Willingness to Subscribe to a Meal Kit Delivery Service: A First Investigation on Its Generated Impact in Italy

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Abstract. Meal Kit Delivery services are home delivery services of pre-portioned ingredients for meals' preparation. Meals are based on seasonal products sourced from local workers to shorten the supply chain. Rely on dedicated apps and home deliveries, meal kits aim to drastically reduce the time spent planning meals and purchasing food; moreover, since ingredients are pre-portioned in adequate quantities, the amount of food waste can be significantly minimized.

Main players in the meal kit delivery market are companies such as: HelloFresh; Blue Apron; Marley Spoon; Gousto, covering 50.91% of the revenues at worldwide level. The service is mainly widespread in the United States, but also several European countries started using it.

An online survey on the willingness to use meal kit delivery services is conducted to Italian inhabitants. The survey is organized in several sections: socio-economic characteristics of the respondents; habits about grocery (person in charge in the household and frequency; preference for large-scale retail trade or neighborhood shops; distance from shops and transport mode adopted; behavior in case of urgent need for specific products); personal attitudes regarding technology, online services, e-commerce, value of time, environment, food waste and food market sustainability; willingness to use a meal kit delivery service depending on type of subscription.

The main aim of the study, from the logistics and transportation side, is to evaluate potential reduction in trips for grocery and if changes on food logistic chains can be generated with consequent environmental benefits in terms of pollutant emissions.

Keywords: meal kit · food delivery · pollutant emissions

1 Introduction

1.1 The New Frontier of Food Delivery

Nowadays the desire to rediscover the house walls and the attention to the balance between home and work life are becoming stronger and stronger, along with a renewed centrality of well-being and healthy lifestyle. However, the frenzy of everyday life

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allows little time to dedicate to household and grocery, making difficult to obtain fresh ingredients and plan regular healthy meals.

The combination of all these factors makes solutions such as food delivery no longer enough: the need to know what you have on your plate and cooking it with your own hands is emerging forcefully.

For a few years now, a trend that intercepts all these needs has been gaining more and more traction: meal kit delivery (MKD), a home delivery service that offers boxes containing seasonal, quality, fresh ingredients, mainly sourced from local workers, semi-finished and pre-portioned (based on the number of people who consume the meal) for cooking a chosen recipe included itself in the box.

Worldwide, various companies offer this service: basically, through a dedicated app, you order online the dishes you like, whether for one, two or more people, and receive at home everything you need to cook them, including instructions. Usually, the proposed preparations are all attentive to a healthy and balanced diet and the leading companies in the sector offer a variety of dish options (e.g. Mediterranean, vegetarian, vegan, gluten free).

Born between 2007 and 2012 as a niche market, with first attempts in north Europe, Australia and United States, online MKD services have known a fast-growing. The global MKD services were valued at around 20.54 billion US dollars in 2022 and is forecast to exceed 25 million US dollars by 2027 with an expected compound annual growth rate (CAGR) of 15.3% from 2023 to 2030. North America gave the largest contribution to the market in 2022 (46.01%). However, Asia Pacific is the fastest-growing market (expected CAGR of 16.7% from 2023 to 2030) due to the increasing number of time-poor consumers in the region (i.e. China, Japan, and South Korea). In Europe, the northern range, especially Germany, has taken on an important role in the sector and the MKD service market is expected to grow at least in line with the global average [1].

Definitely, technologies and digitalization played a key role in its development: food shopping started to steadily move into the digital domain pushing towards online shopping options. The COVID-19 pandemic has been another major factor for its rapid evolution as people tried to avoid shopping in-store in the midst of the emergency causing a shift in consumer behavior still visible [2]. According to a survey conducted in 2020, 54% of US consumers cook more than before, and 22% order meal kits more frequently. Dining out has lost its appeal, especially among boomers and millennials that demonstrate increasing preference for staying at home and cooking or ordering in rather than spending money at restaurants [3].

1.2 Meal Kit Delivery: A Sustainable Option?

As mentioned, the growing awareness of the benefits of consuming fresh healthy meal options is a major factor in driving the shift in consumers attitudes, but the convenience of meal kits is not only given by receiving high quality products at home: this service can provide significant social benefits (e.g. time saving for meal planning and grocery shopping, that implies more time for leisure activities, family and/or work) and economic implications (e.g. encouragement for the development of small local business, so that many meal kit providers plan their menus a year in advance to contract with enough local suppliers before the growing season).

Moreover, meal kits have the potential to positively contribute to the environmental sustainability (e.g. shorter supply chains, fewer and shorter freight transport and so less traffic congestion, less food waste).

First, meal kit operators estimate that with meal kit boxes, 21% less food is wasted compared to those bought at the supermarket [4]. Food waste has a significant environmental impact (i.e. about 16–19% of the total Greenhouse Gas (GHG) emissions from the EU food system), not only for its disposal into landfill, but also for the huge waste of energy used through the entire supply chain (from production to consumers). Considering that, globally, approximately a third of the all food produced for human consumption is lost, and around 88 million tons of food is wasted only in Europe each year (i.e. according to data collected in 2023 by Eurostat, households cause more than half (54%) of the total food waste in the EU, with 70% of food waste arising at household, food service and retail [5]), the saving guaranteed by meal kits can have important consequences on the carbon footprint of the food supply chain as described by Scherhaufer et al. [6]. They illustrate the impacts of food waste in relation to the total food utilized, demonstrating that most of the impacts originate from the production step and food waste prevention can improve the situation as less food needs to be produced [6].

Also, Notarnicola et al. [7] identified food processing as a crucial phase in terms of environmental impacts (i.e. energy intensity and related emissions for the production of heat, steam and electricity), but they also found that logistics (i.e. transportation in terms of distances, number of voyages and transport modes) similarly contributes to carbon emissions.

Especially, the so called "last mile", the distance that the food travels through from the processor or retailer before entering consumer house, can notably affect GHG emissions reduction [8–10].

Last mile emissions account for 11% of the average grocery meal emissions compared to 4% for meal kit dinners. In fact, MKD services shorten the supply chain since the ingredients, to be fresh and not perished, usually arrive from local producers. Moreover, meal kit boxes are delivered all together on a single truck route (splitting the distance travelled over many customers, so that the actual miles per meal kit is much smaller). Consequently, the transportation pollutants related to meal kits are a little fraction compared to the total vehicle emissions that are normally detected when each consumer drives back and forth to the supermarket with a personal vehicle [11]. However, Allen et al. [12] point out that the benefits in terms of GHG emissions reduction are significant only if the route is specifically designed to optimize distances and waiting time, otherwise food delivery options become counterproductive. Analogously, appropriate truck/vehicle fuel sources can further reduce emissions (i.e. electric vehicles, bicycles). Thinking to transportation, positive consequences could be detected also in terms of traffic congestion due to less private vehicles driving in urban areas.

Another aspect to account for is the more packaging required by meal kits that could offset any energetic benefits of reducing food waste and miles travelled. Through a "lifecycle approach" that considers all the stages of each ingredient, from its creation to consumer home, the detailed research conducted by Heard et al. [11] found that the environmental impact of that packaging is counterbalanced by meal kits savings in emissions due to less food waste and fewer miles of transportations compared to grocery

stores (i.e. 8.1 kg of carbon dioxide equivalent for a "grocery store-bought meal" *vs* 6.1 kg cooking that same meal using a meal kit, around 33% less GHG emissions).

Pre-portioned ingredients and a streamlined supply chain seem the key factors for minimizing the carbon footprint of meal kits. Additionally, using eco-friendly packaging (e.g. selecting recycled and recyclable materials, as well as minimizing the amount of packaging), and favoring seasonal local organic products (for minimizing production processes and transport related emissions) can further make meal kits a sustainable option [10].

According to Yoon et al. [13], meal kits with organic, local, and pre-cut ingredients prepared in fully recyclable packaging induce consumers to opt more willingly for MKD services. Same attention of consumers to quality of product, minimization of wastage (in all aspects, whether as time and effort or as food waste), quality, functionality, and visual appeal of meal kit packaging was found by Sharnock who investigated what factors consumers mainly consider for deciding to subscribe to a MKD service [14].

Despite all this, still a minority of consumers regularly ordered fresh food meal kits to cook at home. A major drawback is their high cost. According to a survey conducted in 2020 [2], around 13% of high-earners in US planned to spend more for MKD services as a consequence of the COVID-19 pandemic. Nevertheless, people with a yearly income lower than 100,000 US dollars were much less prone towards this tendency, pointing out that MKD services still have obstacles to solve in order to gain mainstream popularity.

Anyway, they can be more cost-effective than ordering in or eating out. In addition, they can make accessible high-quality ingredients otherwise not affordable, and allow to save money by buying only the amount of food needed.

1.3 Objectives of the Study

Since transport logistics, as previously discussed, is one of the most important phases for the overall food supply chain in terms of environmental impacts, creating advances in transportation logistics to reduce last mile emissions plays a key role. To succeed in this goal, the understanding of customers attitudes, tastes, habits, inclinations and perceived value is fundamental. Bearing this in mind, this study aims at analyzing the potential of MKD for making significant changes in the overall food supply chain mainly by reducing private vehicle transport to and from grocery shops.

Considering that MKD services are a relatively new topic and limited specific literature exists on this matter, exploring the potential user segment and its characteristics is a primary need. The proposed investigation, carried out through an online survey on the willingness to use MKD services in Italian metropolitan urban areas, can provide useful insights for better understanding consumers perceived costs/benefits and identifying the main factors that could induce consumers to subscribe to a MKD service and how their behavior could change, mainly in terms of transportation. Consequent implications for both researchers and operators can be detected providing the basis for further research on the topic.

What just described has been developed in the paper as follows: Sect. 2 illustrates the methodology adopted for the survey and the related results analyzed with a view to identifying the most relevant factors for subscribing to a MKD service. Based on survey results, Sect. 3 proposes a computational procedure for estimating the potential of MKD

services to reduce travelled distances and related externalities (i.e., pollutant emissions). Section 4 deals with the implementation of a behavioral model able to generalize survey outputs and provide useful information for forecasting potential MKD services users. A final summary section concludes the contribution.

2 Methodology

Given the fact that people often act differently from what they state, in order to capture the most realistic picture of consumers' behavior and a solid understanding of their intentions, the paper combines revealed preferences (RP) and stated preferences (SP) surveys to investigate current knowledge about MKD service and the willingness to use it as a function of different types of subscriptions and attitudes of respondents. Specifically, SP come from direct questioning and create scenarios using hypothetical data, whereas the approach based on RP relies on data coming from the observation of actual behaviors (it assumes that users' preferences are revealed by their actions and habits).

The survey (in Italian language), directed to consumers, was conducted online through the LinkedIn social media network.

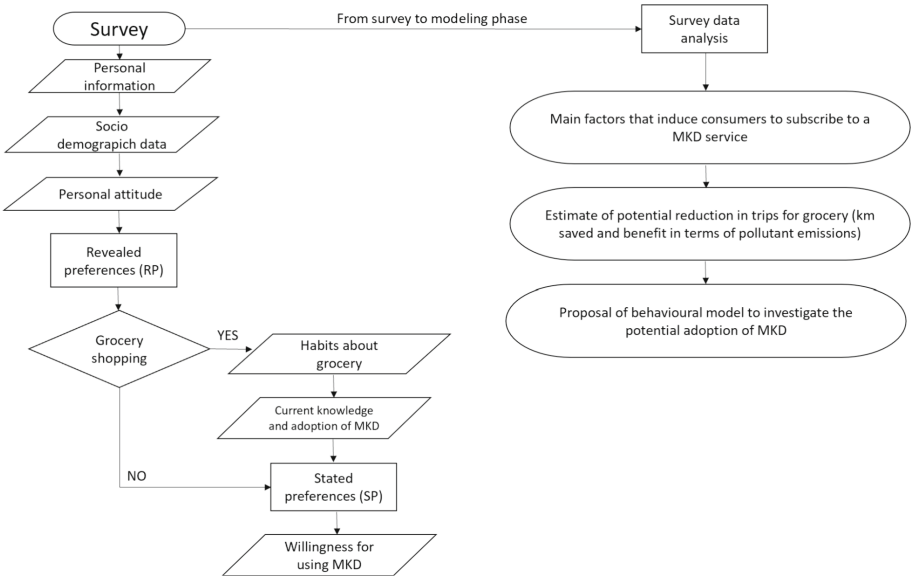

Fig. 1. The proposed methodology: from survey structure to the modeling phase.

Figure 1 schematizes the methodology adopted in the study: the survey has been organized according to different sections, including the RP and the SP ones. Data collected through the survey feed the modelling phase, which terminates with the proposal for the behavioural model for MKD demand forecasting.

2.1 RP and SP Survey

Survey Design. The survey, conducted between January and February 2024, involved 150 respondents. The questionnaire was preceded by an introduction aimed at emphasizing the novelty of MKD service and focusing attention on some main keywords such as "food industry", "food trends and future", "sustainability". Despite the potential impact on the response rate as well as on the overall representativeness of the sample, incentives were not offered to respondents due to budget constraints.

The survey consisted of 5 sections as follows:

(i) personal data section (age, gender and employment status);
(ii) socio-demographic data section (further data on users and their household, such as number of household members, number of household members with an age lower than 15 years old, household vehicle fleet);
(iii) habits about grocery (person in charge in the household, frequency; preference for large-scale retail trade or neighbourhood shops; distance from shops and transport mode adopted; behaviour in case of urgent need for specific products);
(iv) personal attitudes regarding technology, on-line services, e-commerce, value of time, environment, food waste and food market sustainability;
(v) willingness to use a MKD service depending on type of subscription.

All the factors considered in the survey were based on a comprehensive literature review related to MKD, as well as on previous research experience and knowledge in the field of e-commerce and e-grocery.

Survey Results. Table 1 shows the socio-demographic characteristics of the users' pool (data gathered through sections (i) and (ii) described in the previous section). First, it should be noted that the gender of respondents is quite uniformly distributed, as well as their age (except for the age higher than 67, probably due to very low attitudes toward technology that, consequently, makes this population segment little interested in using services such as MKD). Most of the sample (76%) is employed, aspect that makes the analysis more relevant since the adoption of MKD is mainly reported for people that have no time available to prepare meals. Further, the number of household members was recorded, together with the number of household members younger than 15 years old: the latter information was specifically investigated since often teenagers and children do not appreciate meals generally proposed by MKD services [14].

Household vehicle fleet was also collected during the survey as direct indicator of income levels: as a function of number of household members and number and type of vehicle fleet, four income levels have been derived (low: 38%, medium: 27%, high: 24%, very high: 5%). 6% of the sample did not contribute to derive the income level since the respondent declares to not have any vehicle.

Section (iii) investigated the habits about grocery: 77% of the sample usually goes grocery (alone or in collaboration with another household member). Hence, this portion of the sample was asked other questions relating to grocery shopping, whereas the remaining 23% was redirected to a subsequent section of the survey. Mostly, shop is conducted using a car (69%) or by foot (29%); generally, supermarket and large-scale retail trade centres are visited (58%), small retail stores or food markets only for 10% of the respondents, 33% usually visits both. The choice is strictly correlated with the

Table 1. Socio-demographic description of the sample interviewed

Sample characteristics	
Age	[%]
18–29	28.0%
30–39	18.0%
40–49	22.0%
50–67	27.0%
>67	5.0%
Total	100%
Gender	
Male	41.0%
Female	54.0%
Not specified	5%
Total	100.0%
Employment Condition	
Employed	76.0%
Student	11.0%
Retired	7.0%
Unemployed	5.0%
Total	100.0%
Number of household members	
1	12.0%
2	28.0%
3	32.0%
4	22.0%
>4	6.0%
Total	100.0%
Number of household members (<15 years old)	
None	73.0%
1	18.0%
2	5.0%
>2	3.0%
Total	100.0%

distance one is willing to travel to reach the store location: in case of large-scale retail trade, travelled distances are mainly between 1 and 3 km (42%), but also higher distances are considered (17% between 3 and 5 km). In case of small retail stores or food markets, 88% of the sample stated distances lower than 1 km. The travel mode and the type of shops visited for grocery are interconnected: 72% of users using a car prefers to shop in supermarkets and large-scale retail trade centres; instead, if moving by foot, the type of shops visited are more distributed (25% supermarkets and large-scale retail trade centres, 28% small retail stores or food markets, 47% both type). In the event of urgent need for missing products, the choice for the grocery shop type changes: most of the respondents searches for the nearest shop located within a maximum walking distance of 1 km (94%), regardless of store size and products variety. Finally, a high share of respondents carries out shopping on the way back from work, important finding strictly correlated to the need of optimizing time and activities (thus, trips) during workdays.

About the frequency related to grocery shopping, 40% of the sample makes it once a week, 34% twice a week, 19% more than twice a week ("frequent shopper") and only 7% not every week. On average the frequency for grocery shopping is equal to 1.77 times a week.

Moving to section (iv) related to personal attitudes:

- 64% of the sample has a medium to high attitude toward e-commerce (with regard to both products and services), 54% is familiar with social network, 65% is interested in new technological solutions;
- more than 80% of the sample found economic convenience and time saving fundamental factors for joining an online service; instead, environmental concerns have lower importance with respect to previous factors;
- most of the sample finds buying healthy and tasty foods, as well as avoiding food waste, main factors influencing grocery shopping; eating variedly and food price are considered important, but not as the previous ones; finally, preparation time and recipe complexity are of intermediate importance.

In the last part of section (iv), the inclination in improving habits related to grocery shopping and meals preparation are investigated. Quite surprisingly, the time spent for shopping and the time spent for planning meals were not found to be critical factors. Instead, the respondents declared the desire to contribute to food waste reduction. Regarding increasing the variety of meals and learning new food recipes, the sample is divided between those who do not consider them important and those who consider them noteworthy but not crucial aspects for choosing.

Finally, the willingness to use a MKD service depending on different types of subscription was investigated in section (v). The fact that MKD is not yet widespread in Italy is easily recognizable in sample answers: 50% of the respondents has never heard of it, 29% has heard of it but is not sure on how the service work, only 22% has a clear knowledge of what MKD can offer.

The analysis of subscription's scenarios proposed shows that 23% of the sample would join the service with the current conditions (i.e. accepting the cost proposed by the major MKD platforms existing today: approximately 6.80 €/MK with a minimum order of 6 MK/week); 38% of the sample would join the service in the event of a decrease

of meal cost (depending on the scenarios:11% if the cost is 5.90 €/MK with a minimum order of 6 MK/week, 12% if the cost is 5.00 €/MK with a minimum order of 6 MK/week, 7% if the cost is 3.00 €/MK with a minimum order of 6 MK/week, 8% if the cost is 3.00 €/MK without minimum order), whereas the remaining 39% would not join the service even in the event of a drastic reduction of the cost.

Correlation Between User's Features, Attitudes and MKD Subscription. A first analysis is conducted computing the percentages of respondents that would potentially subscribe to the service as a function of different values of their features and attitudes.

The aim is to find some useful dependences (we refer to as "correlation", despite classical correlation measures are not computed) that could be adopted in the following of the study and specifically in the behavioural modeling phase. The survey underlines a high correlation between age of respondents and their potential MKD subscription: that is, younger respondents showed a higher willingness to subscribe the service (Table 2). Moreover, some attitudes have a certain impact: it is the case of the familiarity with social network, the importance of time saving in on-line shopping and avoiding food waste (Table 3). More the respondent recognizes the importance of these factors and more is the percentage of potential MKD subscription.

Table 2. Correlation between age and MKD subscription

MKD potential subscription		
Age	Yes	No
18–29	88%	13%
30–39	70%	30%
40–49	56%	44%
50–67	38%	63%
>67	29%	71%

Table 3. Correlation between attitudes and MKD subscription

MKD potential subscription percentage [%]			
	Attitude toward adoption of social media	Importance of time saving for on-line services	Importance of avoiding food waste in grocery shopping
Very Low	40%	52%	33%
Low	50%	54%	50%
Average	64%	61%	47%
High	75%	62%	68%
Very high	83%	86%	78%

3 Results Analysis

3.1 Estimation of Kilometers Saved Through MKD

Based on survey results, a first estimate of the kilometers that can be moved from single round-based trips for grocery shopping to MKD routes is hereafter proposed considering the trips currently made by car, in order to understand if MKD can help in reducing travelled distances and related externalities.

The adopted procedure works as follows:

1. The number of users making their grocery shopping by car (g) is estimated:

$$n_{car}^{g} = \frac{N_{car}^{g}}{N^{g}} \cdot 100 \tag{1}$$

   where N_{car}^{g} is the number of users that stated to make grocery shopping by car during the survey, while N^{g} is the total number of users that makes grocery shopping;
2. As highlighted in the previous paragraph, those who use cars are more likely to going to supermarkets and large-scale retail trade centers s ($n_{car}^{g,s} = \alpha^{s|car} n_{car}^{g}$), where $\alpha^{s|car}$ is the survey share of users going to supermarket; thus, $n_{car}^{g,s}$ is divided according to revealed travelled distances (the distances are investigated in the survey according to specific classes $c^{d|type}$ that are a function of the *type* of shop reached; for supermarket and large scale retail trade centers, classes can be seen in Table 4, where the median value is adopted for each class, except for the last one where a value of 5.5 km is assumed):

$$n_{car,c^{d|s}}^{g,s} = \alpha^{c^{d|s}} n_{car}^{g,s} \; \forall \, c^{d|s} \tag{2}$$

3. For each distance class, users interested in adopting MKD services are computed:

$$n_{car,c^{d|s}}^{g,s,MKD} = \alpha^{MKD|c^{d|s}} n_{car,c^{d|s}}^{g,s} \; \forall c^{d|s} \tag{3}$$

4. The average weekly frequency $f_{car,c^{d|s}}^{g,s,MKD}$ of grocery shopping of users belonging to each distance class and joining MKD services is computed;
5. The kilometers traveled by car per week to carry out grocery shopping (round trips) are estimated as:

$$km_{car}^{g,s,MKD} = 2 \sum\nolimits_{c^{d|s}} n_{car,c^{d|s}}^{g,s,MKD} \cdot \overline{c}^{d|s} \cdot f_{car,c^{d|s}}^{g,s,MKD} \tag{4}$$

6. The kilometers of point 5. Are scaled based on different assumptions on the frequency related to the adoption of MKD, thus computing the kilometers that can be moved from round-based trips to MKD routes.

Points from 2. to 5. Are repeated for those who move for grocery shopping by car but adopting a mixed behavior: i.e. those users who revealed to visit both supermarkets and small retail stores. In such a case, since the survey did not collect the weekly frequency

Table 4. Distances investigated in the survey as a function of shop type

Supermarket or Large-Scale Retail trades	d < 1 km	1 km ≤ d < 3 km	3 km ≤ d < 5 km	d ≥ 5 km
$\bar{c}^{d\,|s}$	500 m	2 km	4 km	5.5 km
Small retail stores or food markets	d < 0.5 km	0.5 km ≤ d < 1 km	1 km ≤ d < 2 km	d ≥ 2 km
$\bar{c}^{d\,|srs}$	250 m	750 m	1.5 km	2.5 km

differentiating between the two different shop types, two extreme assumptions have been made:

Hp1: a unit weekly frequency is associated to the supermarket, while the remaining fractional share of the weekly frequency is associated to small retail stores; in such a case, the obtained kilometers $km_{car}^{g,mixed-Hp1,MKD}$ are an overestimation of round-based trips since it is assumed a higher frequency for the supermarket which implies higher travelled distances.

Hp2: a unit weekly frequency is associated to small retail stores, while the remaining fractional share of the weekly frequency is associated to supermarket; in such a case, the obtained kilometers $km_{car}^{g,mixed-Hp2,MKD}$ are an underestimation of round-based trips since it is assumed a higher frequency for small retail stores which implies lower travelled distances.

At the end, a range of travelled distances can be computed (Table 5) combining both users moving by car to supermarkets and users moving by car considering the two mixed options (supermarkets and small retail stores).

A similar approach can be found in Gonzalez Felieu et al. [15] that proposed a substitution procedure for estimating number of trips and corresponding travelled distances for shopping drive, home delivery and reception points' strategies. Among all the scenario simulated, they found that the joint usage of home deliveries and proximity reception points the most realistic combination which results in a reduction of around 13% of road occupancy rates in urban areas.

Table 5. Computation of km travelled by car per week: round-based trips for grocery shopping every 100 households

kilometers traveled by car per week to carry out grocery shopping [km/100 households]		
$km_{car}^{g,s,MKD}$	$km_{car}^{g,s,MKD} + km_{car}^{g,mixed-Hp2,MKD}$	$km_{car}^{g,s,MKD} + km_{car}^{g,mixed-Hp1,MKD}$
164	188	207

According to point 6., and given the kilometers computed in Table 5, it is possible to derive the kilometers that can be moved from round-based trips to MKD routes (Table 6). Finally, an estimation of possible reduction in emissions of CO is conducted

adopting the kilometers per week moved from round-based trips to MKD routes and considering the MKD service provided through electric vehicles such as cargo bikes; thus, CO emissions can be considered proportional to the kilometers moved to MKD, according to the average emission factor for passenger cars provided by ISPRA [16].

Table 6. Estimation of km moved to MKD and related reduction of externalities

		km per week moved from round-based trips to MKD [km/100 households]		
MKD adoption behavior	MKD adoption frequency [times/month]	$km_{car}^{g,s,MKD}$	$km_{car}^{g,s,MKD} + km_{car}^{g,mixed-Hp2,MKD}$	$km_{car}^{g,s,MKD} + km_{car}^{g,mixed-Hp1,MKD}$
Frequent user	8	47	54	59
Average user	4	23	27	30
Under Average user	2	12	13	15
Occasional user	1	6	7	7
		g of CO saved for each week [g/100 households]		
MKD adoption behavior	MKD adoption frequency [times/month]	$km_{car}^{g,s,MKD}$	$km_{car}^{g,s,MKD} + km_{car}^{g,mixed-Hp2,MKD}$	$km_{car}^{g,s,MKD} + km_{car}^{g,mixed-Hp1,MKD}$
Frequent user	8	20	23	25
Average user	4	10	11	12
Under Average user	2	5	6	6
Occasional user	1	2	3	3

Results, summarized in Table 6, show that the kilometers per week moved from round-based trips to MKD can range from 6 km/100 households (scenario related to MKD occasional user and minimum value of km travelled for grocery shopping) to 59 km/100 households (scenario related to MKD frequent user and maximum value of km travelled for grocery shopping); the reduction of CO emissions is equal to 2 g/100 households and 25 g/100 households, respectively.

4 The Work Ahead: Development of a Behavioral Model

The next step of this work consists in the investigation of the potential adoption of MKD through the development of a behavioural model; indeed, the behavioural model will allow to generalize the results, simply computed on the basis of the percentages derived

by the survey, while considering socio-economic factors and personal attitudes of each single user. Thus, interviews output is the basis for the development of a random utility model (RUM).

Given a study area U and a number of households N, the potential users adopting MKD service, N^{MKD}, can be forecasted as follows:

$$N^{MKD} = \sum\nolimits_{z \in U} N_z^h \cdot p_z^{MKD}\left[m(h_g|\boldsymbol{T}), \boldsymbol{sc}, \boldsymbol{at}, \boldsymbol{MKD}\right] \tag{5}$$

where

- N_z^h is the number of households living in a certain traffic zone z within the study area U;
- $p_z^{MKD}\left[m(h_g|\boldsymbol{T}), \boldsymbol{sc}, \boldsymbol{at}\right]$ is the percentage of households living in zone z with socio-economic characteristics ***sc*** (e.g. income, family size) and attitudes ***at***, usually travelling with mode m for grocery shopping, that potentially can adopt a MKD service;
- $m(h_g|\boldsymbol{T})$ is a function of the habits related to grocery shopping, primary influenced by travel costs expressed as a vector $\boldsymbol{T}$;
- ***MKD*** is a vector that correlates MKD subscription conditions (e.g. cost of each order, minimum order, shipping cost)

Within RUMs family, logit one is the model type chosen for the analysis [17]. Logit models propose the simplest formulation based on the fundamental hypothesis of user rationality (i.e. user chooses the alternative with the maximum perceived utility). The utility U for each alternative j belonging to the set of alternatives J for the user i is composed by a systematic element V and a stochastic error ε:

$$U_i^j = V_i^j + \varepsilon_i^j \; \forall j \in J \tag{6}$$

Logit model assumes that the random elements ε_i^j are distributed independently and identically as a Gumbel distribution with a parameter ϑ. This hypothesis allows the computation of the probability of choice, p_i^j, as follows:

$$p_i^j = \frac{e^{V_i^j/\vartheta}}{\Sigma_{j' \in J^e} e^{V_i^{j'}/\vartheta}} \; \forall j \in J \tag{7}$$

The systematic utility component V_i can be expressed as a linear combination of the attributes X_k through their relative coefficients β_k and an additional coefficient ASC (alternative specific constant) which represents all the factors not expressed through the parameters:

$$V_i^j = \left(\Sigma_k \beta_k * X_{i,k}^j\right) + ASC^j \tag{8}$$

$$\ln L(\beta, \vartheta) = \Sigma_i \ln p^{j'}(i)\left(V_i^{j'}\left(X_{i,k}^{j'}, \beta\right)\vartheta\right) \tag{9}$$

In the case of MKD adoption, the logit model can be easily formulated as a binomial model where the alternatives are: 1) subscribe a MKD service; 2) not subscribe an MKD service. In such a case, the alternative 2) is equal to zero, while all attributes X_k are included in the systematic utility.

The calibration of the behavioural model in (5) is currently ongoing: preliminary results showed as socio-economic characteristics ***sc*** influencing the choice are the age of the family member who usually does the shopping for grocery and the household income; instead, statistically significant attitudes ***at*** are the importance toward the time saving and the avoidance in food waste.

5 Conclusions

The online survey conducted provided some important indications, highlighting that some specific attitudes and habits have a greater impact on the choice to join MKD services, as well as age and propensity towards technology and social media play an important role. The analysis highlighted the importance for users to optimize time, travel and costs for shopping, but at the same time showed a certain attention for aspects such as food waste reduction and healthy foods preference.

Based on the information obtained from the survey, the potential reduction in trips (i.e. km travelled) for grocery was estimated (i.e. km moved from single car trip to MKD routes) along with the related reduction of externalities. Results show the potential of save approximately 60 km per week for every 100 households if the use of MKD services became frequent. The related environmental benefits in terms of pollutant emissions could be equally important, as demonstrated by the calculation of the CO reduction if only electric vehicles were used for MKD services.

In the end, a behavioral model (logit model) to generalize the results of the survey and reliably predict the willingness to use a MKD service is proposed as a function of socio-economic factors and personal attitudes. Future works will focus on the calibration, and subsequent validation, of the behavioral model, as well as the check and possible generalization of the results considering larger sample data.

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