (ii) and (iii) are key indicators in our analysis. By lagging (ii) from each snapshot, we identified actual transactions, ranging from no sales to the maximum available MBs, indicating purchases made by TGTG consumer users. Indicator (iii) represents the sales window for each MB provided by each shop, which also reflects how early in advance these MBs are prepared for consumers. This hints at whether the MBs listed on TGTG are part of the platform's initiative to combat food surplus waste. Supplementary information included the shop category, the MB category, and the ratings of the shop and the MBs (Table 3).

4.3. Methods used

Given the characteristics of the high-frequency time-series data and the binary dependent variable (sales transaction occurs or not), we tested several analytical approaches including panel regression, logistic regression, decision tree classification, and the Random Forest (RF)

Table 3

List of variables and supplementary information.

Independent variables	Short codes respectively
Sales window (by hour)	time_left
Soldout status (binary)	soldout
Pickup window (by hour)	pickup_window
Ratings of the shops and the MBs	popular
Pickup (categorical: morning, afternoon, evening, midnight)	pick_am, pick_pm, pick_ev, pick_mn
Surplus status (binary)	surplus
Weekday (categorical)	mon, tue, wed, thu, fri, sat, sun
Shop category (categorical: bar, grocery, pizza shop, restaurant and bistro, fruit and vegetable shop, bakery, burger shop, self service shop)	store_bar, store_gr, store_pi, store_res, store_fv, store_ba, store_bur, store_ser
MB category (categorical: grocery, meal, baked goods, other)	cat_gr, cat_me, cat_ba, cat_ot

³ Full code for the *tgtg-python* library available at <https://github.com/ahivert/tgtg-python>.

method. The fixed-effect panel regression approach was discarded due to the high skewness towards zero values in the target variable (sales of MBs). Subsequently, we evaluated the predictive accuracy and AUC scores of the remaining three models. Both metrics rely on a binary classifier with a confusion matrix, which is a two-by-two table of instance outcomes. Predictive accuracy depends on the proportion of correctly predicted instances (true positives and true negatives). The AUC score measures a model's ability to discriminate between positive and negative instances across all classification thresholds [30].

Random Forest (RF) is a collection of classifiers with a tree structure, where each tree consists of independent and identically distributed random variables. RF is a non-parametric machine learning model that can be employed for regression, classification, and forecasting. It is particularly effective in identifying patterns that may be hidden in traditional regression models, such as linear and generalized linear regressions [14,27]. RF reduces errors by minimizing prediction variance while maintaining bias, which reflects the difference between the model prediction and the actual value of the target variable. Furthermore, Breiman [14] remarked that RF is a particularly effective tool in prediction without overfitting with a large sample and delivers good results in classification by random inputs and random features.

The number of independent variables randomly selected for each tree was equal to 3 while the number of trees generated was set at 500.

To identify potentially important independent variables, we measured variable importance with Mean Decrease Accuracy and Mean Decrease Gini, representing the relative influence of each predictor variable.

5. Results

5.1. Economic performances and patterns of business users on TGTG

Given that Perugia and Viterbo have significant differences in population – 162,367 and 66,178 respectively as of 2023,⁴ it is not surprising that the density of shops (business users) on the TGTG platform varies between the two cities. Specifically, 100 shops in Perugia were listed on TGTG, compared to only 42 shops from Viterbo.

The economic performance of TGTG was evaluated by considering all users, both businesses and consumers, in these two cities. In Perugia, the total sales revenue achieved by all shops amounted to 27,666.09 euros, while consumers saved a total of 52,763.91 euros by purchasing MBs at discounted prices. In Viterbo, shops earned a total of 16,278.3 euros in sales, with consumers saving a total of 30,668.7 euros.

Noteworthy figures include the revenue generated from selling MBs with a sales window of no >12 hours – potentially representing "real" surplus food. In Perugia, this amounted to 4415.36 euros (approximately 16 % of total sales revenue). Similarly, in Viterbo, this figure was 3079.81 euros (nearly 19 % of total sales revenue). This result aligns with the sales revenue data (Fig. 1), which shows a peak in sales revenue for MBs with a sales window of nearly 21 hours in both Perugia and Viterbo.

Were shops indeed selling food surplus to stay with TGTG's social initiative? From a business perspective in the two cities, MBs were listed throughout the entire day and the average duration of the sales windows ranged from 30 min to nearly 24 hours. The violin plot (Fig. 2) illustrates how the MBs were organized by the shops throughout the whole data collection period. It showed the accumulated volume of MBs released at each hour of the day and their respective sales windows. There is a clear downward trend in the length of the sales window from around 7 pm to 6 pm the next day. The longest sales windows (20 to 24 hours) were observed for MBs released at approximately 7 pm, whereas the shortest sales windows (immediate ordering up to 5 hours) were for MBs listed around 6 pm.

After aggregating the active MBs for purchase by unique item names, we found that the percentages of potential surplus food, identified by a sales window of <12 hours, were 62.7 % in Perugia and 67 % in Viterbo. These were mostly labelled as groceries (MB category). The MBs in Perugia suspected not to be food surplus shared similar item characteristics to those MBs with the potential to be surplus food. In Viterbo, MBs with a sales window longer than 12 hours were possibly groceries, baked goods, or meals. Table 4 presents the frequency distributions of MBs under different categories in the two cities.

Disparities in the sales window of MBs are not only evident across different MB categories but also vary with shop types and days of the week in the two cities (Fig. 3). Bars and groceries share a similar pattern: MBs have shorter sales windows on Saturdays and longer sales windows on Sundays. In Viterbo, some burger shops and self-service points utilised the TGTG service, a trend not observed in Perugia. Their sales windows ranged from approximately 10 to 15 hours.

Viterbo had significantly fewer bakeries and shops selling fruits and vegetables compared to Perugia. However, the sales windows of these shops in Viterbo were slightly longer throughout the week. Pizza shops in Viterbo tended to extend their MB sales windows over the weekend compared to those in Perugia.

Restaurants and bistros present an interesting case. In Viterbo, these establishments were not very active on TGTG. Most MBs from these categories listed on specific days (Mondays, Wednesdays, and Saturdays) had long sales windows (20 to 25 hours). In contrast, Perugia displayed more balanced participation. MBs had shorter sales windows on Fridays and Saturdays, while longer sales windows were seen on Sundays.

5.2. Patterns of consumer users on TGTG

Among these, the RF classification model demonstrated the best performance with the highest predictive accuracy over the other two methods and good AUC scores across two cities' datasets, as illustrated in Table 5. This result aligns with findings from another study on food surplus redistribution using a sharing-for-charity model [21].

We therefore applied RF models to the datasets from the two cities. The occurrence of sales transactions was set as the binary dependent variable. The independent variables included MB and shop categories, sales window (in hours), pickup window (in hours), pickup period (categorical), the popularity of the MBs, weekdays, and the perceived status of surplus food (binary). Both models achieved very good Out-of-Bag (OOB) error rate estimates, which measure the prediction error (performance) of the RF models [27] – 2.2 % for Perugia and 1.98 % for Viterbo.

We extracted variable importance indicators to understand the intentions and usage patterns of TGTG's consumer users in the two cities. Fig. 4 and Table 6 display the significant variables identified by the RF models.

The two cities exhibit similarities with minor differences in the influencing factors. Variables such as the sales window, the popularity of the MBs, the pickup window, and the sold-out occurrence were significant factors affecting the occurrence of sales. However, in Viterbo, the importance of the sold-out status exhibited a stronger influence compared to Perugia. In Perugia, the perceived status of being food surplus influenced consumers' purchasing decisions – a result not presented significantly in Viterbo.

6. Discussion and conclusion

Does TGTG effectively mitigate the food waste problems?

Before answering this question, we must emphasize the success of TGTG in terms of the economic benefits created for both the businesses and consumers, as well as the invisible influence on the entire society regarding the awareness of food surplus waste and the easy contribution which every individual can make. Our results show a concrete

⁴ <https://www.istat.it/>

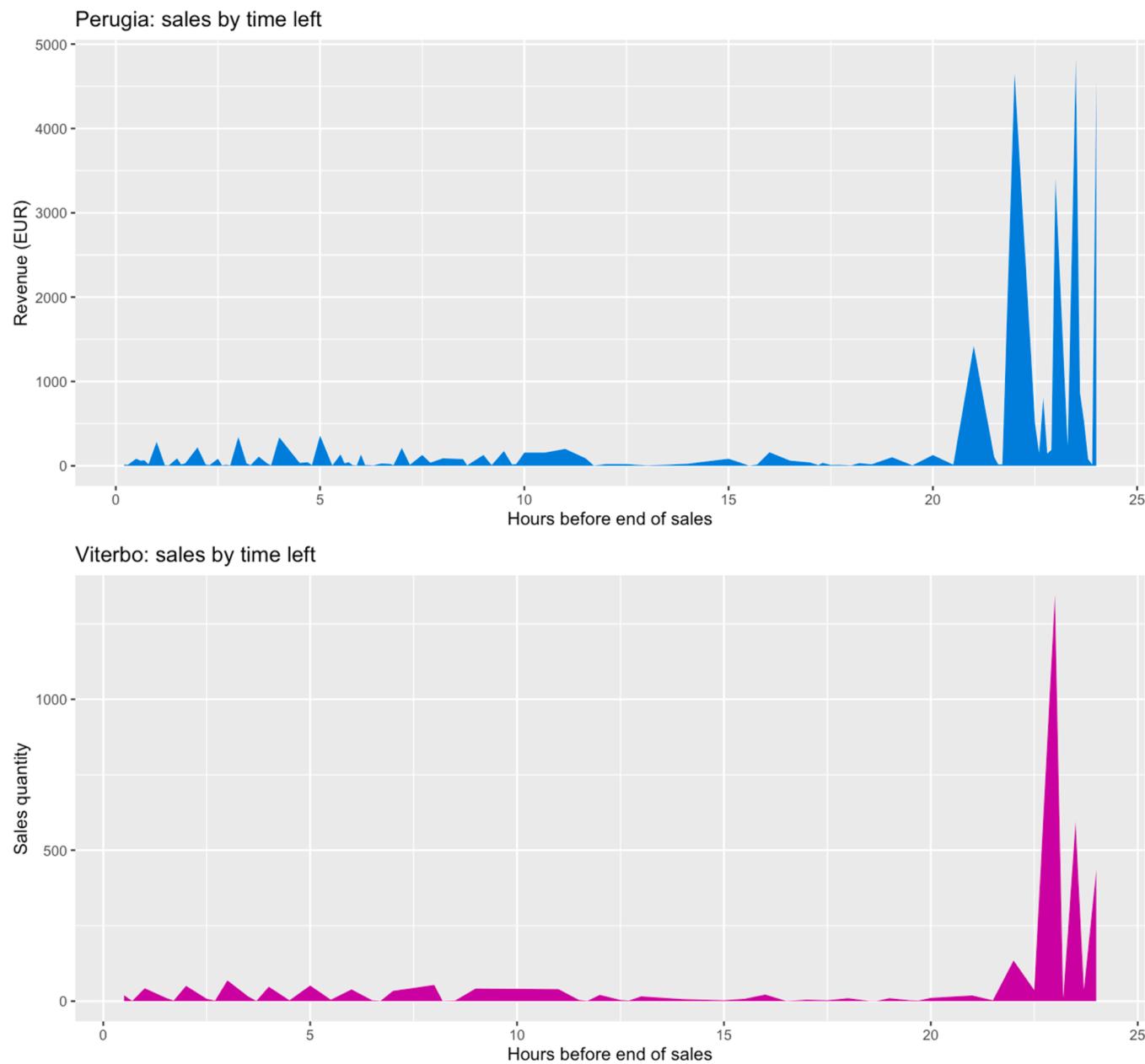


Fig. 1. Revenue (EUR) of the sold items with their sales window (hours) in Perugia and Viterbo.

measurement of the economic benefits of at least 16,000 euros for businesses and 30,000 euros for consumers in city centers of small-to-median-size Italian cities. TGTG's functional value, in terms of quality food at an affordable price and increased food establishments' turnovers, is highlighted [33]. Furthermore, it seems TGTG were more attractive to food establishments with smaller business scales, for example bars, bakeries, and pizza shops. This is possibly due to the lower budget and know-how in their operations and marketing, as well as the investment in technologies.

However, our results provide inspiring insights into the social and emotional values, as proposed by Vo-Thanh et al. [33] – encouraging and challenging at the same time.

6.1. Perspective of businesses

We observed a commendable practice among businesses utilizing TGTG to sell surplus food in both cities. As the observation, the MBs sharing the same unique item name were with the same pattern in terms

of sales window. Therefore, we aggregated the MBs by item name and discovered that a minimum of 62 % of the aggregated MBs were listed for orders within 12 hours, indicating the presence of a perceived food surplus. In Perugia, MBs with extended sales windows were predominantly grocery items, which were likely to be non-perishable products and thus could remain listed for longer periods. Similar patterns were observed in Viterbo; however, some MBs with long sales windows were found in the bakery and meal categories. This suggests a potential shift from managing surplus food to planned food production.

Regarding the engagement of businesses in the two cities, notable disparities are evident. In Viterbo, a smaller city, there is a significant lack of participation from bakeries, fruit-and-vegetable shops, restaurants, and bistros compared to Perugia. This discrepancy can be attributed to Viterbo's smaller population and reduced commercial activity. Conversely, businesses in Viterbo tended to offer MBs with slightly longer sales windows, aligning with the previously observed trend of longer sales windows for certain MB categories. Combining our earlier experimental analysis of data from Rome [20], it appears that in larger

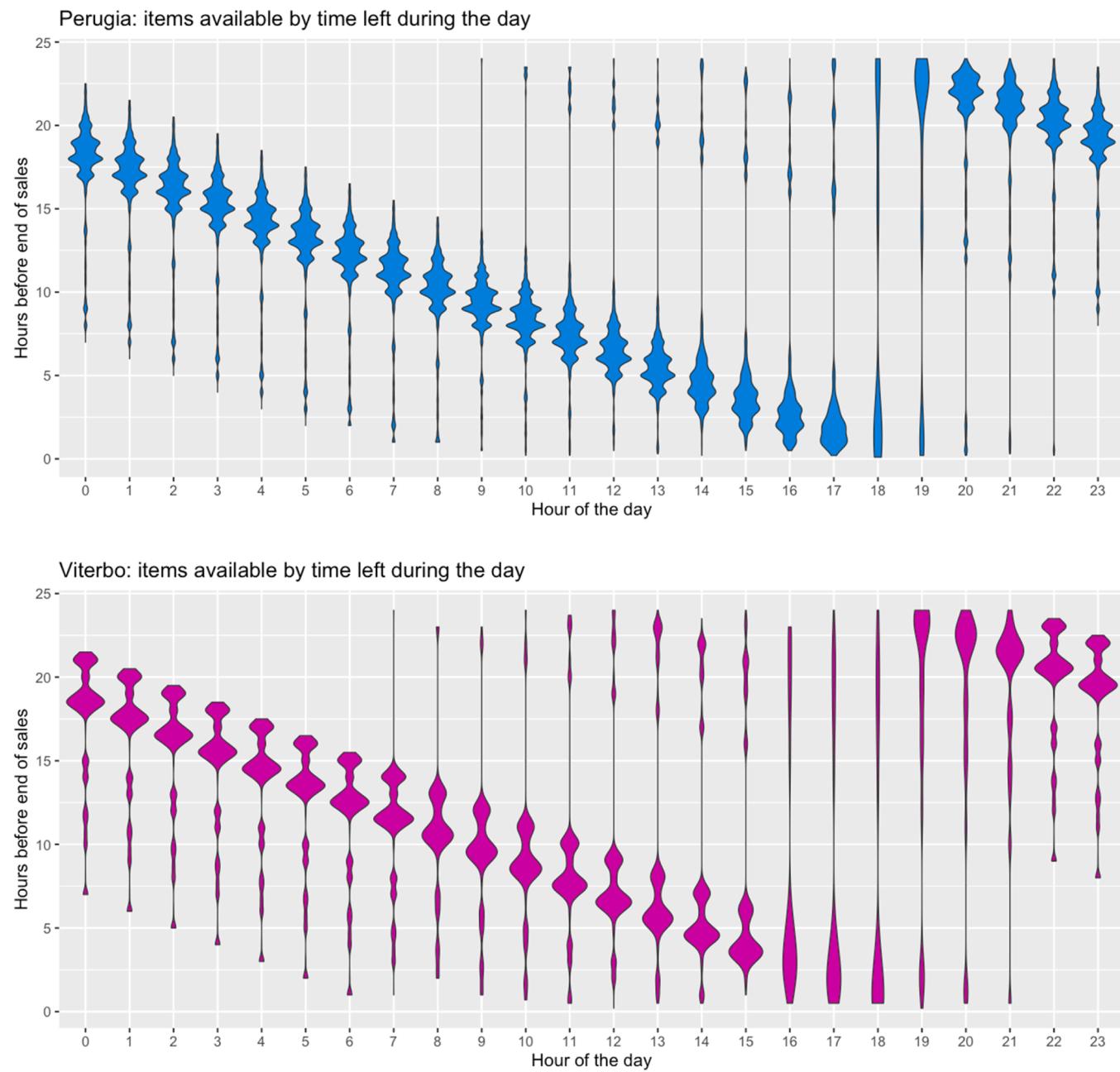


Fig. 2. Items available by hours left for ordering during the day in Perugia and Viterbo.

Table 4

Frequency distributions of the MBs under MB categories in Perugia and Viterbo.

	Sales Window < 12 hours	Sales Window ≥ 12 hours	MB category
Perugia	33 (29.73 %)	17 (25.76 %)	Baked goods
	48 (43.24 %)	36 (54.55 %)	Groceries
	26 (23.42 %)	9 (13.64 %)	Meal
	4 (3.61 %)	4 (6.05 %)	Other
Viterbo	12 (17.39 %)	11 (32.35 %)	Baked goods
	42 (60.87 %)	11 (32.35 %)	Groceries
	11 (15.94 %)	11 (32.35 %)	Meal
	4 (5.8 %)	1 (2.95 %)	Other

cities with higher populations and more commercial activities, the MBs on TGTG tend to have shorter sales windows. The underlying intentions behind this practice warrant further investigation.

6.2. Perspective of consumers

The role of consumers is crucial, as they can encourage businesses on the TGTG platform to practice more responsibly and commit to reducing food waste by rewarding their loyalty and trust [26]. Conversely, businesses might exploit commercial opportunities due to opportunistic consumers who intentionally wait for low-cost food [15,24].

Comparatively, while there is a medium-high proportion of MBs with shorter sales windows, the accumulated sales revenue predominantly comes from MBs with longer sales windows (20–25 hours), as shown in Fig. 1. On the contrary, sales revenue generated by MBs with sales windows in <12 hours only ranges from 16 % to 19 % of the total revenues. The results of our RF modelling reinforce this finding, showing that the sales window is the most significant variable affecting the occurrence of sales. Additionally, the pickup window also plays a crucial role in influencing consumer purchase behaviors. This underpins that

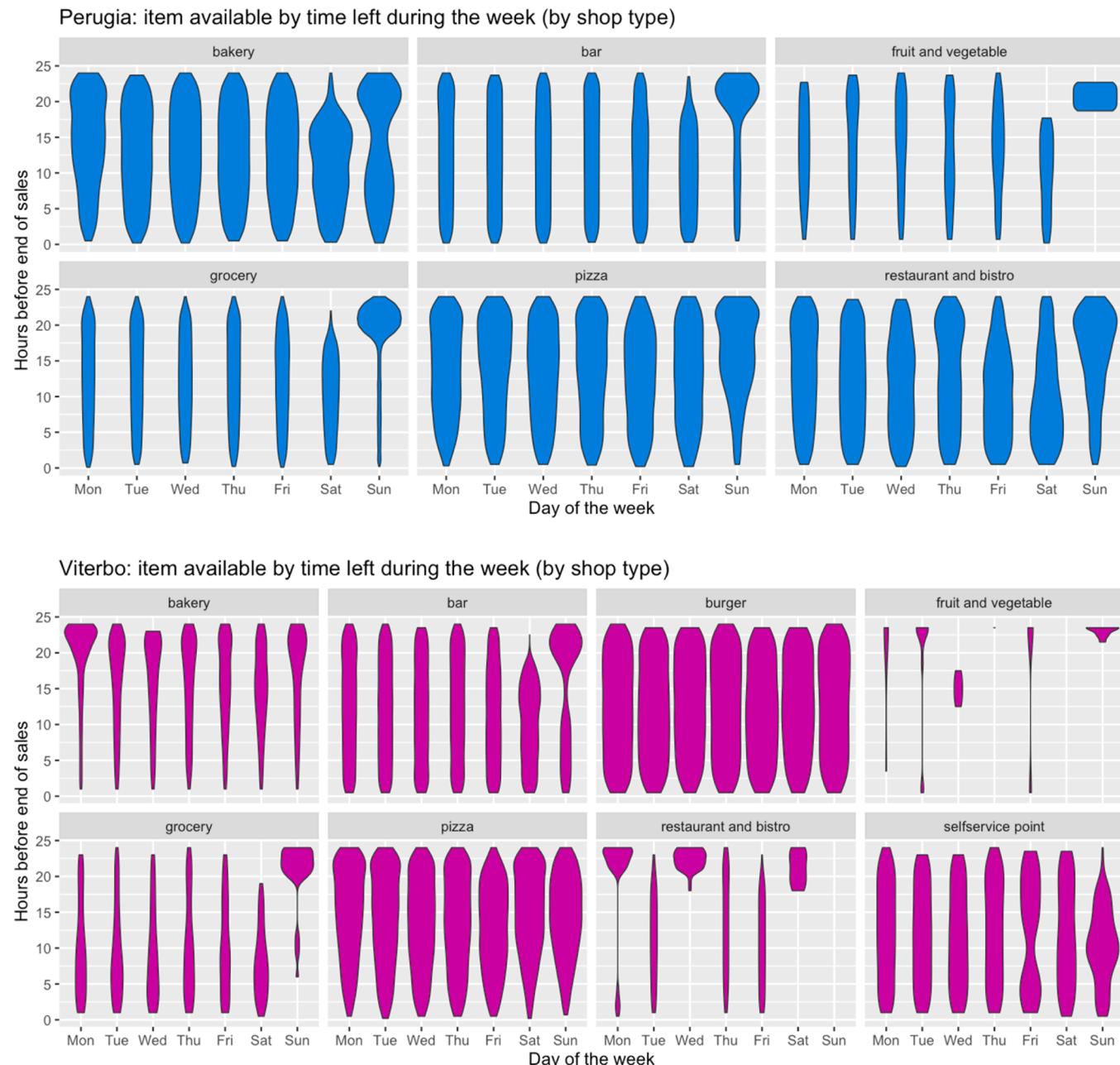


Fig. 3. Items available by hours left for ordering during the week by shop category in Perugia and Viterbo.

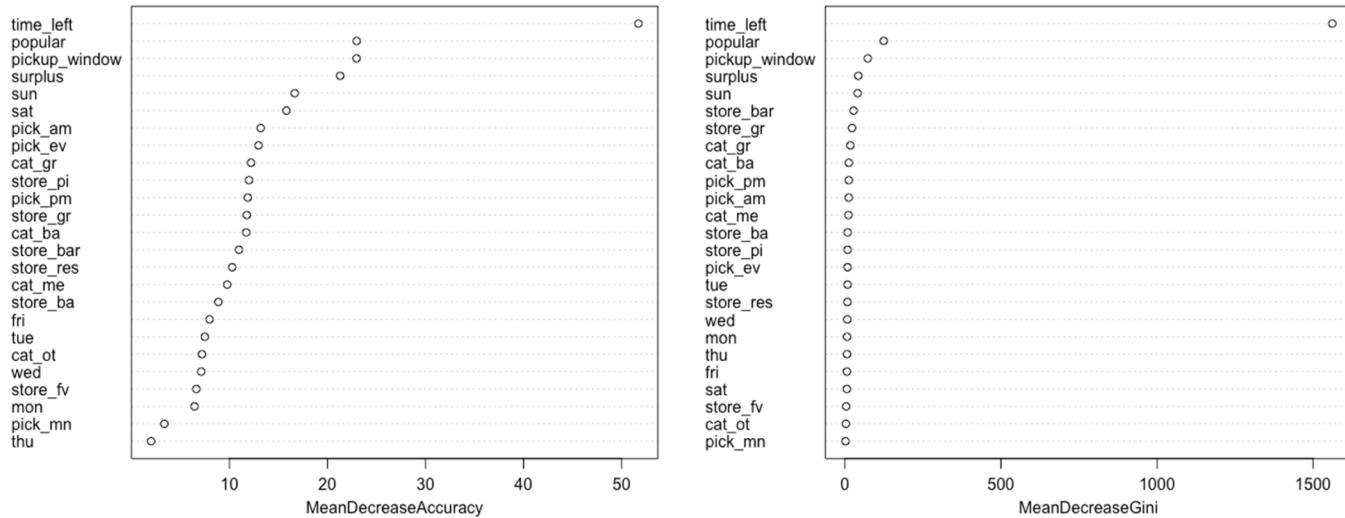
Table 5
Performance comparison of data analytical approaches.

	Logistic Regression*	Decision Tree*	Random Forest (RF)
Perugia			
Predictive accuracy	0.968	0.977	0.983
AUC score	0.803	0.664	0.760
Viterbo			
Predictive accuracy	0.970	0.983	0.986
AUC score	0.558	0.768	0.876

Note: Logistic regression and decision tree classification models are applied after min-max data transformation.

consumers in the two cities might prioritize convenience over the intention to reduce food waste. Longer sales windows and pickup windows mean more availability and less urgency for consumers to make their purchase decisions and actions., hence, more convenience. Moreover, the popularity of MBs, linked to shop reputations through TGTG platform ratings, significantly affects consumer choices. The drivers behind consumer choice of purchase align with the perceived convenience and popularity over the intention of food waste reduction. This finding is consistent with the research conducted on TGTG and its implications for Italian consumers, as outlined by Fragapane and Mortara [26]. Consumers tend to prioritize the quality, quantity, and variety of products within the MBs. Meanwhile, the significance of the perception of food surplus is particularly emphasized in our results. This indicates the increased awareness and willingness to reduce food waste. This could be highly relevant to consumers' lifestyles which influence their food waste behaviors as the empirical study by Secondi et al. [16,17].

Variable Importance of RandomForest Model (Perugia)



Variable Importance of RandomForest Model (Viterbo)

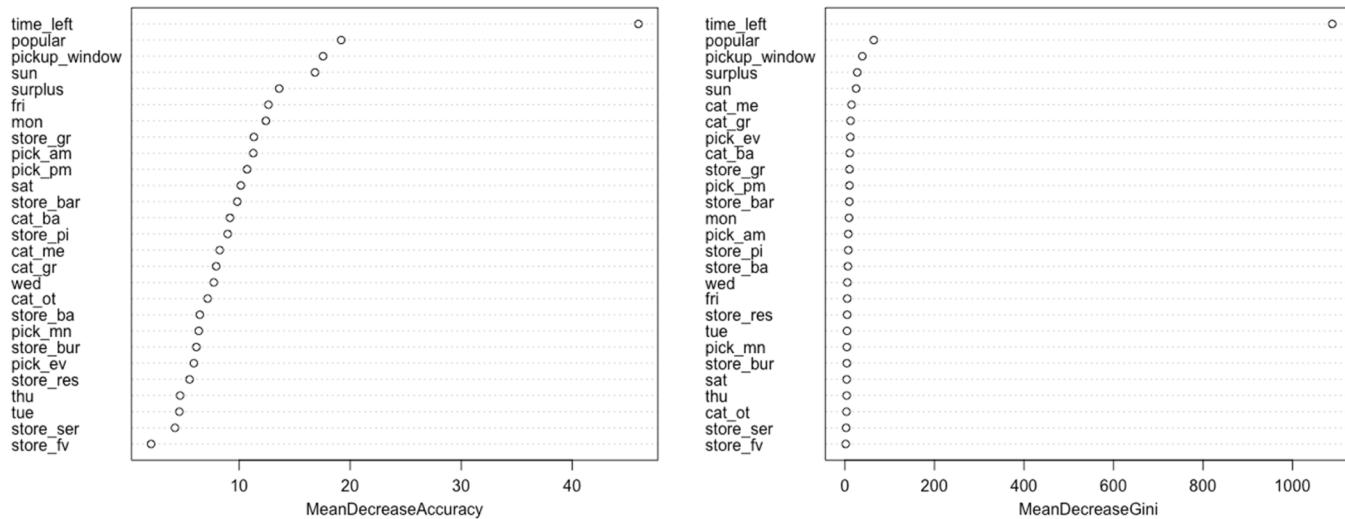


Fig. 4. Variable importance of RF models for Perugia and Viterbo dataset.

Table 6
Selected variable importance of RF models for Perugia and Viterbo dataset.

	Perugia		Viterbo	
	MDA	MDG	MDA	MDG
Time_left (Sales window)	51,720	1,561,339	45,969	1,088,897
Popular	22,983	124,332	19,184	64,485
Pickup_window	22,966	73,314	17,544	38,880
Surplus	21,293	42,736	13,600	27,531

Note: MDA – Mean Decrease Accuracy; MDG – Mean Decrease Gini.

Simultaneously, the business-customer relationship, which aligns with TGTG's mission, is highly valued by community members who are committed to sustainable food consumption.

6.3. Conclusion and managerial implications

This paper incorporates empirical primary data analysis by utilizing web scraping on one of the largest social enterprises in the market, Too Good To Go. The high-frequency time-series data captured illuminate the economic performance and usage patterns of both businesses and consumers. Our findings affirm the positive contribution of TGTG, which operates under a sharing-for-money model to facilitate a community for food surplus redistribution with economic benefits. Nevertheless, we observe a potentially weaker presence of certain types of food establishments and a lack of social motivation from consumers. Scholars have argued that user intentions regarding food-sharing services are driven

more by economic and environmental concerns than by social responsibility, with a stronger customer-to-retail effect compared to the reverse. This dynamic may influence the participation and engagement of businesses in food-sharing applications [12,24,28].

Inspiring findings highlight the positive business-customer relationships that can be established when businesses commit to reducing food waste and effectively communicate with their customers through well-prepared MBs. Stakeholders and managers of food establishments, particularly small businesses, should leverage the platform's advantages – such as ease of use, low required investment, and proven market reputation – to manage their food surplus effectively.

TGTG has expanded its network of business partners beyond profit-driven food establishments to include potential donors from the retail and wholesale sectors. Furthermore, the company collaborates with governments and institutions to enhance sustainable production and consumption outcomes. Raising consumer awareness about the value of food surplus, the cost of food waste, and their role in reducing food waste by using food-sharing applications appropriately remains crucial. This responsibility falls to platforms like TGTG and policymakers, who must consistently regulate and refine the marketplace through various methods, such as monitoring, regulation, or incentives.

Limitation and future work

This paper examines the sharing-for-money business model in practice using an objective data source and at a territorial level in two relatively small urban areas. The methodology is scalable to other cities or regions, which are likely to exhibit different results due to variations in social norms, culture, tradition, and levels of economic and sustainability development. However, challenges exist with technical barriers, such as data collection through web scraping technology, due to constant changes or anti-scraping technology enforced by the platforms. Moreover, the data obtained are limited to the platform's pre-configurations. Using TGTG as an example, it is impossible to ascertain the exact food items in an MB, making it difficult to identify potential surplus food and planned food production. Future improvements could incorporate insights from interviews or surveys with food establishments. On the other side, this preliminary study draws on data scraping technology to obtain real-life data from the platform in business. However, the scope of the dataset used in the study is limited in time and space due to the limited capacity of computing power and data storage. This might compromise the generalization of the study results. Future research could extend the data collection geographically to bigger cities or regions, as well as apply a longer time frame for data collection, especially taking seasonal or festival influence on the possible results into consideration.

Some scholars have conducted research in this area, including one of our ongoing projects, which confirms that economic motivation is the primary driver for food establishments, particularly in terms of cost savings from waste reduction. Another avenue for future research is to further identify consumer intentions and potential barriers to using food-sharing applications such as TGTG. Content analysis using innovative technologies, such as large language models, may enable scholars to delve deeper into user-generated content on these platforms. It is crucial to understand how to engage consumers and influence them towards a more sustainable consumption lifestyle, considering territorial differences.

CRediT authorship contribution statement

Mengting Yu: Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation. **Luca Secondi:** Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Tiziana Laureti:** Writing – original draft, Supervision, Methodology, Conceptualization. **Luigi Palumbo:** Writing – original draft, Validation, Software, Methodology,

Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Luca Secondi reports financial support was provided by European Commission. Luca Secondi reports financial support was provided by Ministry of Education and Research. Tiziana Laureti reports financial support was provided by Ministry of Education and Research. Mengting Yu reports financial support was provided by European Commission. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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