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10 April 2016

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– This version 16 March 2016 –

Abstract: Food security, along with growing population and the associated environmental concerns, make food waste and loss a central topic in economic analysis. While food losses occur mostly at the production, postharvest and processing phases of the supply chain, food waste takes place mainly at the end of the chain and therefore concerns primarily the habits and behaviour patterns of retailers and consumers. Many solutions and practices have been proposed and oftentimes implemented in order to "*keep food out of landfills*", thus reducing food waste at the source. However, little attention has been paid to the possible sharing of consumer-side food surplus. In this context, food sharing could represent an effective way to tackle food waste at the consumers' level, with both environmental and economic potential positive effects. Currently, several initiatives and start-ups are being developed in the US and Europe, involving the collection and use of the excess of food from consumers and retailers and the promotion of collaborative consumption models (e.g. *Foodsharing, Growington, Feastly,* etc.). Nevertheless, there is still little empirical evidence testing the effectiveness of introducing sharing economy approaches to reduce food waste. This study seeks to fill this gap through a framed field experiment. We run two experimental treatments; in the *control treatment* students were asked to behave according to their regular food consumption habits, and in the *food sharing treatment* the same students were instructed to purchase food, cook and consume it collectively. Preliminary results showed that the adoption by households of food sharing practices do not automatically translate into food waste reduction. A number of factors (environmental and economic *awareness*, *domestic skills* and *collaborative behaviors*) might act as 'enablers' to make sharing practices effective.

Keywords: Food waste, sharing economy, food sharing, framed field experiment

1. Introduction

Food waste is recognized as a major issue for global environmental, economic and health security (e.g. Sobal and Nelson 2003; WRAP, 2015). In particular, recent demographic trends and worsening environmental conditions contributed to place food waste reduction on the policy agenda of national and international institutions[1].

According to the US Environmental Protection Agency (EPA), food waste currently represents the single largest type of waste entering landfills. Wasted food leads to over utilization of water and fossil fuels and to increasing greenhouse gas emissions, i.e. methane and carbon dioxide arising from degradation of food in landfills (Hall et al., 2009). Therefore, the environmental impact of food waste is twofold: on the one hand, it is associated with the depletion of natural resources used for its production (e.g. soil depletion) and distribution; on the other hand, it relates to the costs associated with waste disposal. In addition to these environmental costs, there are substantial economic costs for producers, consumers and institutions, as well as a number of social costs.

Globally, per capita food waste by consumers amounts to 95-115 kg/year in Europe and North-America, compared to 6-11 kg/year in South/Southeast Asia and Sub-Saharan Africa (Gustavsson et al., 2011). Waste reduction at the consumption level represents, indeed, a target for medium- and high-income countries, where evidence shows that the main source of the problem is the domestic setting (e.g. Monier et al., 2010; Braun, 2012). From an exclusively economic standpoint, an average family in the UK would save £470 a year just by eliminating avoidable food and drink waste (Quested et al., 2013). Further, food waste reduction would also contribute to reducing food prices (see Parry et al., 2015).

A number of prevention and mitigation measures, proposed by various countries, have been already put in place to reduce food waste (FAO, 2014). However, along with such practical solutions, new and alternative consumption models are gaining influence in wealthy countries. As pointed out by Cohen (2013), modern high-income societies are entering into a phase of post-consumerism. This has created a situation where the transition towards a more participatory and shared economy has become ever more widespread. Belk suggests that the sharing economy approach involves "the act and process of distributing what is ours to others for their use and/or the act and process of receiving or taking something from others for our use" (2007: 126). Thus, introducing sharing economy principles to food consumption may represent an effective way to reduce food waste.

Recently, food sharing has generated a great interest among analysts, scholars and grassroots organisations as an increasing number of startups have been spreading across Europe and the US (see for instance Foodsharing in Germany and Cookening in France). However, the re-use of food surplus among different families, but also within the same family, is a highly complex issue owing to the particular way food is perceived by society (Evans, 2012). Accordingly, the assumption that this type of approach necessarily leads to food waste reduction, with benefits for the environment, local municipal bodies and household savings, is not a foregone conclusion. Not only but there is still a general lack of empirical studies testing this potential beneficial relationship. This paper seeks to fill this gap by a framed field experiment analysis, involving students living in campus apartments.

[1] Zero food loss and waste within the UN Zero Hunger Challenge, FAO Global Initiative on Food Loss and Waste Reduction. EC's goal to cut down food waste to one-half by 2020. See also German Government's Waste Prevention Programme and The Italian National Plan for Food Waste Prevention.

The paper is organized as follows: Section 2 is a review of the literature on food waste and food sharing. Section 3 describes the experimental methodology and design. Section 4 shows the pilot results and, section 5 discusses the main outcome of our findings. Finally, section 6 concludes the paper and sets out the lines of our future research.

2. Literacy review

Wastage of food originally produced for human consumption may occur in all stages of the food chain, from primary production to the consumer level. However, as put by Parfitt (2010), food waste is mostly associated with later stages of the supply chain, mainly during distribution and consumption. In line with several studies (e.g. Gustavsson et al., 2011 and Kummu et al., 2012), we will follow this approach throughout the paper, referring to food loss as wastage occurring during production, post-harvest and processing level of the food supply chain, mainly due to the weak infrastructure of countries and their limited skills.

As mentioned above, a core issue is the extent to which food is wasted at the consumption stage in industrialized countries; indeed several studies showed that food waste occurs largely at the consumer level rather than at the processing and distribution levels (e.g. Griffin et al., 2008).

Until now, most of the empirical evidence on household food waste has been based on regional, country and community level studies, using a wide variety of different methods (Gallo, 1980; Parfitt et al., 2010). These include questionnaire surveys (e.g. Pekcan et al., 2006), food diaries (e.g. Langley et al., 2010; Williams et al., 2012), composition analysis of consumers' waste (e.g. Ventour, 2008, Quested and Johnson, 2009), estimations based on population metabolism and body weight (Hall et al., 2009), archaeological techniques in contemporary landfills (see the Arizona Garbage Project, Jones, 2004) and inferential analyses (e.g. Sibrian et al., 2006). In addition to the variety of methods, researchers often also use different definitions of food waste. For instance, some studies (e.g. Ventour, 2008) focus on three distinguished kinds of food waste: 'avoidable', 'possibly avoidable' (that is food that not all believe they can eat, such as bread crusts and potato peelings) and 'unavoidable' (e.g. orange peel), while in others (e.g. Kantor, 1997; Gustavsson et al., 2011) unavoidable waste is not calculated. The heterogeneity of methods and definitions makes it difficult, if not impossible, to compare across different studies (Parfitt, 2010).

With regard to consumers' high propensity to generate waste, the literature points at several main reasons such as the tendency to purchase more than needed, increased nutritional standards (Evans, 2011) and the careless attitude of affluent consumers (Gustavsson et al., 2011). Moreover, many consumers incorrectly interpret food labels (Halloran et al., 2014) and are highly influenced by promotional offers of supermarkets and, in general, by packaging (Williams et al., 2012). Overall, many of these behaviors can be recognized as inadequate domestic skills, which include poor purchase planning, limited culinary skills and inadequate house storage (Cox and Downing, 2007).

Recent studies suggest that, most probably, household waste production will be negatively affected by the increasing population growth (Parry et al., 2015) and particularly by the expected growth of world middle class (Morone, 2016). Accordingly, new models of consumer behavior are being evaluated. In this regard, there has been an increasing interest in food sharing as a solution to this threat (Ganglbauer et al., 2014). Food sharing practices have been first documented by anthropological studies on primitive and contemporary hunter-gatherer societies (e.g. Peterson,

1993; Hunt, 2000; Ziker and Schnegg, 2005; Jaeggi and Gurven, 2013). To avoid wasting parts of the hunted animal (those that the hunter and his household would not be able to consume by themselves), the meat is shared. Although these nomad societies are based on an egalitarian political organization, their practical purpose is still suitable to the non-egalitarian sedentary society, which represents the prevailing structure of modern economies. That is, people share food to avoid unnecessary resource waste. Against this background, we propose a novel study, which applies experimental methodology to the field of food waste. This is, to the best of our knowledge, the first attempt to assess the existence (or not) of a causal relation between food sharing and waste reduction. In fact, through a framed field experiment, we will be able to single out the direct effects of food sharing on waste production, controlling for several other variables influencing subjects' behaviors. The following section will provide a brief description of the methodology applied to this aim.

3. Experimental methodology and design

3.1 Methodology and research hypothesis

Going beyond correlation analysis in order to establish causation is one of the major empirical challenges social scientists must face. Specifically, economists using variations in naturally occurring data manage answering causal questions through the use of theoretical models and econometric techniques. However, an important recent innovation in the study of causation is the use of controlled laboratory experiments, where causation among variables is typically achieved via randomization.

In the past decade, many studies that collect data via field experiments have complemented laboratory and naturally occurring data research (e.g. Harrison and List, 2004; Levitt and List, 2007). Similar to laboratory experiments, field experiments use randomization to achieve identification. Differently from laboratory experiments, however, field experiments occur in the 'natural environment' of the agent under observation. As put by List (2009), field experiments are "a useful marriage between laboratory and naturally occurring data" in that they represent a mixture of control and realism not usually achieved in the laboratory or with naturally occurring data. Moreover, field experiments can play an important role in the discovery process by allowing to make stronger inference than the one that can be achieved from laboratory or uncontrolled data alone. Additionally, field experiments might help to uncover causes and underlying conditions necessary to produce data patterns observed in the laboratory or in the field.

As mentioned earlier, in this study we use a specific class of field experiments: namely *framed field experiment*.[2] Framed field experiments share many features with laboratory experiments, but incorporate important elements of the context. Like laboratory experiments, they are conducted in a manner that ensures that subjects understand that they are taking part in an experiment, with their behaviour subsequently recorded and scrutinized. This class of field experiment is well suited to address our research hypothesis, that is:

RH – *sharing practices associated with food purchase and consumption might lead to a reduction in the amount of organic food waste generated at household level*.

[2] Harrison and List (2004) categorised field experiments into three types: artefactual field experiments, framed field experiments, and natural field experiment.

As regards the method used to analyse the organic food waste, we conducted a composition and weigh analysis of the waste generated by respondents. That, in turn, has allowed a more objective analysis than consumer self-measurement methods – e.g. kitchen diaries (Langley, 2010). At the same time, this choice has resulted in a smaller sample size since this type of approach entails higher costs for data collection.

3.2 The experimental design

The framed field experiment was conducted by the research unit at the University of Bari (Italy) over the period November/December 2015. Twenty students living in private shared flats (ranging from 3 to 5 students) were randomly selected. Our reasoning for focusing on young people is that several studies found that they waste more compared to older people (e.g. Hamilton et al., 2005). Additionally, shared flats were identified among those where more food is wasted (Baker et al., 2009). In line with other pilot studies (Langley et al. 2010), the small sample size was deemed sufficient to run this pilot experiment as the emphasis was not on the quantity and proportional significance of the results but in testing a novel experimental methodology in food waste studies, the level of effort required by participants and the objectivity of the data collected.

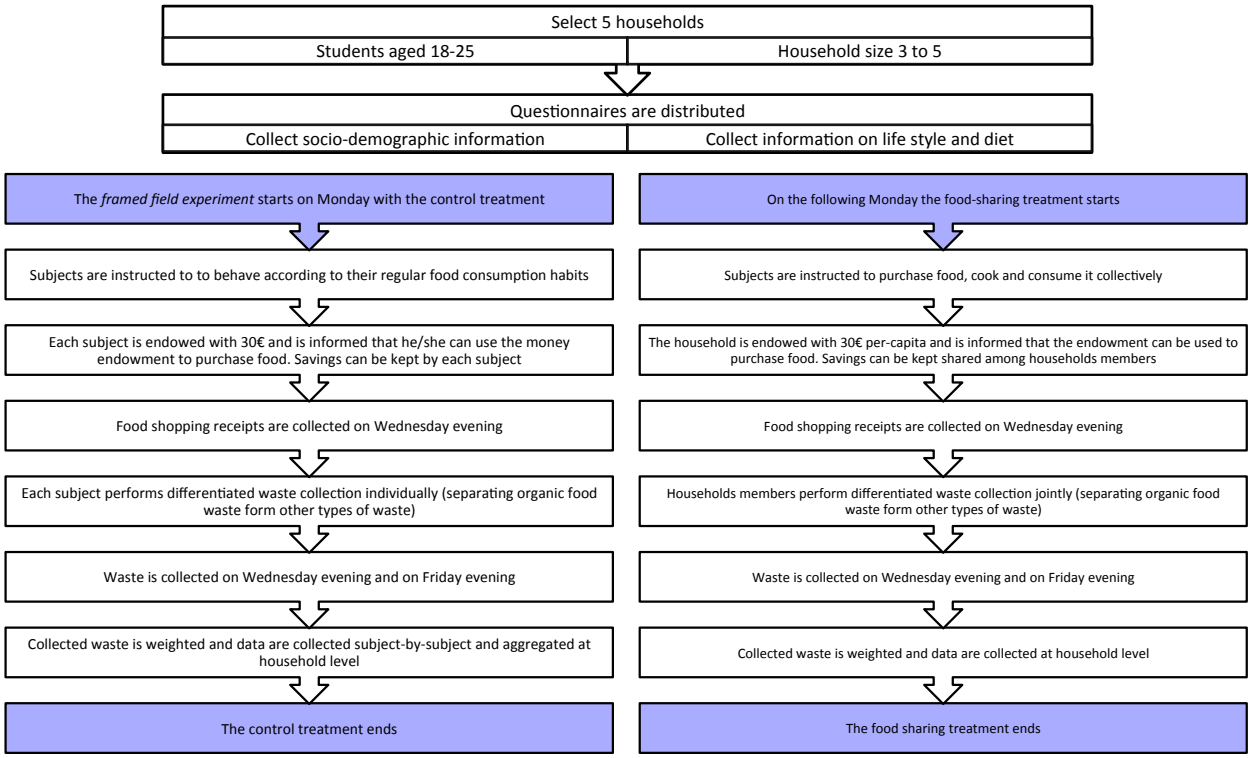
We first submitted a questionnaire to all subjects taking part in the experiment. The questionnaire is composed of two sections designed to collect socio-demographic information (section I) as well as information on life style and diet (section II).[3] We then run two pilot experimental treatments, each lasting 5 days (from Monday to Friday of two succeeding weeks), where students were endowed with a shopping budget of 30€ each and asked to purchase and consume food. In the *control treatment* students were asked to behave according to their regular food consumption habits; food waste produced over the first week was collected and weighted on Wednesday evening and on Friday evening, differentiating organic from other types of waste.[4] Our waste analysis covered all food types (avoidable and unavoidable); moreover, as mentioned above we performed a waste composition analysis, which allowed us controlling for possible errors incurred during the organic food waste differentiation process. Subsequently, in the *food sharing treatment*, starting from the following Monday, the same students were endowed with the same budget and were instructed to purchase food, cook and consume it collectively. Also in this treatment organic food waste was collected and weighted on Wednesday evening and on Friday evening. A detailed description of the experimental design is provided in figure 1.

As we believe, this experimental design allowed us understanding whether the introduction of sharing practices associated with food purchase and consumption has induced a reduction in the amount of waste generated at the household level. Moreover, combining questionnaires data with field experimental data allowed us undertaking a more fine-grained analysis of the effectiveness of food sharing practices with respect to the pre-existent socio-demographic conditions, life style and diet of subjects.

[3] The questionnaire is available from the authors upon request.

[4] We decided not to consider other types of differentiated waste related to food consumption (e.g., plastic, paper and glass associated with packaging), as the timeframe considered was not deemed sufficiently long and also because it might have added an extra burden to subject participating at the experiment.

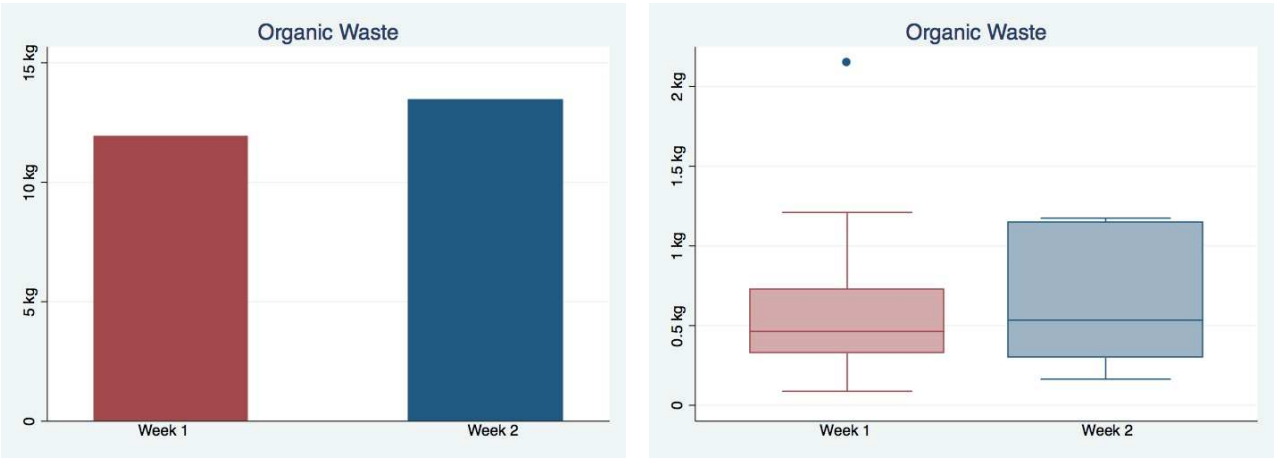
Figure 1. *Experiment flowchart*



4. Pilot results

We commence our analysis by looking at the total organic waste produced by all the participants over the two weeks. The average amount of per capita waste produced in the first treatment is 595.55 g and it rises to 671.75 g in the second treatment. This data correspond to a per capita per week waste equal to 833.77 g and 940.45 g, respectively and is in line with earlier findings (which estimated the average amount of food waste for Italy equal to 884.62 g per capita per week, EC DG-ENV, 2010).

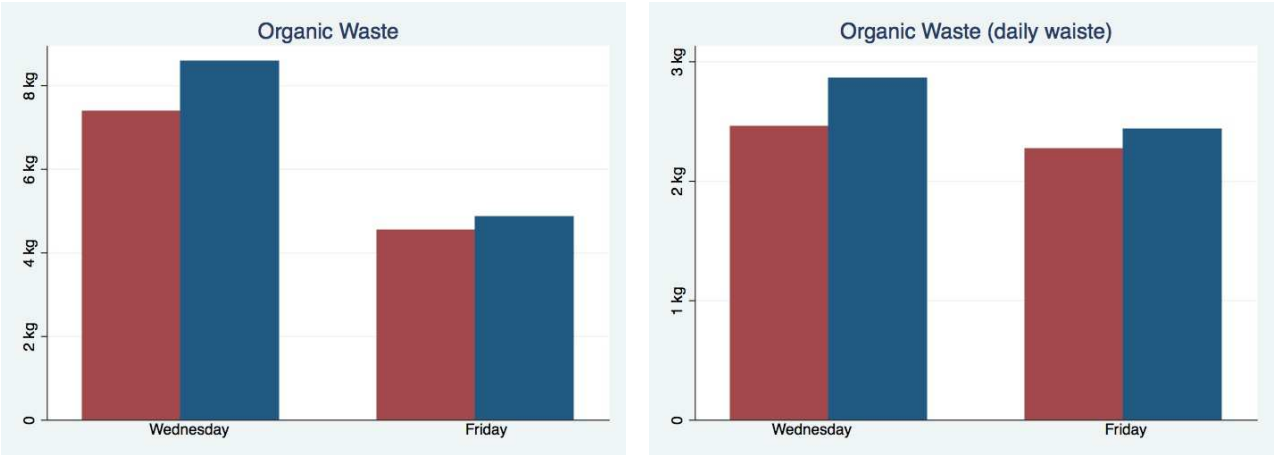
Figure 2. *Cross-weeks comparison of total organic food waste and distribution*



As showed in figure 2 (left box), the overall production of organic waste increased slightly over the second week. However, results from a paired t-test show that the amount of waste produced in the first week is not statistically significantly smaller than the waste produced in the second week (i.e. we cannot reject the hypothesis that difference between the waste produced in the two weeks is statistically different from zero at any significance level). This is confirmed by the box plot distribution diagram (see figure 2, right box).

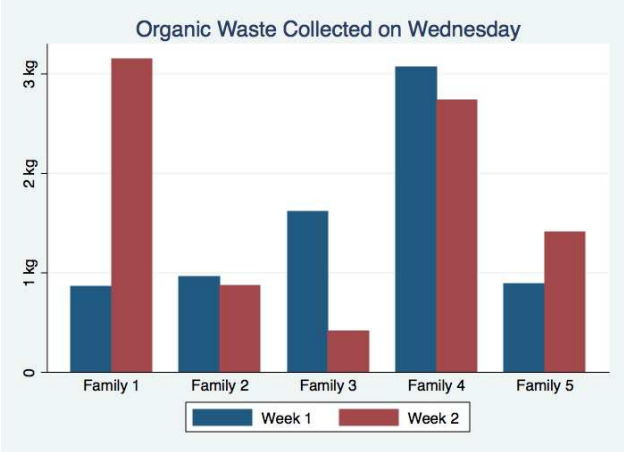
In order to get more insights, we split the total waste production between the two days of collection (figure 3). Also in this case we observe an increase in waste over the second week in both collection days (which again is not statistically different from zero at any significant level). An interesting outcome of this preliminary analysis is the reduction in the amount of waste produced in the second part of both weeks. In fact, when comparing Wednesdays collections with Fridays collections, we see that waste drops by nearly 45%. This result is partially imputable to the fact that waste collected on Friday refers only to two days whereas waste collected on Wednesday refers to three days. Normalizing the data to daily waste (see right box in figure 3) we can still observe in the second part of the week a reduction in the organic waste, though less marked. When looking into the causes of such a drop, we discovered that the composition of two households was not stable in the second half of the week, as some of the flat mates had left the apartment on Thursday evening and returned on Monday morning. Due to this occurrence, we decided to drop observations collected on Fridays since it was impossible to state whether waste production levels was linked to genuine behavioral differences or to variations in households' size.

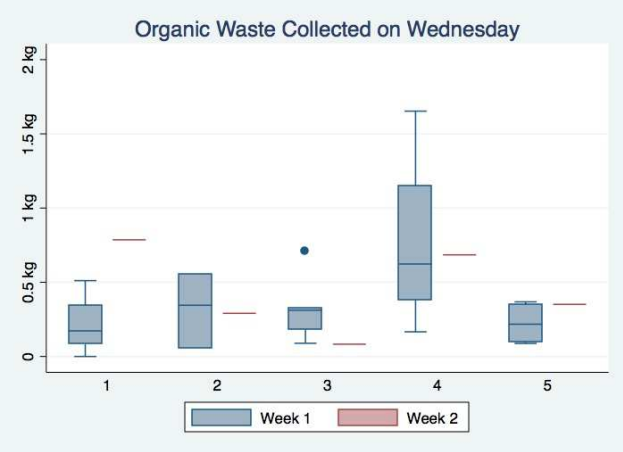
Figure 3. *Cross-weeks comparison by the two days of collection*



Concentrating on Wednesday waste collection data, we can look at within-households variations and observe that, in three families out of five, organic waste reduces when introducing food sharing, whereas in the remaining two families organic waste has actually increased (figure 4, left box). The distribution reported in the box plots (figure 4, right box) shows that cross-treatments variations are relatively small in three households out of five (families 2, 4 and 5) and more marked in the remaining two households (families 1 and 3).

Figure 4. *Cross-weeks comparison by families and distribution*





When examining the socio-demographic characteristics as well as the differences in life styles, we observe that in the three families where food sharing led to a reduction in waste production, family members had previously engaged in separate waste collection, whereas this had not been the case in the remaining two families. This finding is in line with other empirical evidence (e.g. Williams et al., 2012) and points at the importance of environmental awareness in such cases.

Another interesting emergent feature is the awareness to food shopping. Specifically, we confronted individual data on declared average food expenses retrieved through the questionnaires[5] (*ex-ante food expenses*) with data on actual food expenses retrieved through collection of all receipts of food expenses over the duration of the experiment (*ex-post food expenses*).

Table 1. *Ex-ante vs. Ex-post expenses*

All families	*Ex-ante food expenses*	*Ex-post food expenses*
Ex-ante food expenses	*1.00*	
Ex-post food expenses	***0.51***	*1.00*
Families 2, 3 & 4	*Ex-ante food expenses*	*Ex-post food expenses*
Ex-ante food expenses	*1.00*	
Ex-post food expenses	***0.83***	*1.00*

[5] A specific question asked the weekly amount of budget devoted to food shopping.

As showed in table 1, the correlation index between ex-ante and ex-post food expenses is equal to 0.51 when considering all families. It rises to 0.83 when restricting the sample to those families that reduced food waste over the second week of the experiment. As it seems, this finding would suggest that these three families were more aware about their food budget. Therefore, economic awareness seems to be an important feature when it comes to assess the effectiveness of food sharing practices over waste reduction.

Concentrating our attention on families 1 and 5, other anecdotal occurrences were registered during the experiment. Specifically, household members of the first family made several mistakes while differentiating organic waste. Notably, while performing the waste composition analysis (before weighting organic waste) on the first Wednesday, experimentalist reported that all subjects incurred in differentiation problems mixing organic with other sources of food waste (as an example, a tuna tin and an empty box of cigarettes was found in the organic collection bag of one subject). Moreover, 2 subjects out of 4 systematically jointly collected their organic waste (although clear instruction where given to collect organic waste individually over the first week). Similar problems associated with separate waste collection, were observed in the fifth family. Additionally, in this household, 2 subjects out of 4 reported to have special diet needs due to food intolerances. A fact that might have added complications when putting in place food sharing practices. Finally, as mentioned above, families 1 and 5 where the only two groups who did not experience previously separate waste collection. All in all, this finding would suggest that a general lack of domestic skills might have hindered food sharing effectiveness in terms of waste reduction.

Finally, in some cases non collaborative and antisocial behaviors have been observed in families 1 and 5. Specifically, some subjects were caught cheating as they declared to be home during the whole time-frame of the experiment, while it emerged from a cross-inspection that they had left the apartment on Thursday going back home to their parents' families. Moreover, in the fifth family we found out that during the second week of the experiment (the food sharing treatment) a household member was permanently replaced by another person, without informing the experimentalists. Both these occurrences, suggest that non-collaborative behaviors might have hindered food sharing effectiveness.

Going back to our research hypothesis, and bearing in mind all the limitations of this pilot investigation, we can preliminary conclude that *sharing practices associated with food purchase and consumption might lead to a reduction in the amount of organic food mostly for those families (or groups of individuals) showing a certain degree of environmental and economic awareness, adequate domestic skills and collaborative behaviors*. We shall further discuss these outcomes in the following section.

5. Discussion

This study probably represents the first attempt in the literature to investigate the causal relationship between food sharing practices and food waste reduction. Results from a pilot experiment show a drop in the organic food waste, associated with food sharing practices, only in three families out of five. On the other hand, two families out of five increase the amount of food waste when confronting the control treatment with the food sharing treatment. This shows that food sharing practices would not automatically lead to food waste reduction. Actually, both occurrences (waste

increase and waste reduction) were observed, suggesting that pre-existing subjects' heterogeneity resulted in different responses to the sharing treatment.

An in-depth analysis of this puzzle led us to identify three key elements, which appear to enable food waste reduction when sharing practices are undertaken. These are: (1) awareness; (2) skills; (3) collaborative behaviors.

First, people need to be aware both of the environmental and the economic benefits associated with sharing practices. Moreover, specific skills are required in order to make food sharing practices effective, e.g. the above mentioned domestic skills. Finally, people react to sharing practices in accordance with their more general attitude to collaboration and might be inclined to undertake antisocial behaviors in the attempt to maximize their private utility. As it seems, the lack of all or any of these elements might jeopardies the potential positive impact of food sharing practices over waste reduction. At the same time, stimulating both environmental and economic awareness might initiate a virtuous circle leading eventually to specific skills acquisition and enhance collaborative behaviors. This sets a challenge for the policy makers.

6. Conclusions and further analysis

Along the preliminary results and many insights described above, conducting this framed field experiment has been very instructive also in terms of future developments of the research. The experience gathered through this study enhanced our methodological underpinnings and will provide a valuable starting point for running a larger scale experiment. Indeed, the sample size represents a limitation of this study, which should thus be seen as a pilot investigation. As a further step we intend to replicate our experiment over a larger sample, capitalizing on the many lessons learned while conducting the pilot experiment. Specifically, key lessons for future developments are the following:

1) The experimental timeframe should be extended at least to four weeks (two weeks for each treatment). This will allow considering, along with organic waste, food waste related to packaging;
2) Rules for waste collection and separation need to be simplified as much as possible. This would reduce the burden for the participants and minimize non collaborative and antisocial behaviors;
3) Waste should be collected on a daily base. A thorough check should be conducted on-site before weighting and any error incurred in waste separation should be registered and weighted;
4) Waste composition analysis should be complemented with additional information collected through food diaries;
5) Families comprising members with special diet needs (due, for instance, to food intolerance) should not be included in the experiment as they most likely introduce a distortion in terms of extra skills needed to perform effectively food sharing.

Building on these insights learned during the pilot experiment, we will run a larger experiment which, hopefully, will allow us further investigating the relevance of the identified enablers in order to unlock the full potential of food sharing practices.

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