HOUSEHOLD FOOD WASTE BEHAVIOUR IN EU-27 COUNTRIES: A MULTILEVEL ANALYSIS

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Abstract

A large amount of food is lost along the entire food supply chain, causing serious environmental, economic and social impacts and most food is wasted during the final consumption phase especially in industrialized countries. Starting from the analysis of the main regulations and initiatives at various administrative levels and by introducing a two-level framework for modelling complex household food waste behaviour, this paper aims at investigating the behaviour of EU-27 citizens towards food waste by referring to the 2013 Flash Eurobarometer survey (n.388).
The multilevel statistical perspective enabled us to jointly consider factors at both individual and contextual levels as potential variables associated with food waste.
Firstly, by analysing territorial variability it was possible to identify groups of countries characterized by similar behaviour patterns and therefore target them according to the need and exigency of public policy interventions.
Secondly, at individual level it was observed that people living in towns and large cities tend to produce more waste thus emphasizing the need of diversifying policy interventions at local level according to the extent of urbanization. Moreover, education level, sorting practices, attitudes and concern regarding food waste proved to be associated with individuals' behaviour towards food waste.
Thirdly, public-private partnerships as well as targeting community-based interventions to address food waste should be encouraged.

Key words: EU-27 countries; food waste; multilevel analysis; policy; waste management

Introduction

In recent years there has been increasing awareness worldwide towards the loss of food (Kummu et al., 2012; Beretta et al., 2013; Evans et al., 2012; Quested et al., 2013; Jörissen et al., 2015) and it has been estimated that as much as one third of edible food is thrown away each year (Steinfeld et al., 2006; Gustavsson et al., 2011) due to losses that occur during the various phases of the Food Supply Chain (FSC). However, while in developing countries food loss occurs mainly during the earlier stages of FSC - i.e. production and industrial transformation - and are due to a lack of financial, technical and managerial resources, in developed countries loss usually occurs in the final stages of the FSC because of the cultural, social or economic decisions made by producers and final consumers (Dorward, 2012).

Food waste is defined as the loss of food at the end of the FSC, i.e. distribution, retail and final consumption (Griffin et al., 2009; Parfitt et al., 2010; Gustavsson et al., 2011). By focusing on households, which are responsible for most of the food wasted in developed countries (Parfitt et al., 2010), we can divide food waste into: (1) avoidable and possibly avoidable waste referring to "edible" food thrown away and (2) unavoidable food waste which is waste deriving from food preparation that is not and was not edible (WRAP, 2009; Parfitt et al., 2010) such as bones, shells and skins.

The avoidable and possibly avoidable waste of food has various environmental, economic and social impacts as shown in previous studies (Graham-Rowe et al., 2014; Göbel et al., 2015).

From an economic point of view, loss of food in the consumption stage represents a cost for households which was estimated as being equal to £420 a year for an average UK household or approximately € 454 in the case of an average Italian household according to Segrè and Falasconi (2011).

Secondly, several studies have emphasized the environmental impact of food waste (Beretta et al., 2013; Garrone et al., 2014) in terms of Greenhouse Gas (GHG) emissions (WRAP 2008a, 2009; Venkat, 2011) or water wastage (Lundqvist et al., 2008). In 2011, the British Waste and Resources Action Programme (WRAP, 2011a; 2011b) calculated that the average carbon footprint of avoidable household food waste is approximately equal to 330 kg CO_2 equivalent per person per year, corresponding to one third of the CO_2 emissions associated with household electricity use per person in the UK.

Lastly, it was observed that the average amount of food wasted in developed countries every year (220 million tons) is almost equal to the total net food production of Sub-Saharan Africa (Gustavsson et al., 2011) thus underlining the social impacts of food waste.

According to the European Commission, in Europe as much as 42% of all food produced in the FSC is wasted during the final consumption stage, without considering the agricultural phase (Monier et al., 2011). Two thirds of this amount refers to avoidable and possibly avoidable food waste (WRAP, 2009)[1].

In terms of weight, it has been estimated that at household level, EU-27 citizens throw away approximately 76 kg of edible food per capita per year according to BIO Intelligence Service data (Monier et al., 2011). From the same source – which represents the only current reference concerning the amount of food wasted (in terms of weight) in the EU-27 countries – the minimum value equal to 25 kg per capita was observed for the Czech Republic and Slovakia while the highest values were observed for households located in Luxembourg (113 kg per capita) and the United Kingdom (133 kg per capita).

Considering the magnitude and importance of the phenomenon, there is much debate on this issue in Europe at central, national and sub-national levels with the aim of reducing household food waste.

At EU regulatory level, the European Parliament debated on how to avoid food wastage and approved (19 January 2012) a resolution recommending that the European Commission should take practical measures in order to halve food waste by 2025.

[1] According to Gunders (2012) US families throw away approximately 25% of the food and beverages purchased. The estimated cost of food wasted by an average family of four members ranges from $1,365 to $2,275 annually.

At national and sub-national levels, numerous initiatives have been implemented in EU countries to reduce the accumulation of food waste by raising citizens' awareness through campaigns, information, training and improving logistics[2]. Moreover, many retailers have started activities aimed at reducing household food wastage, i.e. the Spanish supermarket chain Eroski donates damaged perishable food products while the UK Tesco supermarket chain created the "buy one, get one free later" initiative, aimed at cutting down food wastage of perishable products deriving from 2X1 promotions by allowing customers to take home the second free product at a later date (BCFN, 2012).

Although much effort has been made to tackle this issue at the various levels – mainly by preventing food waste through recommendations, regulations, reduction targets and research programs – and to identify factors that motivate citizens to minimize household food waste, the available information for Europe is extremely heterogeneous and the lack of common and harmonized methodologies for gathering food waste data have hindered global surveys at EU level and have made it difficult to carry out comparisons between the results obtained from existing studies and statistics at national level (Bräutigam et al., 2014). Unique, harmonized and complete surveys are required for investigating the roles played by the economic, social and environmental factors of the citizens' place of residence (Southerton et al., 2011; Quested et al., 2013) in shaping individual behaviour towards food waste.
Two recent Flash Eurobarometer surveys (n. 316 in 2011 and n.388 in 2013) provided statistically representative information at EU27 level concerning citizens' attitudes and behaviour towards resource efficiency, household waste management as well as towards food waste. By considering edible food waste at household level, these surveys collect the individuals' estimation of the percentage of food wasted[3] through self-administrated questionnaires, which is an indirect method of gathering data previously used in the context of food waste (Moller et al., 2014). The representativeness of the surveys for EU-27 countries makes it a valuable source of information for analysing individuals' food waste behaviour by controlling for the context in which they live.[4]

Bearing in mind the hierarchical structure of the most recent Flash Eurobarometer data (survey n.388), this study aims at exploring the phenomenon of household food waste at European level, within the multilevel statistical model framework from a two-fold perspective.
Firstly, by modelling the unobserved heterogeneity at country-level with multilevel models, we will determine whether and to what extent differences in individuals' behaviour towards food waste are associated with the socio-economic context in which they reside thus obtaining statistical information concerning the territorial variability across countries as well as adjusting individuals' behaviour for their country of residence.
Secondly, we will assess if and to what extent the strong association between the demographic and socio-economic characteristics of individuals and their behaviour towards food waste, which were highlighted in previous studies carried out at national or subnational level, is confirmed. Moreover, the role of individuals' motivations, attitude and values is explored.

The remainder of the paper is structured as follows. A review of the main regulations, initiatives and policies implemented at the various administrative levels for the prevention, management and reduction of food waste are reported in the next section followed by our conceptual framework which includes both individual and contextual variables as potential factors associated with household food

[2] For example, in 2009 the Bruxelles Environment (IBGE) organized a training program for citizens aimed at helping households to reduce their food waste production by means of cooking courses. Several countries (e.g. Austria, France, Italy, UK, Spain) have launched food bank programs in order to distribute surplus food to people in need and in Italy the Last Minute Market project puts retailers, stores and producers who have unsold food, which would otherwise be discarded, in touch with charities and people in need.

[3] By asking the respondents "*Can you estimate what percentage of the food you buy goes to waste?*", this study focuses on edible food waste at household level, which includes home-grown food and beverages, food purchased from shops and takeaways and consumed within the home (the United Kingdom Waste & Resources Action Programme,WRAP, 2009).

[4] As further explained in the following pages, a comparison between the statistics at EU-27 country level obtained from the Flash Eurobarometer source of data and the BIO Intelligence Service data was carried out in order to test the concordance of the two sources of data and therefore the reliability and robustness of the analysis carried out in the paper.

waste behaviour. The 'Household food waste behaviour at European level' section focuses on the 2013 Flash Eurobarometer (n.388) survey regarding the EU-27 countries by providing descriptive analyses and addressing the reliability of these data. The random effect model is discussed in the 'Method' section as well as the variables to be included in the estimation process at both individual and country levels. Our findings concerning territorial variability and the association between individual and area-level covariates and food waste are reported in the 'Results' section. Lastly, we discuss the results, propose some implications and put forward suggestions for future research.

Management policies and initiatives towards food waste reduction

The management of food waste involves several policy areas including sustainable resource management, climate change, energy, biodiversity, habitat protection, agriculture and soil protection. This section proposes a systematic review of the most important initiatives and programs carried out at various levels (EU, national, intra-national) in recent years.

Most of the initiatives towards food waste reduction implemented by the EU are included in the broad framework of the EU waste policy which foresees a series of environmental programs and legislations aimed at reducing the negative effects that waste has on people's health and the environment and promoting a resource-efficient economy (European Commission, 2010).

From an environmental perspective, in 1999 the "Biodegradable waste diversion targets of the Landfill Directive 1999/31/EC" was approved in order to halve the emissions of methane caused by the decomposition of biodegradable waste in landfills which accounted for approximately 3% of total GHG emissions (in the EU-15 in 1995). This directive, also known as the *Landfill Directive*, is aimed at gradually reducing the amount of Biodegradable Municipal Waste (BMW) to be landfilled. However, the Landfill Directive does not instruct countries how to dispose of the BMW which is not landfilled thus leading most Member States to opt for incineration (Monier et al., 2011).

Moreover, the EU's Sixth Environment Action Programme (2002-2013) identified waste prevention and management as one of its top priorities. This led to the development of a long-term waste strategy within which the "Thematic Strategy on Waste Prevention and Recycling" [5] was approved in 2005 (December) and the Waste Framework Directive was revised.

In 2008, the revision of the Directive (EU Waste Framework Directive 2008/98/EC) set the basic concepts and definitions related to waste management, such as waste, recycling and recovery. In fact, it defined a clear strategy for the separation, collection and treatment of bio-waste[6] since Article 22 foresees that "Member States shall take measures, […] to encourage:

(a) the separate collection of bio-waste with a view to the composting and digestion of bio-waste

(b) the treatment of bio-waste in a way that fulfils a high level of environmental protection

(c) the use of environmentally safe materials produced from bio-waste".

This Directive requires that Member States adopt waste management plans and prevention programs and that by 2020 each state must recycle 50% of their municipal waste. In July 2014 this target and deadline were updated by the European Commission which proposes a legislation for increasing the amount to 70% by 2030.

The EU is also keen on supporting research programs that focus on the prevention of food waste during the production and retailing phase, as well as on the valorisation of edible by-products[7].

[5] The Thematic Strategy on Waste Prevention and Recycling established the guidelines for EU waste reduction initiatives and illustrated ways for improving the waste management process and reducing the negative impact caused by waste on the environment by means of recycling. This approach means that every item of waste is seen not only as a source of pollution to be reduced, but also as a potential resource to be exploited.

[6] According to the Waste Framework Directive, "bio-waste" is defined as "biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants".

[7] For example, the research project "Processing Raw materials into Excellent and Sustainable End products while Remaining Fresh (PRESERF) launched in 2010, focuses on the development of novel food preservation techniques for a wide product range (frozen and dried products, and ready-to-eat meals). Moreover, in 2010 one of the first joint projects was launched under the coordination of the EU and the Department of Biotechnology (DBT) of Government of India. The aim of this project known as "NAMASTE" (New advances in the integrated management of food waste in India and Europe: use of sustainable technologies for the exploitation of byproducts into new foods and feeds) was to develop innovative, comprehensive and industry-relevant approaches for the conversion of fruit and cereal processing byproducts and waste into new healthy foods.

As citizens' awareness is an essential element for addressing the issue of food waste, the European Commission provided information, proposed good practices and organized campaigns and initiatives in order to reduce food waste and promote a more efficient use of resources[8].
Many European governments have implemented policies or programs regarding food waste. According to the "Preparatory study on food waste across EU27" carried out by Monier et al. (2011), more than a hundred food waste prevention initiatives have been launched across EU countries over the last few years. Most of these initiatives focus on waste reduction and prevention and approximately 25% are research programs implemented to enhance the collaboration of stakeholders in developing new prevention methods. Awareness campaigns represent the second most popular kind of activities (about 21% of the initiatives) and are mainly addressed to families, school children and restaurants. Furthermore, informative leaflets and brochures are also created and distributed by public authorities, industrial associations and non-governmental organizations (NGOs) in order to help specific sectors to minimize food waste.
Most of these programs were implemented by local municipalities or NGOs and are based on voluntary participation. For example, in the UK, the no-profit organization "Waste & Resources Action Programme" (WRAP) is carrying out the 'Love Food, Hate Waste' campaign in order to increase UK citizens' awareness on food waste. Moreover, since 2009 the NGO "Feeding the 5000" has held a series of events where 5000 members of the public are given a free lunch using only ingredients that otherwise would have been discarded. "Feeding the 5000" is also a partner in the delivery of EU-FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies) which is a 4-year project funded by the European Commission whose aim is to create a European Multi-Stakeholder Platform in order to develop a common strategy for preventing food loss and waste throughout the entire FSC by means of social innovation. With a similar intent, in 2013 the Foundation Barilla Center for Food and Nutrition (BCFN) implemented the Milan Protocol which is an international agreement under which signatory countries and organizations commit themselves to halve food waste by 2020 and to promote sustainable agriculture and healthy lifestyles.
Table 1 summarizes the initiatives, campaigns and research programs activated by most EU27 countries.

TABLE 1 HERE

Lastly, there are many important initiatives organized by the private sector. In 2008, the CIAA association (Confederation of the Food and Drink Industry in the EU) published the report "Managing Environmental Sustainability in the European Food and Drink Industries", that established the goals and provides guidelines for avoiding food waste. The main purpose of the report is to invite all stakeholders inside and outside the FSC to participate in a common debate and collaborate together with the aim of demonstrating that collective cooperation is a possible alternative to regulation measures.

Food waste at household level: a conceptual framework

Since food waste at consumer level is a fairly new research topic, the factors that lead to this phenomenon are still under analysis and discussion (Principato et al., 2015).
Food waste is the result of multiple, complex factors and behaviour relating to various aspects rather than the outcome of a single behaviour (WRAP, 2011c; Quested et al., 2013) therefore it is not an easy task to find a "one fits all" conceptual framework concerning this issue. In fact, as stated by Quested at al. (2013), there are various factors that encourage people to reduce their food waste, by acting at individual and household level and considering the variables regarding attitudes and values,

[8] For example it published the articles "10 tips to reduce food waste", clarification of "best before" and "use by" labels in all EU languages on its website. It also supports the annual European Waste Reduction Week aimed at improving citizens' awareness concerning sustainable resources and waste management. Since its introduction in 2009, more than 25,000 awareness-raising initiatives on waste prevention have been implemented through its framework.

motivation, habits, perceived social norm, knowledge and skills related to behaviour, facilities and resources.
With the aim of developing a conceptual framework, we referred to previous studies which examined specific personal and attitudinal factors at individual level that contribute to food waste by adding an additional level represented by the context (in terms of economic, social and cultural characteristics) in which the individuals reside, a dimension often evocated in the waste management issue especially concerning food waste (Ostrom, 1988; Refsgaard and Magnussen, 2009; Evans et al., 2012; Quested et al., 2013).

Firstly, we included the most relevant demographic and socio-economic factors associated with individual behaviour towards food waste, as observed in existing literature. Age and gender are two relevant personal characteristics whose effects on food waste have been highly debated in literature. Regarding gender, most studies found that women waste more than men (Gallo, 1980; Buzby and Guthrie, 2002) although Barr (2007) found that women are more likely to reduce food waste compared to men. As for age, studies carried out in the UK (Osner 1982; Brook Lyndhurst 2007) and Australia (Hamilton et al., 2005) found that the youths waste more than elderly people, above all compared with people aged 65 or over who were found to waste significantly less food than the rest of the population (Koivupuro et al., 2012; Quested et al., 2013; Jörissen et al., 2015). Focusing on socio-economic status and standards of living, it was found that highly educated individuals and with higher disposable income (WRAP, 2008b) as well as higher income families waste more than poorer households (Brook Lyndhurst, 2007; Engstrom and Carlsson-Kanyama, 2004; Buzby and Guthrie, 2002; Koivupuro et al., 2012) while other researchers found little or no correlation between income and food waste (Dowler, 1977; Wenlock et al., 1980).
Age and gender were added to the framework in order to obtain confirmation regarding the magnitude and sign of the correlation with food waste. In addition the level of education (measured in terms of age at which individuals finished their education) and the occupational status were considered at individual level as proxies of socio-economic status, while the income adjusted for Purchasing Power Parities (PPPs) was introduced at contextual level in order to carry out correct comparisons among countries.
We added the variable which accounts for the individuals' place of residence by distinguishing between rural areas, towns and large cities. To our best knowledge, this is the first study which explore the association between these variables and food waste behaviour.

Secondly, some attitudinal variables were included since behavioural theories state that attitudes play a crucial role in influencing a specific behaviour (Ajzen, 1991). This association has also been observed concerning food waste behaviour (Quested et al., 2013). According to these models many factors such as social norms, habits, etc. are useful for obtaining a better understanding of food waste generation and prevention.
Regarding environmental issues, there are contrasting results concerning the association between values and attitudes towards the environment and food waste. On one hand, it was observed that raising individuals' awareness on the environmental impacts of food waste does not seem to reduce it (Principato et al. 2015). On the other hand, it was found that highly conscious individuals regarding the environment waste less food (Williams et al., 2012; Parfitt et al., 2010; Barr, 2007) and that environmental values are associated with recycling behaviour (Vining and Ebreo, 1992).
We believe that it may be beneficial for the analysis to add some pro-environmental variables as well as to consider household waste management practices since it was observed that these recycling tendencies play an important role in explaining household food waste according to the theory of interpersonal behaviour (Triandis, 1977).

Lastly, it is essential to consider not only individual variables, but also variables referring to the context in which individual reside in order to obtain a comprehensive behavioural model regarding

food waste generation and prevention. Several dimensions can be considered concerning individuals' standard of living in the country (area) of residence. Cultural, governmental, technological, economic and industrial variables have been identified as being potential characteristics which can influence household food waste (Quested et al. 2013). In addition food price variations should be taken into account since as Evans et al. (2012) stated "…since 2008 food prices have actually begun to increase cyclically" (p.16) and "the increasing cost of food creates an environment where it is both less desirable, and harder to afford, to waste food". Furthermore, we included disposable income expressed in terms of PPPs at country-level in accordance with previous studies which analysed the association between the average socio-economic status of a country and the generation of food waste (Monier et al., 2011). Graham-Rowe et al. (2014) stressed that the minimization of household food waste was hindered by "the perception that the responsibility for food waste lay with food industry and supermarkets rather than individuals" (p.20). To this purpose an active participation of the entrepreneurial and economic organizations in promoting pro-reduction behaviour regarding food waste as well as focusing their attention towards environmentally-friendly products and services may represent the starting point for involving a wide range of partner organizations – farms, food manufacturers and industries, local authorities, grocery shops and community groups – in the implementation of programs and campaigns (Quested et al., 2011; Quested et al., 2013). Variables as proxies of the eco-friendly and pro-active behaviour towards food waste reduction are introduced in the framework at contextual level.

As yet, little is known concerning the share of heterogeneity in individuals' behaviour that can be attributed to contextual variables. Applying the multilevel framework (illustrated in Figure 1) to the available hierarchical dataset may contribute to shedding light on this issue. To the best of our knowledge this is the first study which jointly considers the two levels of variables for analysing the food waste behaviour of individuals.

Figure 1 illustrates the proposed framework where the variables are divided into two levels: (i) individual level variables and (ii) contextual variables.

FIGURE 1 HERE

Households' food waste behaviour at European level

The Flash Eurobarometer survey n. 388: structure and contents

The Flash Eurobarometer (FE) survey *"Attitudes of Europeans towards resource efficiency"* (n. 388) requested by the European Commission (Directorate-General for the Environment) was carried out in December 2013 on a sample of over 26,000 individuals – 58.9% females and 41.1% males - representative of the national EU-28 countries according to age and gender[9]. The main aim of this survey was to analyze the opinions, attitudes and behaviour of EU citizens concerning the efficient use of resources, waste generation and management as well as elements of the so-called "circular economy" including second-hand products and alternatives to buying new products (European Commission, 2014a). To our best knowledge, this is the most recent official EU representative source regarding individuals' behaviour towards food waste carried out at European level.

As far as the aim of our paper is concerned, this sample survey concerns issues that – if analyzed in depth – can help policy makers as well as social marketers to plan strategies at both European and single-country levels aimed at limiting food waste production effectively. In fact, apart from the socio-demographic characteristics of the respondents, the questionnaire includes questions regarding:

[9] It is important to note that in our study we referred to the EU-27 countries since a comparison with the previous edition of the survey was carried out. In fact, the first edition of this survey (FE n. 316) was conducted in December 2011 and referred to the EU-27 population (European Commission, 2011).

(i) the percentage of food that each individual buys which goes to waste, by distinguishing six categories ranging from "none" to "more than 50%";
(ii) initiatives and actions that would help individuals to waste less food;
(iii) citizens' willingness to pay for waste management;
(iv) perception of the amount of waste generated by the country in which the individuals reside as well as generated by their households;
(v) information concerning the various types of waste sorted (paper, plastic bottles, kitchen waste, glass, etc.);
(vi) citizens' willingness to buy second-hand products as well as attitudes towards the purchase of environmental-friendly durable goods;
(vii) perception of the amount of litter present in the area of residence.

A descriptive analysis

According to the Eurobarometer survey, in 2013 approximately 24% of EU citizens wasted between 6% to 15% of the food they purchased (Figure 2), 10% of citizens wasted more than 15% of food and approximately 1% of individuals threw away more than 50% of the food purchased. On the other hand, 61% of EU-27 citizens declared that they throw away up to 5% of the food they buy, while approximately 5% of the respondents replied that they do not waste any food they purchase.

FIGURE 2 HERE

In all countries most respondents replied that no more than 5% or none of the food purchased goes to waste thus establishing an empirical threshold that makes it possible to divide individuals according to food waste behaviour into two groups: i) those who waste 5%, less than 5% or none of the food they purchase; ii) those who waste more than 5% of food. This division can be considered as a reasonable cut-point in order to distinguish individuals and to analyze behaviour from a policy-makers' perspective, since it is impossible to avoid wasting a minimum amount of food[10].

The highest percentages of individuals *who do not waste any food or no more than 5%* reside in Czech Republic (80.07%), Malta (79.06%) and Estonia (77.05%) while Denmark (51.85%), Sweden (43.68%), the Netherlands (43.03%) and Ireland (41.98%) represent the countries with the highest percentages of individuals who throw away more than 5% of the food they purchased.
Concerning the socio-demographic characteristics, 54% of individuals aged between 15 and 24 wasted more than 5% of food. The percentages of individuals of other age groups are considerably lower: 43.63% for individuals aged between 25 and 34, 30.76% for individuals aged between 45 and 54 up to 16.56% for people aged 65 and over. The strong and significant relationship between the amount of food wasted and age was confirmed by the Chi-square test of independence for which we were able to reject the null hypothesis of independence between variables (Pearson chi2(5) = 1,903 p-value = 0.000). Moreover, the relationships concerning food waste behaviour and gender (Pearson chi2(1) = 154.9848 p-value = 0.000) as well as between food waste behaviour and level of education were found to be statistically significant (Pearson chi2(6) = 827.5064 p-value = 0.000). On one hand, females appear to be more conscious of food waste than males (68.8% of females produce no more than 5% of waste compared to 64.02% of males). On the other hand, people who left school aged 15 or under waste less food than those who left education aged 20 or over: 80.35% of them stated that they waste 5% or less of the food they buy compared to 63.72% for more educated individuals.

[10] The 5% threshold was used when we modelled household food waste behaviour and the results obtained can be seen in Section 4. However in order to test whether a different threshold produces similar results and therefore assess the robustness of our estimates, we made some variations in the cut-off points (15% and 0% respectively). The estimates of these models are reported in Appendix A.

By comparing responses about the amount of food waste generated[11] at country level in 2013 with the results of 2011 survey, a general increase of the percentage of more conscious individuals was observed. In fact, in 2013 about 86% of respondents replied that they waste no more than 15% of the food they buy while in 2011 about 71% of citizens stated that they wasted about 15% or less of the food they purchased (European Commission, 2014a). Moreover, the percentage of respondents who waste none of the food they buy decreased from 11% in 2011 to 5% in 2013.
The greatest positive variation – meaning an increase of the number of people who wasted 15% or less – was observed in Cyprus (+27 percentage points), Luxembourg (+20 points), Ireland (+18 points) and Lithuania (+16 points), as underlined in the report by European Commission (2014a).
Another important aspect that could help in the implementation of policies concerns the practices and information that would help citizens to waste less of the food purchased. As shown in Table 3, the three most helpful actions for EU-27 citizens are identified as using freezers to conserve food longer (60.45%), better estimation of portion sizes (how much food you cook) to avoid wasting food (59.58%) and re-using leftovers instead of throwing them away (58.45%). Besides these general results, it is interesting to assess if differences exist between individual behaviour on the basis of the self-declared amount of food waste generated (Table 2).

TABLE 2 HERE

It was observed that the availability of smaller portion sizes of food in shops would help people who tend to waste a greater quantity of food to reduce food waste, compared to individuals who tend to waste 5% or less (53.42% versus 50.19%). They would also benefit from receiving information concerning the use of freezers in order to conserve food longer (61.39% versus 58.63%). On the other hand, people who already waste less food could further reduce food waste by planning their purchases better. To this aim it would be of help to stimulate people to make a shopping list and identify the factors that can enhance this type of behaviour, as underlined by Stefan et al. (2013) and Principato et al. (2015).
A considerable level of variability was observed across the various nations. It was found that better and clearer information for interpreting best before dates were mainly requested by citizens of Bulgaria, Belgium, Portugal and Spain. The highest proportion of individuals who request better and clearer information on food product labels reside in Portugal and Bulgaria, while more than 66% of UK and Belgian citizens request the availability of smaller portion sizes in shops. Lastly, Cypriots and Greek believe that better household shopping planning would help to reduce the amount of household food wasted more than the other EU-27 citizens.

Evaluating the reliability of self-assessed data for modelling household behaviour towards food waste

As already mentioned, the Eurobarometer data on household food waste are collected through questionnaires in which the respondents are asked to declare the percentage of food they throw away per week. This method[12] of collecting data leads to a subjective estimation of the percentage of food

[11] It is worth noting that the questions in the two waves of the survey (FE n. 316 and FE n.388) have the same text but a different classification of the responses since in the 2013 edition of the survey respondents can distinguish the percentage of the food they buy which goes to waste also between "5% or less" and "6 to 15%" while in the 2011 survey there only was "15% or less".

[12] Various methodological approaches can be used for studying individual and household behaviour towards food waste (Moller et al, 2014). Up to now studies at national level have used household surveys, household diaries or waste composition analyses in order to collect data concerning the weight of food waste. However, each of them have both advantages and disadvantages. It is usually quite simple to implement household surveys which provide primarily qualitative information since quantitative estimates made from memory regarding the weight of food purchased and discarded are very prone to error (Jorissen et al., 2015) and individuals are likely to underestimate the amount of food they waste when self-reporting. Although household diaries can provide reliable data, keeping a diary is time consuming for the respondents and may lead to variations in the handling of food stuff as a result of the conscious participation. Waste composition analyses, which can be carried out without the knowledge and active participation of households, are considered to be the most objective and accurate method for determining the amount of food wasted at consumer level. On the other hand, the limitation of this approach is that there is no international standardized collection methodology and no commonality of the definitions used thus leading to unreliability of the comparisons across countries.

thrown away but this can result in a potential bias of underestimation when determining household food waste (Priefer et al., 2013).
However it is important to note that this source of data provides us with valuable information, since few studies have been conducted at EU or global level (Moller et al., 2014) due to the lack of common and harmonized methodologies for gathering food waste data. Therefore it is difficult to compare the results obtained from the existing studies (Brautigam et al., 2014; Hanssen et al., 2013). In fact, self-administrated questionnaires are a useful tool for collecting data from respondents in a formal and structured way and in this context[13] they can be effectively used for obtaining standardized responses regarding food waste and additional information (Moller et al., 2014).

Bearing these difficulties in mind and with the aim of comparing and determining the reliability of the Eurobarometer data at country level with other official data, we referred to the study carried out by the BIO Intelligence Service (Monier et al., 2011) on behalf of the European Commission which represents the only current reference regarding the extent of food wastage in the EU-27 countries, although "one can doubt whether they reflect the real quantities of food waste generated at the different stages of the food chain"[14] as stressed by Brautigam et al. (2014, page 685). From the study carried out by Monier et al. (2011), we extrapolated the values concerning the quantity of food waste in terms of kg per capita produced by households in a year for each EU-27 country.
With the aim of comparing the Eurobarometer data with the measure collected by the BIO Intelligence Service, we estimated (by referring to our data) the percentage of households in each country who declared to waste food thus excluding the percentage of households that declared not to waste food from this estimation[15]. From a statistical point of view, the concordance between the two sources of data firstly emerged from the magnitude of the Bravais-Pearson correlation coefficient across countries which was equal to 0.71 (p-value=0.000). On carrying out an in-depth analysis, we computed the Spearman rank correlation which was equal to 0.73, the absolute mean deviation across rankings equal to 4 as well as the Spearman and Kendall rank tests – which verify the similarity of the orderings of the data when ranked according to each of the quantities – leading us to reject the null hypothesis of independence at 1% level (p-value=0.000 for both the tests) thus confirming the congruity between the two sources of data. As a result, it seems that household food waste is well portrayed by the subjective measures collected by means of Eurobarometer data thus proving to be useful tools for exploring individual food waste behaviour across countries.

Methods

Specification of the random effect model

The hierarchical structure of the micro data (European Commission, 2014b) – namely individuals (level 1) grouped in countries (level 2) – enabled us to adopt a multilevel framework for analysing the influence of covariates both at individual and national level on food waste behaviour. From a statistical perspective this structure of the data (grouped-data) implies a violation of the assumption of independence among observations within the same second-level units, i.e. individuals living in the same country (Agresti, 2002). In order to deal with this issue we referred to the class of random effect models and specifically to the random-intercept specification in which a country-specific (level-2) random intercept β_{0j} is included in the linear predictor thus enabling us to explicitly model the hierarchical structure of the data and the unobserved heterogeneity (Raudenbush and Bryk, 2002; Skrondal and Rabe-Hesketh, 2004; Goldstein, 2011).

[13] By considering the nature of waste behaviour and the conceptual approach required for the measurement, the self-report methodology through questionnaires (indirect survey) was also used by Barr (2007).
[14] Further details on the methods used for collecting and calculating the figures for the EU27 countries can be found in the studies by Brautigam et al. (2014) and Monier et al. (2011).
[15] It was impossible to compute the exact percentages of food thrown away since the question in the Eurobarometer survey is based on four categories of response, as explained in Section 3. However the comparison between the two sources of data was carried out bearing in mind the 5% threshold which provided similar results (Spearman rank coefficient equal to 0.5 and Spearman test significantly different at the 5% level, p-value=0.0190).

We modelled a dichotomous variable Y_{ij} which represents the self-declared percentage of food waste, produced by individual *i* living in country *j* and which is equal to 0 if the percentage of food wasted is greater than 5% while it is equal to 1 if the amount of food wasted is 5% or less of the food purchased.

Bearing the above in mind, the level 1 model corresponds to a logistic regression model:

$$\text{logit}\left\{\Pr\left(Y_{ij}=1\right)\right\}=\beta_{0j}+\sum_{h=1}^{H}\beta_{1h}X_{hij} \tag{1}$$

in which X_{hij} is the h-th individual-level covariate and β_{1h} the corresponding regression coefficient. In order to account for the higher level of nesting it is assumed that the intercept parameter β_{0j} in (1) is expressed as follows:

$$\beta_{0j}=\gamma+\sum_{m=1}^{M}\beta_{2m}Z_{mj}+u_j \tag{2}$$

where γ represents the overall mean, Z_{mj} represents the m-th covariate at national level and β_{2m} the related regression coefficient. The term u_j is the country-specific random effect that represents also the level 2 error. According to the latter perspective, the random intercept can be deemed as the combined effect of omitted country specific covariates that cause homogeneity among individuals within the same country (Rabe-Hesket and Skrondal, 2008).
Combining the level 1 model in equation (1) and the level 2 model in equation (2), the reduced form of the model is:

$$\text{logit}\left\{\Pr\left(Y_{ij}=1\right)\right\}=\gamma+\sum_{h=1}^{H}\beta_{1h}X_{hij}+\sum_{m=1}^{M}\beta_{2m}Z_{mj}+u_j \tag{3}$$

In the multilevel model framework, the specification of the random effects u_j is a key and challenging task (Grilli and Rampichini, 2014). In fact, the term u_j can be interpreted as an adjusted measure of 'performance' (Grilli and Rampichini, 2009) since it is a residual component that captures all the relevant factors at country level that were not accounted for by the covariates. For consistency of the estimates, the crucial assumption on u_j is that its expectation conditionally on the covariates is null (exogeneity) $E\left(u_j\middle|\mathbf{X}_{hj},\mathbf{Z}_j\right)=0$. In other words, this assumption requires that any unobserved country characteristics included in the error term should not be correlated with the observed characteristics. Homoscedasticity and the normality of the distribution, $u_j\sim N\left(0,\tau^2\right)$ represent less crucial yet standard assumptions (Grilli and Rampichini, 2009).
Since the stochastic part of the multilevel models is more complex compared to single-level models, the endogeneity phenomenon is more difficult to handle. In fact, the standard solution for this type of problem in panel literature is represented by the Within or FE (Fixed Effect) estimator (Wooldridge, 2002). However this estimator does not allow for any cluster-level covariate since these covariates would be perfectly collinear with the cluster indicators which fully explain the cluster-level variability thus leading no scope for cluster-level explanatory variables. For these reasons, the random effect approach is generally preferable in the multilevel framework, even if there is a risk of misspecification of the conditional distribution of the random effects given the covariates thus yielding biased inferences (Grilli and Rampichini, 2006).

A consistent solution for addressing this issue which is generally applied in the multilevel cross-section framework (Grilli and Rampichini, 2006; Snijders and Berkhof, 2008; Rabe-Hesketh and Skrondal, 2008; Hanchane and Mostafa, 2010) is to use the Mundlak approach (Mundlak, 1978) which consists of adding the cluster (group) means $\overline{X}_{hj}$ of individual variables as additional covariates to the model. The Wald test on the slope of $\overline{X}_{hj}$ can be used to verify whether the assumption of exogeneity holds for individual regressors. In fact, Baltagi (2001) demonstrated that the Wald test on the cluster means is equivalent to the Hausman test.
In our study the inclusion of the cluster means of selected covariates in model specified by equation (3) was carried out, as suggested by Rabe-Hesket and Skrondal (2008), for those covariates where both the within (individual level covariate) and the between effects (the related country-level mean) are significantly different from zero. In the estimated model reported in Table 3 we considered a maximum level of significance equal to 10%.
Finally, insight concerning the territorial variability that characterizes the phenomenon in question can be obtained by focusing on the random effects u_j as well as on the country-level variance τ^2 which enabled us to estimate the Intra-class Correlation Coefficient (ICC)[16] representing the percentage of total unexplained variance among Europeans' behaviour towards food waste due to their country of residence.

Variable selection at individual and contextual levels

Bearing in mind the conceptual framework, the initial selection of the variables to be included in the model specification was carried out by computing association measures, correlation and Chi-square tests according to the nature of each variable (Hosmer and Lemeshow, 2000). After identifying the first set of potential variables, various specifications of the model were estimated in order to verify the presence of collinearity among predictors by using the values of the Variance Inflation Factors (VIF) and its inverse, the tolerance factor as selection criteria. Although a common cut-off threshold is a tolerance value of 0.10 which corresponds to a VIF value of 10 (Hair et al., 2010), approximately three quarters of the covariates included in the selected model specification presented VIF values lower than 1.75 with an overall cut-off value equal to 3 which is substantially below the suggested threshold.

Concerning the individual-level covariates, we firstly introduced the following demographic and socio-economic characteristics of the respondents: gender, age in classes (15-24, 25-34, 35-44, 45-54, 55-64, 65 or more), socio-economic status of individuals in terms of level of education according to the age at which an individual finished his/her studies (Up to 15; 16-19; 20 years and older; still in education; no full-time education), occupational status (self-employed, employee, manual worker, looking for home, unemployed) and the ownership of mobile phone, landline phone (or both), area of residence in terms of level of urbanization (metropolitan, urban, rural).

Secondly, the following attitudinal and behaviour variables related to waste management and food waste issues were included in the model:
(i) individuals' opinions concerning the impact of a more efficient use of resources on economic growth and employment opportunities in one's own country;

[16]According to Hedeker (2008), for the ordinal logistic model assuming normally distributed random-effects, the estimated Intra-class Correlation Coefficient equals (τ^2 / (τ^2 + π^2 / 3)), where the latter term in the denominator represents the variance of the underlying latent response tendency. In fact, for the logistic model, this variable is assumed to be distributed as a standard logistic distribution with variance equal to π^2 / 3 by referring to the threshold concept and the underlying latent response tendency that determines the observed response. The ICC can also be referred as the "intra-level-2-unit correlation" (Goldstein, 2011).

(ii) level of agreement with statements regarding the level of waste produced by one's own household as well as the commitment and efforts made for reducing the amount of household waste;
(iii) household waste management practices: it was observed whether kitchen waste was sorted or not;
(iv) initiatives that would convince individuals to separate some (or more) of their waste;
(v) initiatives that each individual views as an effective way for financing the management of household waste by distinguishing whether it was better: to pay a fixed sum for waste management through taxes; to pay in proportion of the quantity of unsorted waste; to include the price of waste management in the price of products purchase;
(vi) environmentally-friendly dimension as a factor taken into account when buying a durable good and being willing to buy second-hand products;
(vii) perception concerning litter in the street and in natural surroundings of the area in which individuals reside (collected by means of an ordinal scale from "a lot" to "none").

A number of second-level variables were included in the model with the aim of adjusting individual behaviour for the context in which the respondents reside thus accounting for the influence of both socio-economic, cultural and industry-related factors on their behaviour towards food waste.
The economic situation of each country was taken into consideration by including in the model: i) the median equivalised net income (2012 - EU-SILC) expressed in PPPs and the ii) food price annual variation (2013 – Eurostat) expressed by the annual rate of change of Harmonized Indices of Consumer Prices (HICPs) for Food products.
Moreover, the share of the entire population who have successfully completed education at university level or similar (ISCED 5 or 6 level, 2013 - Eurostat) was introduced in order to account for the socio-cultural peculiarities of each country.
Furthermore considering that a direct link between behaviour towards food waste and environmental issues at individual level was not observed in previous studies (Quested et al., 2013) – despite the significant impact of food waste on the environment – in accordance with our theoretical framework two variables at country-level were introduced as proxies of the connection between environmentally-friendly behaviour and the agricultural and industrial-tertiary sectors. The rationale of this choice was to study whether and to what extent the diffusion of "good-practices" towards the environment at country-level can be associated with individual behaviour. A significant relationship would help to explain both differences between countries as well as to implement campaigns involving a wide range of partners composed of local authorities, community groups as well as food producers and manufacturers from the industrial sector (Quested et al., 2011). As proxies of the attitudes of consumers and firms towards the environment, the share of total Utilized Agricultural Area (UAA) in each country occupied by organic farming (2012 – Eurostat) and the number of Ecolabel or "EU Flower" licenses – which are awarded to products and services with reduced environmental impacts – per 100,000 inhabitants in each European country (2010 – Eurostat) were introduced in the model as contextual variables.

Results

The territorial variability

The estimation of multilevel models was carried out in two steps. Firstly by only including the individual-level variables in the model; secondly by adding the contextual variables in order to determine the effect of the place and context of residence in the reduction of the second-level residual variability which is responsible for the differences in intra-country behaviour which cannot be explained by individual-level variables.

By focusing on the random part of the models and specifically on the country-level variance τ^2, the estimated ICC shown in Table 3 as well as on the random effects u_j (Figure 3a and 3b), we obtained valuable insights concerning the territorial variability of individual behaviour towards food waste.

TABLE 3 HERE

The existence of intra-country heterogeneity in the behaviour towards food waste is confirmed by the country-level variance τ^2 and the ICC coefficient whose statistically significant value was equal to 4.6% when only individual level covariates were considered in the model. After introducing the contextual variables, a further reduction of the second-level variability was observed which in turn lead to a reduction of the ICC up to 0.6%. From a statistical perspective this result confirms the validity of our theoretical framework, which also takes into consideration the contextual effects as factors that explain individual behaviour towards food waste.
The random effects u_j – which summarize all the factors at country level that were not observed and explained by the variables introduced in the model – provided us with useful information on the cross-country differences. The predicted random effects were computed as the mean of the posterior distribution of the random intercept with model estimates plugged in (Rabe-Hesketh and Skrondal, 2008), the so-called Empirical-Bayes (EB) residuals[17].
Countries with negative (positive) values reveal the presence of unobserved factors at country level that reduce (increase) the likelihood of wasting small amount of food.
Figure 3a reports the country random effects u_j estimated for the model - which only considered variables at individual-level - while the estimated random effects for the full model can be seen in Figure 3b.

FIGURE 3 HERE

Figure 3a shows that countries such as the Czech Republic, Lithuania, Estonia and Poland, lie in the upper right-hand corner thus proving to be less likely to waste food while Denmark, Ireland and Sweden are more likely to waste large amounts of food.
When considering the full model there are fewer differences among countries, which can be seen in the overlapping confidence intervals in Figure 3b (Grilli and Rampichini, 2009). Belgium, the Czech Republic, Lithuania and Austria are situated in the upper-part of the graph and are the countries showing the best performance in terms of food waste. The performance of these countries significantly differs from Hungary, the United Kingdom and Ireland which are situated on the left-hand side and therefore are more likely to waste large amounts of food.

Individual and area-level covariates

Table 4 shows the results obtained through the random intercept model presented in equation (3). The estimates are presented in terms of Odd Ratios (ORs), a widespread measure of association used in logistic regression models (Hosmer and Lemeshow, 2000). Considering a categorical covariate, an OR greater than 1 implies that the event under study (in our case the generation of small amounts of food waste) is more likely to occur for the specific category compared to the reference category. On the other hand, an OR less than 1 implies that the event is less likely to occur in that category. An OR equal to 1 implies that the event is equally likely to occur in both categories.

[17] It is worth noting that since the residuals are affected by sampling variability and other sources of error, the corresponding ranking has a degree of uncertainty which is difficult to represent since it implies carrying out multiple comparisons. The usual approach is to build pairwise confidence intervals (Goldstein and Healy, 1995; Grilli and Rampichini, 2009).

Before analysing the results obtained from the model, it is worth noting that our study considers a subjective measure of the food wasted by households (i.e. the self-estimated percentage of the food wasted) and therefore it may be subject to some errors of quantification. However, to the best of our knowledge, the Eurobarometer data are the most recent and complete source of information to be used for analysing household food waste behaviour at European level and proved to be a reliable source of data as shown in section "Households' food waste behaviour at European level".

Demographic and socio-economic individual characteristics, as well as attitudinal variables, proved to be strictly correlated with the respondents' behaviour towards food waste. In fact, the effect of these individual-level variables is also confirmed when introducing contextual variables in the models, as can be seen in the last two columns of Table 4 which reports both the estimates of the models with the solely individual-level variables and the estimates of the full model.
In order to avoid misunderstandings, the comments of this section refer to the magnitude and sign of the ORs concerning the covariates included in the full model.

TABLE 4 HERE

A significant positive association was observed for age: the older you are, the more likely you are to waste small amounts of food. In fact, the OR was equal to 0.458 for youths and equal to 2.3 for people aged 65 or over (compared to individuals aged between 35 and 44) therefore old people waste less.
Regarding gender, the OR of females (equal to 1.292) indicates that they waste less food than males.
Occupational status and level of education proved to be associated with food waste behaviour. On one hand, it was observed that individuals not in the labour force as well as job seekers generate less food waste compared to self-employed individuals who represented our reference category (OR=1.232). On the other hand, the education level is correlated with food waste: individuals who stopped education at an early age are more likely to waste less food (OR=1.564 for individuals who left school at 15 years of age and OR=1.337 for individuals who left school between 16 and 19 years of age).
Moreover, individuals living in small or medium-sized towns or in large cities are more likely to produce food waste than individuals living in rural areas (OR=0.821 and OR=0.791).

The variables concerning attitudes and commitment towards food waste are strongly associated with food waste behaviour: individuals who make an effort to reduce their amount of household waste tend to waste less (OR=1.614).
Individuals who separate kitchen waste tend to throw away smaller quantities of food as they have a 22.1% higher OR than individuals who do not recycle or compost any portion of their kitchen waste, ceteris paribus. On the other hand, if people are aware that their household produces large amount of waste (not only food) this does not necessarily mean that they waste small amounts of food (OR=0.491 and OR=0.421 for people who tend to agree and totally agree to the statement, respectively).

The fact that the respondents agree to being charged for waste management according to the quantity of unsorted waste produced is positively correlated with the likelihood of producing small percentages of food waste (OR=1.080). However, the individuals who replied "I don't know" to this question, who were approximately 10% of the total number of respondents, are likely to produce small quantities of waste (OR=1.327).
It was also observed that the respondents who agreed to the statement "*a more efficient use of resources (land, water, materials and metals) can create more employment opportunities in one's own country*" are likely to produce less food waste (OR=1.164) holding constant all the other variables in the models.

It is also interesting to note that the individuals' perception of living in an area with little or no litter in the street is positively related with the production of small percentages of food waste (OR=1.099).

As already mentioned, contextual variables play a significant role in explaining differences across countries. The Likelihood Ratio (LR) test supports the significance of the multilevel framework compared to the single-level logistic regression (p-value=0.000).
Both the annual median net income per capita and the variation in the HICP for food – reflecting price changes in the country – are significantly correlated with behaviour towards food waste. On one hand, countries with a higher income per capita are characterized by higher percentages of food waste. On the other hand, individuals residing in countries with higher annual increase in the level of food prices tend to produce small percentages of food waste.
Moreover, a contrasting effect characterizes the variables linked to eco-friendly behaviour. Countries where there is a higher percentage of agricultural land devoted to organic farming are the countries in which individuals are less likely to generate small quantities of waste. On the other hand, the residents of countries with a larger number of eco-licenses (per 100,000 inhabitants) are inclined to produce small amounts of waste.
The group-means of the variables concerning the sorting of kitchen waste as well as the proportion of people living in large town-cities – introduced in the model for solving the endogeneity issue – proved to be significantly associated with individual behaviour.
Finally, some variations were applied to the selection method of the cut-off point in order to test whether using a different threshold produces similar results (Appendix A). When comparing these alternative models and the full model reported in Table 4 very similar results were found. It is important to note that almost all the statistically significant variables maintain a significant association with the same direction of the association observed for the main model, while slightly lower or greater magnitudes of the coefficients was observed. When the 15% threshold was adopted a positive attitude towards resource efficiency as well as a positive individual environmental attitude proved to be directly associated with small amounts of food waste.
In conclusion, these comparisons seem to confirm the robustness of the estimates and the validity of the selected cut-off points with the aim of obtaining insights concerning the relationships between factors at both individual and area levels and food waste behaviour.

Discussion and future directions

Although "*you are what you eat*" is commonly used for describing the physical and mental benefits that can be obtained by following healthy diets, individuals do not appear to be fully aware of the consequences that the uneaten food they throw away may have on the natural and socio-economic environment in which they reside. The food waste issue at household level is therefore an important emerging research area for social scientists in order to raise individuals' awareness of the environmental, economic and social impacts and to reduce the level of individuals' food waste so that they realized that *you live where you generate waste*.
In recent years in order to deal with this problem several initiatives have been implemented at both EU and national level aimed at increasing people's awareness towards food waste and its impacts by implementing campaigns, food redistribution programmes, research and training initiatives. The most industrialized European countries namely the UK, Germany, France, the Netherlands and Italy proved to be the most active in developing and implementing these initiatives.
At the same time many researchers have been carrying out studies aimed at identifying the association between the food waste behaviour and individual characteristics.
By proposing a two-level theoretical framework, the main contribution of our study is to explore the role of the individuals' context of residence in explaining territorial differences of their behaviour towards food waste. In fact, the multilevel statistical framework adopted enabled us to model

unobserved heterogeneity associated with the different countries of residence, thus analysing whether and to what extent differences in individuals' behaviour towards food waste among EU countries can be attributed to the socio-economic, environmental and industrial characteristics of the area in which the individuals reside.
Although, as expected, most of the variability regarding behaviour is related to individual characteristics, we also found empirical confirmation that the context in which individuals live plays an important role in characterizing their food waste behaviour. With the aim of explaining these significant contextual effects we introduced some variables at national level.
Regarding each country's economic situation, it was observed that some of the richest and most developed European countries are those least inclined to produce small amounts of food waste. This is a particularly important finding, which provides empirical support to one of the policy options identified by Monier et al. (2011) and can be used by the European Commission to target intervention at Member States level as well as for groups of Member States. In fact, our statistical analysis can be used for identifying groups of countries with similar behaviour patterns and therefore targeting countries according to the level of urgency of interventions and actions. In general the countries with a negative predicted random effect require more urgent attention and interventions. On the other hand, countries with positive values of the residuals represent countries where inhabitants' are more prone to produce low quantities of waste.

At individual level the association between the individuals' demographic, socio-economic characteristics and food waste was confirmed.
The older the people are the less likely they are to generate waste, with the strongest association found for people aged 65 and over, which confirm the results found in previous studies (Hamilton et al., 2005). On the other hand, youths are the target population who require the most attention as already mentioned by Principato et al. (2015).
Women are more likely to reduce food waste than men, which is a confirmation of the results found by Barr (2007). This may be due to the fact that they generally spend more time in the kitchen and are therefore more aware of the extra-costs caused by throwing away food.
Concerning education, this study was one of the first to underline the association between the level of education and the amount of food wasted, since the lower the level of education, the smaller the amount of food waste generated. There can be various interpretations regarding this result. On one hand, this may be explained by the fact that people with a higher level of education are more likely to have higher incomes, thus confirming the evidence found in literature for highly educated individuals (Monier et al., 2011). On the other hand, some individuals with a low level of education may not be able to estimate correctly the percentage of the food they waste due to the subjective nature of this measure. Further research is required in order to better understand this phenomenon.
Another original finding of this study is the relationship between the level of urbanization and food waste which may assist policy makers when implementing interventions and legislative regulations at local level. In fact, people living in urban areas are more likely to produce higher quantities of food waste than people living in rural areas.
Attitudes and commitments towards food waste appear to be strongly associated with related behaviour: individuals who make an effort to reduce the amount of household waste are also more likely to behave correctly.
Sorting kitchen waste is associated with smaller quantities of food waste and this may be because composting and recycling requires time and enables people to acquire awareness of how much food they waste. A similar result was found at country level, thus probably confirming that if national or sub-national regulations foresee the sorting of waste, individuals are generally more aware of the amount of food they throw away thus confirming the results found by Barr (2007).
Another interesting finding was observed between food waste and the perception of the amount of litter in the local area of residence. The perception of living in a clean area is associated with a virtuous behaviour of the residents. In this context it is believed that local policy makers can play a crucial

role in decreasing the amount of food waste by investing more for the cleaning and maintenance of the areas in which they operate.
An important policy implication that emerges from our study regards the importance of implementing consumer programmes on food waste starting from selected groups of individuals – i.e. the individuals most at risk – may have a 'cascade effect' in order to include other groups. In fact, Quested et al. (2013) stated that awareness campaign alone could be ineffective since individuals behave differently. Therefore we believe that the 'cascade training' proposed in their study in which a group of people are trained and then in turn train others could be beneficial for reducing food waste. This is the reason why we strongly recommend that local policy makers invest in community-based interventions for reducing food waste.
Moreover, since at country level we found an association between environmentally friendly industrial production and food waste, we believe that it is important to further explore this relationship with the aim of involving both the public and private sectors when implementing intervention policies. On this issue, Halloran et al. (2014) encouraged collaboration between multi-stakeholders and especially public–private partnerships in order to reduce food waste.

Although interesting findings were observed, there is still much research to be carried out. It is essential to introduce a harmonized definition of food waste at EU level in order to collect direct data (i.e. the weight of food waste which is not subject to the underestimation problems) concerning food waste and to compare them accurately for all Member States. At the same time an indirect survey could support the direct data collection by only focusing on the food waste phenomenon. In this way we could obtain additional variables, which were not included in our data set, thus representing a limitation of our research study.
Secondly, official sample surveys should be based on such a level of representativeness, which would enable researchers to analyze and compare sub-national levels (such as municipalities) since the local environment is such a crucial dimension for policy makers when planning interventions.
Lastly, considering the cross-section nature of the study, our analysis highlights the association between variables rather than causal relationships. A complete longitudinal analysis would be useful in order to analyze variations in behaviour towards food waste.

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APPENDIX A

TABLE A.1 HERE

FIGURES

Figure 1 The proposed conceptual framework for exploring individuals' food waste behaviour

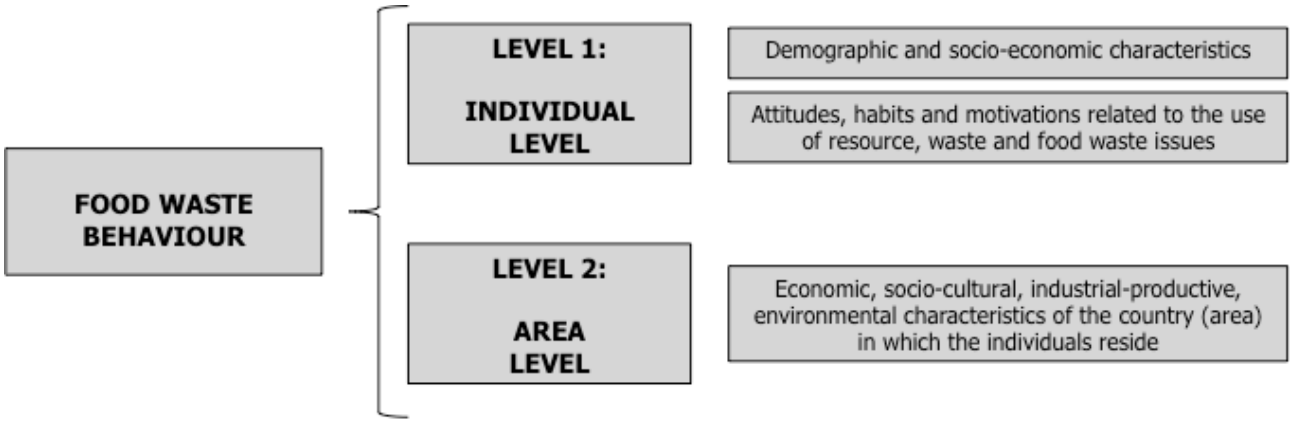


Figure 2 Estimated percentage of food thrown away (FE data 2013)

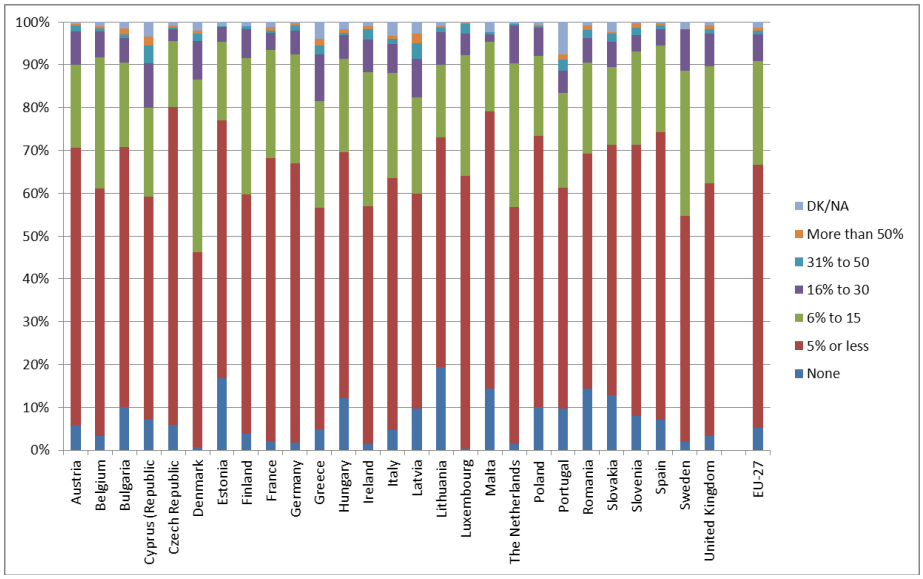
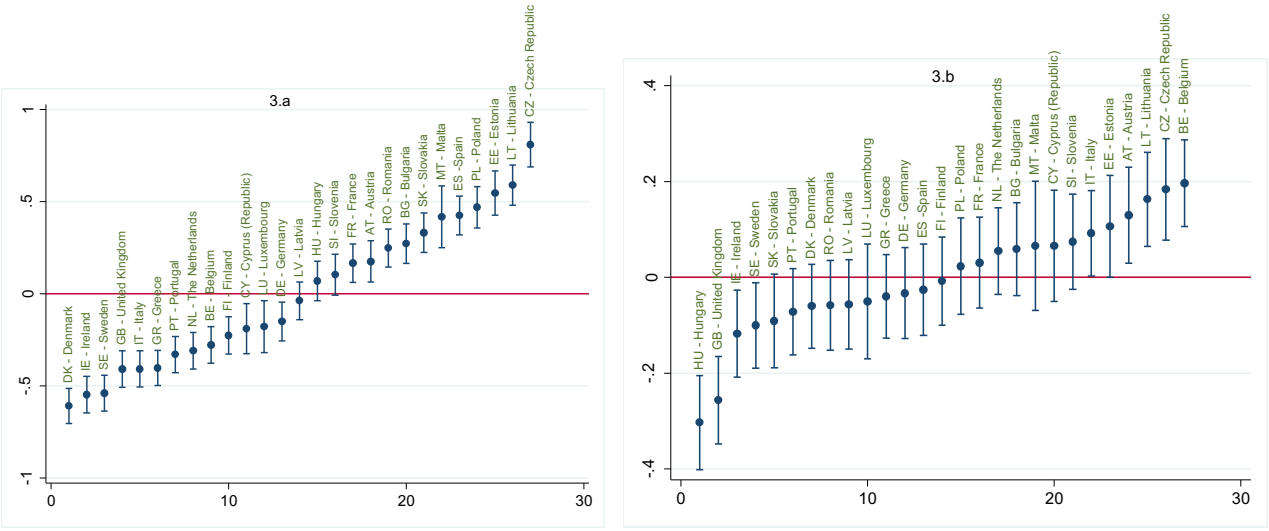


Figure 3 Ranking of country predicted random effect u_j and 95% confidence intervals: **a**. Model with individual covariates; **b**. Model with individual and contextual covariates.



TABLES

Table 1 Inventory of awareness campaigns, informational tools, food redistribution activities, training and research programs against food waste in European countries

COUNTRY	INITIATIVE NAME	INITIATIVE NAME	INITIATIVE NAME	INITIATIVE NAME	INITIATIVE NAME	INITIATIVE NAME	INITIATIVE NAME
Belgium	Eviter le gaspillage alimentaire	Cooking Classes (2009)	Lutter Gaspillage Alimentaire (2009)	GreenCook (2010)			
Denmark	United Against Food Waste	A la carte Menu (2008)	Stop Wasting Food (2008)	Food Bank (2009)	Fish Chips (2009)		
Germany	Foodwaste TV (2010)	Love Green (2011)	We Save Food (2011)	We Love Food (2011)	Zu Gut Fur Die Tonne (2012)	Save Food (2011)	
Ireland	Appetite for Action (2009)	Calling Time on Waste (2009)	Stop Food Waste (2009)	Legislation (SI 508 of 2009)	The Green Initiative (2010)	Green Hospitality Award (2008)	
Spain	Food Bank (2007)	Estrategia catalan residu zero (2011)	Eroski (2012)	Aprovecha la Comida (2012)			
France	Programme local de prevention des déchets	Familles Témoins	Réduisons nos déchets (2005)	Waste prevention in school (2005)	Incentive bin tax (2012)	ANDES Network (2010)	
Italy	Pane Quotidiano (1998)	Banco Alimentare (1989)	Buon Fine (2003)	Last Minute Market (2003)	Buon Samaritano (2005)	Il Buono che Avanza (2010)	IoMiAmo (I Love Myself) (2010)
Hungary	Zero Waste (2009)						
Netherlands	Sensible Fresh Food Guide	Cooperative framework (2006)	Save Food From the Fridge (2009)	Voedselverspilling (2010)	Eten is om op te Eten (2010)		
Austria	Social supermarkets	Team Austria (2010)	Lebensmittel Sind Kostbar (2012)				
Portugal	Menu Dose Certa (2008)						
Finland	The S Group (2012)						
Sweden	Eurest (2010)						
United Kingdom	Feeding the 5000 (2009)	Food Cycle (2008)	Love Food Hate Waste (2008)	Great Taste Less Waste (2009)	School Waste Heroes (2011)	Buy One, Get One Later (2009)	Courtauld Commitment 3° (2013)

Note: Due to space limitation, we do not report here a description of each action. However a summary document can be request to the authors.

Table 2 Actions and information helping the reduction of waste: percentage distribution on the basis of individuals' waste produced.

Q10: Amongst the following elements, which would help you to waste less food?	5% or less	More than 5%	EU-27
Better and clearer information on how to interpret 'best before' dates	48.39	48.05	48.17
Better and clearer information on food product labels, e.g. information on storage and preparation	49.45	51.55	50.83
Better shopping planning by your household	56.94	45.16	49.21
Better estimation of portion sizes (how much food you cook) to avoid wasting food	50.19	53.42	59.58
Availability of smaller portion sizes in shops	54.13	55.42	57.88
Re-using leftovers instead of throwing them away	59.1	58.88	58.45
Using the freezer to conserve food longer	58.63	61.39	60.45

Sources: own elaboration on FE 388 data. Notes: multiple response question. Pearson chi-square test for multiple responses conducted on the sample distribution: Pearson chi2(126) = 633.4769 Pr = 0.000

Table 3. ICC and second-level variability: comparison between models with individual covariates and individual and contextual covariates

Model	VARIANCE		ICC (%)	
	$\tau 2$	(s.e.)	ρ	(s.e.)
Individual covariates	0.397^2	0.056	4.6	0.012
Individual and contextual covariates	0.125^2	0.024	0.5	0.002

Notes: LR test of rho=0: Individual model (p-value=0.000); Individual and contextual covariates (p-value=0.000)

Table 4 Multilevel logistic regression models: estimated ORs

		Model with individual covariates		Model with individual and contextual covariates	
Variable	**Category**	**OR**	**SIG.**	**OR**	**SIG.**
Q2_1: In my opinion a more efficient use of resources have an impact on ECONOMIC GROWTH in my country:	Very negative	Ref		Ref	
	Somewhat negative	0.813	***	0.814	***
	Somewhat positive	0.850	***	0.848	***
	Very positive	0.909		0.906	
Q2_2: In my opinion a more efficient use of resources have an impact on EMPLOYMENT OPPORTUNITIES in my country:	Very negative	Ref		Ref.	
	Somewhat negative	0.995		0.999	
	Somewhat positive	0.978		0.980	
	Very positive	1.162	***	1.164	***
Q3_5: I think reducing waste and sorting recyclable waste at home would make the biggest difference in using resources efficiently	No	Ref		Ref.	
	Yes	1.119	***	1.121	***
Q4_2: I think my household is generating too much waste	Totally disagree	Ref.		Ref.	
	Tend to disagree	0.751	***	0.752	***
	Tend to agree	0.489	***	0.491	***
	Totally agree	0.419	***	0.421	***
Q4_3: I make efforts to reduce the amount of household waste that I generate	Disagree	Ref		Ref.	
	Agree	1.619	***	1.614	***
Q6: Sorting (at least occasionally) kitchen waste	No	Ref.		Ref.	
	Yes	1.217	***	1.221	***
Q7: It would convince me to separate (at least some) more of my waste:					
	More convenient separate waste collection at home	0.844	***	0.845	***
	More and better waste recycling facilities in your area	0.901	***	0.899	***
Q8: Preferred way for dealing with management of household waste	To pay a fix sum through taxes			Ref	
	To pay in proportion of unsorted waste	1.074	*	1.080	*
	To include waste manag. in the price of product	0.974		0.975	
	Don't know	1.324	***	1.327	***
Q11: When buying a durable goods (like a machine or a fridge) I take care about the product is environmental-friendly	No	Ref.		Ref.	
	Yes	1.008		1.009	
Q12: Willingness to buy second-hand product	No	Ref.			
	Yes	1.061		1.064	
Q17: How much litter is there in the area where you live?	A lot-quite a lot			Ref.	
	Not much/None	1.101	***	1.099	***
Age	15-24	0.459	***	0.458	***
	25-34	0.738	***	0.738	***
	35-44	Ref.			
	45-54	1.447	***	1.451	***
	55-64	1.741	***	1.746	***
	65 and over	2.291	***	2.300	***
Gender	Male	Ref.		Ref.	
	Female	1.292	***	1.292	***
Professional status	Self-employed	Ref		Ref.	
	Employees	0.951		0.949	
	Manual workers	1.095		1.101	
	Not working	1.232	***	1.232	***
Area of residence (urbanization)	Ref. Rural area or village	Ref.		Ref.	

		Model with individual covariates		Model with individual and contextual covariates	
Variable	**Category**	**OR**	**SIG.**	**OR**	**SIG.**
	Small or medium-sized town	0.823	***	0.821	***
	Large town-city	0.792	***	0.791	***
Education	Up to 15	1.578	***	1.564	***
	16-19	1.345	***	1.337	***
	20 years and older	Ref		Ref.	
	Still in education	0.903		0.905	
	No full-time education	1.553	*	1.560	*
Ownership of landline and mobile phone	Only landline	0.822	**	0.824	**
	Only mobile	Ref			
	Mobile and landline	0.911		0.915	
CONTEXTUAL COUNTRY-LEVEL VARIABLES					
Percentage of agricultural area devoted to organic farming	≤ 5.8%			Ref.	
	> 5.8%			0.619	***
Median disposable income (expressed in Purchasing Power Parities, PPPs)	I quartile: up to 8630 Euros			Ref.	
	II quartile (8630;14271)			0.805	*
	III quartile (14271,18638]			0.315	***
	IV quartile: more than 18638			0.335	***
Education tertiary attainment	I quartile: up to 18.1%			Ref.	
	II quartile: (18.1;27]			0.928	
	III quartile (27;31.4]			1.207	*
	IV quartile: more than 31.4%			0.744	***
Annual variation of HICP	I quartile: up to 1.9%			Ref.	
	II quartile: (1.9;2.5]			1.107	
	III quartile (2.5;3.6]			1.773	***
	IV quartile: more than 3.6%			3.706	***
Number of Ecolabel licenses (every 100,000 inhabitants)	I quartile: up to 0.033			Ref.	
	II quartile: (0.033; 0.1504]			0.638	***
	III quartile: (0.1504;0.287]			0.824	
	IV quartile: more than 0.287			1.531	***
Sorting (at least occasionally) kitchen waste (country proportion)				1.762	*
Living in large town-city				0.341	***
Constant		1.230		1.843	**

NOTES: LR test vs. logistic regression: Chi2(01) = 538.42 Prob>=Chi2 = 0.0000 * Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Table A.1 – Estimated models based on alternative specification of the thresholds (0% and 15%, respectively).

		Threshold 0% (full model)		Threshold 15% (full model)	
Variable	**Category**	**OR**	**SIG.**	**OR**	**SIG.**
Q2_1: In my opinion a more efficient use of resources have an impact on ECONOMIC GROWTH in my country:	Very negative	Ref.		Ref.	
	Somewhat negative	0.780	**	0.955	
	Somewhat positive	0.787	***	1.186	*
	Very positive	0.843	**	1.238	**
Q2_2: In my opinion a more efficient use of resources have an impact on EMPLOYMENT OPPORTUNITIES in my country:	Very negative	Ref.		Ref.	
	Somewhat negative	0.896		1.139	
	Somewhat positive	0.765	***	1.374	***
	Very positive	0.903		1.372	***
Q3_5: I think reducing waste and sorting recyclable waste at home would make the biggest difference in using resources efficiently	No	Ref.		Ref.	
	Yes	1.127	**	1.226	***
Q4_2: I think my household is generating too much waste	Totally disagree	Ref.		Ref.	
	Tend to disagree	0.691	***	1.082	
	Tend to agree	0.603	***	0.634	***
	Totally agree	0.688	***	0.453	***
Q4_3: I make efforts to reduce the amount of household waste that I generate	Disagree	Ref.		Ref.	
	Agree	0.994		2.005	***
Q6: Sorting (at least occasionally) kitchen waste	No	Ref.		Ref.	
	Yes	1.048		1.265	***
Q7: It would convince me to separate (at least some) more of my waste:					
	More convenient separate waste collection at home	0.941		0.772	***
	More and better waste recycling facilities in your area	0.810	***	0.934	
Q8: Preferred way for dealing with management of household waste	To pay a fix sum through taxes	Ref		Ref	
	To pay in proportion of unsorted waste	0.941		1.112	
	To include waste manag. in the price of product	0.865	**	0.827	**
	Don't know	1.482	***	1.415	***
Q11: When buying a durable goods (like a machine or a fridge) I take care about the product is environmental-friendly	No	Ref.		Ref.	
	Yes	0.983		0.975	
Q12: Willingness to buy second-hand product	No	Ref.		Ref	
	Yes	1.161	***	0.952	
Q17: How much litter is there in the area where you live?	A lot-quite a lot	Ref.		Ref.	
	Not much/None	1.117	**	1.167	***
Age	15-24	0.296	***	0.346	***
	25-34	0.581	***	0.668	***
	35-44	Ref.		Ref	
	45-54	1.405	***	1.191	**
	55-64	1.665	***	1.640	***
	65 and over	2.194	***	1.845	***
Gender	Male	Ref.		Ref.	
	Female	1.258	***	1.097	*
Professional status	Self-employed	Ref.		Ref.	
	Employees	0.823	**	1.178	*
	Manual workers	1.046		1.069	
	Not working	1.253	**	1.296	***
Area of residence (urbanization)	Ref. Rural area or village	Ref.		Ref.	
	Small or medium-sized town	0.763	***	0.916	

		Threshold 0% (full model)		Threshold 15% (full model)	
Variable	**Category**	**OR**	**SIG.**	**OR**	**SIG.**
	Large town-city	0.725	***	0.980	
Education	Up to 15	1.606	***	1.047	
	16-19	1.377	***	1.135	**
	20 years and older	Ref.		Ref.	
	Still in education	1.261		0.795	*
	No full-time education	2.895	***	1.090	
Ownership of landline and mobile phone	Only landline	0.791	**	0.712	**
	Only mobile	Ref.		Ref.	
	Mobile and landline	0.837	**	0.935	
CONTEXTUAL COUNTRY-LEVEL VARIABLES					
Percentage of agricultural area devoted to organic farming	≤ 5.8%	Ref.		Ref.	
	> 5.8%	1.010		0.604	***
Median disposable income (in Purchasing Power Parities, PPPs)	I quartile: up to 8630 Euros	Ref.		Ref.	
	II quartile (8630;14271)	0.352	***	0.791	0.206
	III quartile (14271,18638]	0.137	***	0.332	***
	IV quartile: more than 18638	0.113	***	0.262	***
Education tertiary attainment	I quartile: up to 18.1%	Ref.		Ref.	
	II quartile: (18.1;27]	0.475	**	0.908	
	III quartile (27;31.4]	0.548	**	1.670	***
	IV quartile: more than 31.4%	0.478	***	0.833	
Annual variation of HICP	I quartile: up to 1.9%	Ref.		Ref.	
	II quartile: (1.9;2.5]	0.992		1.238	
	III quartile (2.5;3.6]	1.962	***	1.769	***
	IV quartile: more than 3.6%	2.278	**	4.683	***
Number of Ecolabel licenses (per 100,000 inhabitants)	I quartile: up to 0.033	Ref.		Ref.	
	II quartile: (0.033; 0.1504]	0.803		0.824	
	III quartile: (0.1504;0.287]	1.216		1.157	
	IV quartile: more than 0.287	1.314		1.916	***
Sorting (at least occasionally) kitchen waste (country proportion)		0.458		1.385	
Living in large town-city		2.211		0.084	***