Food waste reduction: empirical findings from the Italian food supply chain

P. Garrone, M. Melacini, A. Perego, M. Pollo
Department of Management, Economics and Industrial Engineering, Politecnico di Milano, P.zza Leonardo da Vinci 32, Milano, Italy

Abstract

The paper explores the Italian food supply chain with a focus on the analysis of "Surplus Food" (SF), i.e. the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to/consumed by the intended customer. The Italian food industry provides the empirical setting. The paper adds to research on sustainable management of the food supply chain and food security in developed countries in two ways. First, it addresses the multifaceted concept of the sustainable management of the food supply chain by developing a conceptual model of the integrated food supply chain (i.e. business, environmental and social players). Second, it uses the model to empirically analyse how SF is generated and managed throughout different supply chain stages and sectors.

Keywords: surplus food, food supply chain, empirical analysis

1 Introduction

Population growth, the recent global economic crisis and the rising prices of raw materials make food management a highly topical issue. It takes on even more importance considering that part of the population, even in developed countries, is in food poverty, while the remaining part is often in food abundance and wastes food.

Effective food management fits into the broader context of sustainable development. According to the World Commission on Environment and Development: "Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987).

Although the issue of food resources management is well recognised in literature, the studies are few and mainly government-based (e.g. Ventor, 2008). Some of them are characterised by ambiguity in the subject definition and analysis. For example, Griffin *et al*. (2009) focus on "all food produced or purchased that is discarded by humans". This approach on the one hand might facilitate the phenomenon’s quantification, but on the other, it may provide a distorted view. Indeed, as underlined by Kantor *et al.* (1997), not all lost food can be suitable for human consumption. Examples are food scraps or non-edible products that fail to meet quality standards. Secondly, other studies have often concentrated on a portion of the supply chain (e.g. Mena *et al*., 2010), unable to give an overall picture of the magnitude of surplus food. Finally, most literature does not underline the characteristics of the stage of the supply chain in which the edible surplus food is generated. These features often involve different difficulties in managing surplus food and different food recoverability degrees. For example, surplus food management at the distribution centres is very different from the one at the eateries, which have unsold food (e.g. pizzas, sandwiches) at the end of the day.

On the basis of these research gaps, the paper’s objective is twofold:

- To develop a conceptual model of the integrated food supply chain (RQ1), which allows a clear definition of the analysis confines and constructs to be analyzed (surplus food and wasted food, particularly);
- To deliver a first application of the conceptual model with reference to the following portions of the supply chain: processing companies and retailers. This application is useful to validate the model (not yet to extrapolate general results) and allows an estimate of surplus food value (RQ2) and food waste value (RQ3) to be obtained.

The model means to have a general validity, while its application to the Italian market can provide an initial basis for comparison with research conducted in other countries. Production companies and retailers have been chosen as first supply chain stages to be analysed because they represent the level at which a greater surplus food recoverability is expected.

The remainder of the paper is organised as follows. We start by highlighting the main literature contributions regarding the quantification and management methods of surplus food (Section 2). Next, we present the conceptual model (Section 3) and finally we present the application of the model to processing companies and retailers (Section 4). Conclusions and future developments are proposed in the final section.

2 Literature review

Since 1980, sustainable development has become a shared global goal. At the international level, the sustainability issues in the food supply chain are still widely debated and have led to the birth of several projects: the Food Industry Sustainability Strategy (FISS by UK Department for Environment, Food and Rural Affairs) and the England Delivery Plan (by WRAP, Waste and Resources Action Programme) are just some examples.

In literature, the sustainability of the food supply chain has been analysed from a social perspective by examining on the one hand the "food security" theme, studying food availability and food poverty, on the other, "food safety", by examining qualitative food aspects and eating problems such as obesity and malnutrition (Aiking and De Boer, 2004). The first of these two themes analyses the surplus food phenomenon with the goal to understand the main potentials and criticalities (Parfitt *et al*., 2010) in order to contribute to meeting the needs of the poor and, more generally, the world's population, which by mid-century is expected to include 9 billion people. In this context Surplus Food (SF) management and its use as humanitarian aid is interesting. Sustainability in the food supply chain was also addressed from an environmental point of view emphasising food waste generation (Bates and Phillips, 1999).
As previously mentioned, the paper assumes the social perspective examining SF and how it becomes wasted food (hereafter referred to as "food waste"). Herein are reported those findings most relevant to the paper's perspective.

2.1 Main findings

2.1.1 Scope of the analysis

A first key aspect in analysing the literature is the definition of the object of analysis, which presents significant heterogeneity across studies. In some cases the object is "food losses" (Kantor *et al*., 1997, Mena *et al*., 2010), in others, "food waste" (Griffin *et al*., 2009; Partfitt *et al*., 2010). "Food losses" refers to edible food, lost at any stage of the supply chain, such as meats, bread, food prepared by restaurants but never served or discarded, or products that are unmarketable for aesthetic reasons, but otherwise nutritious and safe (Kantor *et al*., 1997), and excludes only the inedible part that cannot be used for human consumption (Tarasuk and Eakin, 2005). "Food waste" is often defined as food lost at any stage of the supply chain, including crops damaged during harvesting, food damaged during transport or food discarded and mixed with other wastes (Griffin *et al*., 2009), i.e. food losses that are not necessarily edible. In addition, a distinction should be made between different types of waste generated in a production process. For example Rahimifard and Darlington (2006) distinguish between the waste of finished products and the waste from production, including process waste, overproduction waste and bulk organic waste.

2.1.2 Methodologies

As compared to the heterogeneity of the subjects of the various studies in literature, the methodologies used for analyzing and quantifying the phenomenon (food losses and food waste) differ even more greatly amongst each other.
Except for the agriculture and livestock stage (hereafter farm stage), where there are detailed food balance sheets, quantifying food losses is very difficult (Partfitt *et al.*, 2010) and has led to the development of different approaches (Hall *et al.*, 2009). The approaches differ in the way in which they estimate the food losses percentage and how they estimate food losses at the macro level, e.g. for a certain geographical area. With reference to the food losses and food waste estimates, the majority of the academic papers use third-party sources (Griffin *et*

al., 2009; Kantor *et al.*, 1997). In other cases they consider a sample of companies (Mena *et al*., 2010). In order to avoid creating distortions in the estimates, the different stages are always analysed separately (i.e. production, distribution, consumption) and are often differentiated by product categories. For example, Mena *et al*. 2010 divide the analysis between room temperature, chilled and frozen products. The sample size usually is not high (e.g. 43 case studies in Mena *et al*., 2010, 4 cases for the retailer stage in WRAP, 2010), because detailed data are difficult to find (Griffin *et al*., 2009).
Two approaches are used to estimate the overall extent of food losses and food waste: (i) an analysis of the municipal solid waste (e.g. Hall *et al*., 2009; Ondersteijn *et al*., 2006); (ii) inferential methods, applying the waste factors that are measured in sample populations to the whole food system (e.g. Kantor *et al.*, 1997; Griffin *et al.*, 2009). The first approach may lead to an overestimate of food losses because it considers all the different categories of food wastes (i.e. edible and non edible). As to the second approach, the inference is carried out considering the official statistical data, corrected if necessary and then elaborated. For example, estimates by Kantor *et al*., (1997) are based on the amount of available food, published annually by the USDA’s Economic Research Service (ERS), adjusted by the percentage of non-edible food parts. Griffin *et al*. (2009) consider the number of companies located in one U.S. county as the inferential basis. In some studies the sector turnover is considered as the inferential basis (e.g. WRAP, 2009 for the retail stage). In Gustavsson *et al*. (2011) the amount of food losses is obtained by a "mass flow model". The starting point, for all commodities, is the farm production volume. Then, by suitable coefficients (mostly taken from the literature) the edible mass and the food losses for each stage of the supply chain are computed.
Due to differences in conceptual models and methodologies, quantitative results are different. Kantor *et al.* (1997) analyse the U.S. food supply chain and find that the food losses represent 1% of production in the retail stage and 26% in the consumption stage. If this amount is divided by the number of U.S. inhabitants, it is found that 9.41 kg/year per capita of food losses are generated in the retail stage, while 157 kg/year per capita are generated in the consumption stage. Again with respect to the U.S., Griffin *et al*. (2009) quantify a very different food waste value instead: 21 kg/year per capita in the farm stage, 1 kg/year per capita in the production stage, 20 kg/year per capita at the retail level and 63 kg/year per capita in the consumption stage. In the British food supply chain, according to WRAP (2009), 42 kg/year per capita of food waste amounts are generated in the production stage, 6 kg/year per capita in the retail stage, 134 kg/year per capita in the consumption stage.

2.1.3 Food Losses management

The amount of food waste depends also on the food losses management modalities. In academic papers there are studies that focus on different food losses management modalities.
Firstly, food losses can be used as food recovery, meaning the collection of wholesome food from farmers’ fields, retail stores, or foodservice establishments

for distribution to the poor and hungry; secondly, food losses can be used as livestock feeds, compost, biodiesel (Kantor *et al*., 1997). Finally, there is the possibility to dispose of the waste by using incinerators, by burying the waste in landfills, or, specific to the waste disposal at the household level, by using the food-waste processors.

The comparison between alternatives is very often done in environmental terms (e.g. Lundie *et al*., 2005). Johnston and Green (2004) emphasise the need to create a food recovery hierarchy that privileges food donation to the hungry. In this regard, it should be considered that not all lost food is economically recoverable. Kantor *et al*. (1997), show that food recovery efforts are often limited by financial and logistical constraints that make it difficult to supply recovered food to potential recipients.

Despite the numerous studies in which the various food losses management alternatives are illustrated, few of them provide a quantitative representation of different alternatives. Remarkable exceptions are Kantor *et al*. (1997) and Griffin *et al*. (2009), according to whom in the U.S. a percentage of between 3% and 5% of food losses is donated to charity organisations (e.g. food banks).

In summary, the literature review has shown that there are great difficulties in comparing the results from different studies due to the differences in terms of: geographic setting, samples size, subject of analysis (e.g. food waste v. food losses, food waste v. food scraps, and so on) and supply chain stage considered. It can be argued that new models and methodologies are increasingly necessary to obtain robust information on surplus food and food waste in industrialised countries, and to define appropriate policies and strategies to fight food waste.

3 Methodology to assess Surplus Food

In this section, we present a methodology for the analysis of food losses. The methodology is based on a combination of a conceptual model, designed to accurately define the "Surplus Food" concept, and a quantitative model, that proposes the rules for estimating the "Surplus Food."

3.1 Conceptual model

Our conceptual model relies on information drawn from third-party sources (including articles and interviews with national and international experts), and at the same time it benefits from the empirical evidences offered by several case studies (see paragraph 4.2.1). We claim that our conceptual model contributes to the research on food supply chain sustainability by offering a clear definition of different elements that underlie food waste (RQ1).

We define “Food Availability” as all food produced throughout the food supply chain. It includes foods in different stages (farm, transformation/production, distribution, food service, consumption) and types (food raw materials, half-processed food, and finished products). As illustrated in figure 1 Food Availability can include three categories: “Food for Direct Human Consumption”, “Surplus Food” (SF) and “Food Scrap”.

- Food for Direct Human Consumption is the edible food that is delivered through the traditional market and is consumed by humans (e.g. staples acquired by customers in a supermarket and then consumed).
- SF, instead, is the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to / consumed by the intended customer. It includes food produced at the farm level, processed at the production/transformation level, retailed at the distribution level or served at the food-service level, but then not sold downstream to the customer or final consumer. Moreover, it includes food bought by the consumer but not consumed at the food-service level or at the household level.
- Food Scrap, finally, is the part of Food Availability that consists of non-edible food, i.e. food no longer designated for human consumption. It includes production line leftovers at the firm level (e.g. chocolate leftovers generated during the cutting process), a damaged / broken product that fails to meet quality standards (e.g. a melted ice-cream) and the non-edible parts of otherwise edible food (e.g. vegetable peels or apple cores).

Subsequently, the conceptual model addresses the concept of "food waste" (FW) according to different perspectives. FW from a social perspective is defined as SF that is not recovered for human consumption (i.e. through secondary market, food banks or charitable institutions). On the other hand, FW from a zootechnical perspective is defined as SF that is not recovered for human or animal consumption (i.e. feeding animals directly with SF or using SF as raw material to produce food for animals). Finally, FW from an environmental perspective is defined as SF that is disposed of by methods with a high environmental cost (i.e. landfills), i.e. SF that is neither recovered for human or animal consumption, nor re-cycled by secondary tier suppliers (i.e. to produce fertiliser), nor disposed of by green methods (i.e. aerobic / anaerobic digestion).

The transition from SF to FW is also a function of the "Recoverability Degree", which in turn depends on intrinsic SF recoverability and on management intensity. SF recoverability for human consumption is inherently different in different food supply chain stages and in different product kinds (e.g. edible and healthy grains not collected from the fields are only somewhat recoverable because in order to be consumed they must undergo a physical transformation; conversely, an edible, healthy and packaged product not sold in a store due to a dent in the packaging has a higher intrinsic recoverability, as it is ready to eat). In addition, the Recoverability Degree is influenced by efforts made by firms or other actors to recover SF, i.e. the factor we call "management intensity". In other words, we can conclude that SF exhibits a variable "Recoverability Degree" (RD) and this affects the amount of FW at the different levels (social, animal and environmental).

In mathematical terms, we can say that RD is a function of two main factors: intrinsic recoverability (IR) and management intensity (MI).

IR_{ij} is the degree to which a potential beneficiary could use SF for human consumption in absence of additional management efforts made by firms and intermediaries (i.e. food banks and charitable institutions). It depends on:

- the type of product i (e.g. shelf life, need of refrigeration);
- the activities typically performed at stage j (e.g. certification, scrap elimination).

RD increases with IR: the larger the IR, the larger the RD.

MI_{ij} is the commitment required of firms and intermediaries to make SF usable to the greatest degree by the final beneficiary. There are two distinct components to bring SF to the final recipient:

- maintenance: additional activities necessary to preserve the SF's possible use (e.g. transportation, warehousing);
- enhancement: additional activities that increase the possibility of using SF (e.g. hygienic certification).

RD decreases with MI: the smaller the needed MI, the larger the RD.

Since both IR and MI depend on the variables "i" (type of product) and "j" (stage of the supply chain) we must conclude that also RD should be detailed for each type of product and stage of the supply chain.

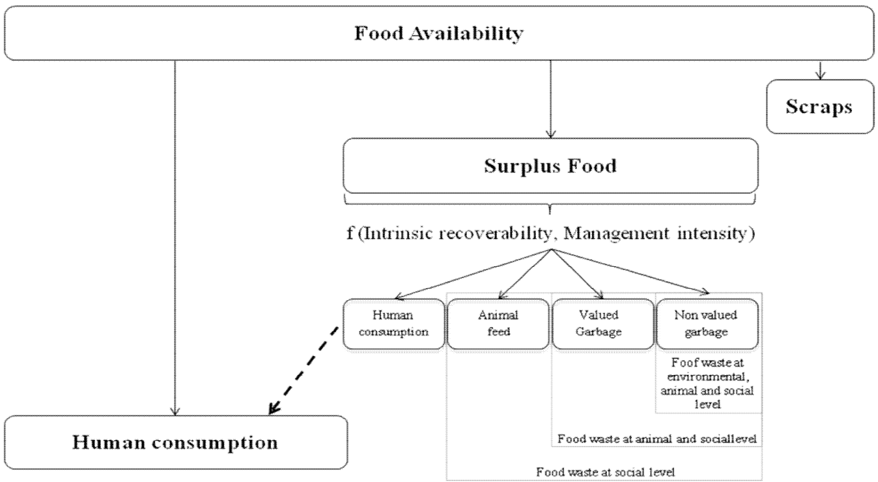

Figure 1: Conceptual model

3.2 Quantitative model

We propose to apply the conceptual model to the different stages of the supply chain, dividing them into homogeneous segments. As emerged from literature, strong differences exist within the same stages both in the setting of the supply chain and in the product characteristics. For example, in the industrial production stage, the frozen sector works in Make To Stock mode with great lots of production and long shelf life, while the meat sector, where possible, works in Make To Order mode in a context with limited shelf life and maximum 2 days of stock. Therefore, in our analysis (Section 4), we will advance a classification of the supply chain in different stage-product classes, i.e. segments from now on.

As shown in Figure 2, once the supply chain has been broken into segments, we estimate the Food Availability as the volume flow of each section (e.g. tons annually produced). To this aim it is useful to refer to official national statistics (e.g. Istituto Nazionale di Statistica, Istat, in Italy). However, these statistics usually report sales, i.e. monetary values (e.g. annual turnover). It is possible to convert these monetary values in volumes (e.g. tons), using the density value of each segment.

The next quantification step consists of the estimation of the SF percentage for each specific segment. This estimate can be computed by different methods, depending on the stage considered, e.g. in production and distribution, case studies can be used to provide evidences for each segment (as shown in the following Sections). FW is then estimated on the basis of the percentage of SF that is not delivered to human consumption, over the total SF generated in each segment. Finally, the SF recoverability degree in each segment is assessed.

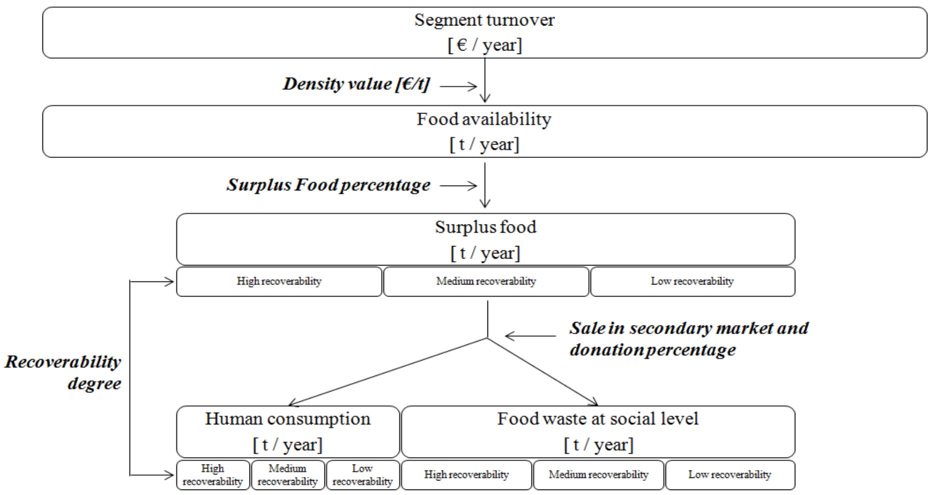

Figure 2: Quantitative model

4 Analysis of Surplus Food in the Italian food supply chain

4.1 Segments topology

Our empirical analysis has focused on two supply chain stages: production and distribution. The production sector includes firms that turn raw food materials or semi-processed products into finished products (e.g. Nestle, Lactalis). The retail sector includes firms that distribute and market food products (e.g. Carrefour, Auchan). The production stage has been divided into 3 segments as a function of the storage temperature of products: room temperature (e.g. Nestle), chilled temperatures (e.g. Lactalis), and frozen temperature (e.g. Findus). The distribution stage has been divided into 2 segments as a function of the tiers of the supply chain network: distribution centres (DCs) and points of sale (POSes).

4.2 Research Methodology

The Italian food supply chain has been analysed resorting to three main methods: indirect sources, expert opinions and case studies.

Indirect sources - such as national publications and databases, sectorial studies and governmental reports (e.g. Istat, 2010; Istat, 2009; Ismea 2009; I-stat, the Istat database; Istat, 2003; Anpa and Onr, 2001) - have been examined with the aim to thoroughly understand the structure and peculiarities of each segment.

Industry experts and institutions involved in the SF collection - e.g. Fondazione Banco Alimentare, a non-governmental organization that collects 12,000 tons/year of Surplus Food in Italy - have been interviewed with the aim to analyse the main causes and management modalities of the phenomenon.

Finally, case studies in several companies belonging to the 5 segments of the supply chain have been developed, collecting and analysing a range of information and data through in-depth face-to-face interviews with supply chain and store managers in each company (3-4 hour conversations). To this aim structured questionnaires have been prepared for each segment. In this way, the case study approach has not only been useful to estimate the SF and FW values, but it has also been particularly suitable for understanding the Surplus Food and Food Waste management practices adopted in each segment, and the role played according to product characteristics, supply chain setting and SF recoverability.

Our final sample includes 74 cases. A first part of the sample consists of 40 production companies, 22 of which work in the room temperature segment, 15 in the chilled temperature segment, and 3 in the frozen temperature segment. For each production segment, a short list of companies has been drawn from the AIDA database (a financial analysis and company information database, containing detailed annual reports under the IV CEE Directive, as well as other information about 300,000 Italian companies). The companies have been chosen in order to involve both small (less than 250 employees) and medium-large companies and on the other hand to include companies producing different product categories (e.g. companies producing cheese, fish, meat, cold cuts and other perishable products have been selected to analyse the chilled temperature segment).The response rate from short-listed companies was around 30%. The sample can be considered relevant both in terms of turnover coverage (depending on the segment, between 10% and 19% of the turnover of each segment), as well as in terms of information quality.

With reference to the retail sector, 5 distribution groups have been identified. 5 case studies have been carried out for the DC segment (distribution company) and 29 case studies for the POS segment (including 4 hypermarkets and 25 supermarkets). Sample distribution groups represent 10% of the turnover of the sector. Interviews have been conducted not only with the supply chain managers, but also with the store managers and the distribution managers.

4.3 Recoverability

Different recoverability levels have been assigned to the 3 production segments (Table 1) and to the 2 distribution segments (Table 2). For each segment, the two inputs of Recoverability Degree (i.e. Intrinsic Recoverability and Management Intensity) have been assigned 3 levels: low, medium and high.

For example, with reference to Table 1, room temperature products have been given a high judgement of Intrinsic Recoverability: they are packaged products ready for consumption and they are characterised by a long shelf life. The shelf life that the distribution companies require when buying from the manufacturers is usually two thirds of the overall product shelf life. Therefore, a production company might have unsold products (i.e. SF) with the remaining two thirds of shelf life still available. Similarly, the Management Intensity required is low: once identified, SF can be stored waiting for collection by a charitable organisation without the use of special equipment (e.g. refrigerators); the transport is not particularly onerous due to the use of ordinary vehicles, i.e. non-insulated, and it is possible to completely fill the vehicle with different types of food. For these reasons the SF Recoverability Degree for the room temperature segment is assessed to be high. In contrast, the SF Management Intensity for the frozen production segment is high, because it is necessary to use specific equipment in both storage and transportation (e.g. refrigerators and refrigerated vehicles).

Comparing the results presented in Tables 1 and 2, it should be underlined that 2 segments show high recoverability (i.e. the room temperature production segment and DC distribution segment) while 3 segments show medium recoverability.

	Segment of production level		
	Room temperature	Chilled temperature	Frozen temperature
Intrinsic recoverability	High	Medium	High
Management intensity	Low	Low	High
Recoverability Degree	High	Medium	Medium

Table 1: Recoverability Degree at the production level

	Segment of retail level	
	DC	Stores
Intrinsic recoverability	High	Medium
Management intensity	Low	Medium
Recoverability Degree	High	Medium

Table 2: Recoverability Degree at the retailer level

4.4 Surplus Food

Consistent with our RQ2, a preliminary estimate of Surplus Food has been provided, focussing on the production and distribution supply chain stages in the Italian food industry.

Table 3 shows that SF amounts to 770,000 tons/year at the overall level. Based on a total volume of 83 million tons/year, the SF percentage is 0.93%. Though small in percentage terms, it is therefore a significant value in absolute terms (approximately equivalent to 10 kg/year per capita). Dwelling in an aggregate analysis, however, may be reductive to obtaining an in-depth understanding of problems and subsequently to designing a strategy to reduce the level of FW

Considering the two stages separately, it can be observed that at the production stage the overall annual volume is around 40 million tons and the SF at this level is approximately equal to 0.5%. At this level the most critical segments, in terms of the relative significance of SF, are chilled and frozen products. The former is particularly exposed to a very limited shelf life, the latter to a greater incidence of production batches. In the distribution stage, instead, the overall annual volume is around 43 million tons and SF is approximately equal to 1.4%. On the other hand it can be observed that at the distribution stage the overall annual volume is around 84 million tons and SF at this level is equal to 0.19% in the DC segment and 2.31% in the POS one. The analysis also showed that POS segment is the most critical and it generates the most part (550,000 tons) of the total SF amount generated at the production and distribution level. This criticality increases for Cash and Carry stores, which have an inventory turnover ratio lower than other formats of stores.

While it is not possible to make a direct comparison with other literature results due to the aforementioned differences in the object of analysis (i.e. we focus on edible food and distinguish between Surplus Food and Food Waste), it is useful to note that the most “industrialised” supply chain stages (i.e. production and distribution) generate a significant amount of Surplus Food (witc the most part in the POS segment) , although less important in percentage terms. It should also be noted that 144,000 tons out of the 770,000 SF tons have a high Recoverability Degree.

	Production level			Retailer level		Total
	Room	Chilled	Frozen	DC	POS	/
Flow value [thousands of tons/year]	30,028	9,235	710	19,048	23,810	82,831
Surplus Food percentage [%]	0.36	0.77	0.73	0.19	2.31	0.93
Surplus Food value [thousands of tons/year]	108	71	5	36	550	770
Recoverability Degree	High	Medium	Medium	High	Medium	/

Legend
(A) Production stage – room temperature firms
(B) Production stage – chilled temperature firms
(C) Production stage – frozen temperature firms
(D) Distribution stage – DCs
(E) Distribution - POSes

Table 3 Surplus Food in the Italian food industry

4.5 Food Waste Management

Focusing on the SF management modalities (Table 4) a significant heterogeneity of behaviours among the different sectors has been observed. Firms belonging to the frozen temperature segment substantially manage all SF by disposing of it through waste management companies (99.1% of the total SF amount). Similar percentages (87.6%) are found for the POS distribution segment. On the other hand, the DC sector donates over 40% of SF to charitable organisations. The impact of secondary markets (e.g. factory outlets) is more important in the room temperature segment (i.e. dry products) than in other segments.

	Production stage			Retail stage	
	Room	Chilled	Frozen	DC	POS
Sold in secondary market	24%	10%	1%	0 %	0%
Donated to charitable institutions	27%	32%	0 %	43%	12%
Used for animal feed	2%	27%	0%	6%	0%
Disposed of by waste management companies	47%	31%	99%	51%	87 %

Table 4 SF management modalities

According to the definition of FW from a social perspective (see 3.1) and according to the last research question (RQ3) the following evidences can be observed (table 5). The total value of FW amounts to around 600,000 tons/year, equal to 78% of the SF volume generated in the two stages considered. Of these, approximately 77,000 tons have a high Recoverability Degree, and thus represent a major waste of resources from a social point of view. On the other hand, approximately 529,000 tons have a medium Recoverability Degree, and thus would require more effort to be recovered.

	Production level			Retailer level		Total
	Room	Chilled	Frozen	DC	POS	/
Surplus Food value [thousands of tons/year]	108	71	5	36	550	770
Food Waste percentage [%]	49	58	99	57	88	78
Food Waste value [thousands of tons/year]	52	41	5	20	484	601
Recoverability Degree	High	Medium	Medium	High	Medium	/

Table 5 Food Waste in the Italian food industry

The reason for the varying FW percentages among the different segments is partly explained by the different Recoverability Degree: the best-performing segments (i.e. room temperature and DC) have a high Recoverability Degree. The other sectors examined have a medium Recoverability Degree. The FW percentage depends not only on the segment recoverability degree but also on the specific behaviour of companies within the same segment. For example, analysing the room temperature segment (with high Recoverability Degree) we found a percentage of FW equal to 35% in a company that produces baby food, while a percentage equal to 86% in a company that produces snacks, showing a different attention to the problem.

5 Conclusions

The paper has presented the first results of an on-going research on the issue of sustainable management in the food supply chain. A replicable methodology has been presented to assess Surplus Food and Food Waste at the micro (i.e. individual players and single supply chain stages) and macro (i.e. the whole country) levels.

For each stage, our model defines the concepts of “Surplus Food” - i.e. the edible food that is produced, manufactured, retailed or served but for various reasons is not sold to/consumed by the intended customer - “Surplus Food recoverability degree” - i.e. the degree to which SF can be “easily” recovered for human consumption - and “Food Waste”, i.e. the wasted part of Surplus Food. Secondly, a quantitative model has been developed which combines official statistics and in-depth behavioural information on individual actors from each stage. Finally, the methodology has been applied to two stages of the Italian food supply chain (i.e. production stage and retail stage), where we have conducted 74 case studies through face-to-face interviews (i.e. our sample covers more than 10% of sales in each supply chain stage).

The results allow us not only to quantitatively assess the phenomenon (i.e. to estimate the overall amount of Surplus Food and Food Waste at different stages), but also to study how Surplus Food and Food Waste are generated, and how they are managed by companies. Overall, the results confirm the validity of our methodological framework: both the case study approach and the focus on different supply chain segments are essential – at least as an exploratory step -, considering the peculiarities of each segment (summarised by the Recoverability Degree). In this way it is possible not only to obtain a clearer understanding of the phenomenon, but also to identify the criticalities/major obstacles to the creation of a sustainable supply chain. We claim that an in-depth analysis allows to obtain more meaningful estimates and to identify the most effective managerial practices. In the segments with a high SF Recoverability Degree, the diffusion of good practices and company’s responsibility are of fundamental importance. In the perspective of supply chain sustainability, companies must “simply” work on the business processes to reduce Surplus Food and Food Waste. By contrast, legislators, companies and food banks/charitable institutions should work together to find innovative solutions to alleviate the Food Waste impact in the segments with medium or low Recoverability Degree. In this regard several business actors and non-governmental organisations have cumulated valuable experience in the SF management and FW reduction.

Further developments of the research will focus on the application of the methodology to other supply chain stages (i.e. farm, food service and consumption) and a deeper analysis of business processes, with the aim of optimising food waste management.

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