

Reducing food waste in food manufacturing companies

*Paola Garrone, Marco Melacini, Alessandro Perego, Sedef Sert
Politecnico di Milano*

Abstract

Putting unsold food at good use is clearly a high-priority option according to the Food Waste Hierarchy, but we still know relatively little about the antecedents, strategies, and processes that make it possible within companies. This paper aims at explaining how food manufacturers can prevent the degradation of generated surplus food into waste. Based on an extensive literature review and 4 exploratory case studies, research questions are formulated about (i) available avenues for managing surplus food, and (ii) internal drivers that make these avenues viable and efficient. In order to adapt, refine and corroborate the conceptual framework, the research conducts 10 descriptive case studies of Italian food manufacturers. Results from the cross-case analysis highlight the multiplicity of reuse and redistribution options, and their viability over the product shelf life. The analysis also shows that a structured surplus food control system and partnerships with food aid organizations are necessary to reduce food waste.

Keywords

Surplus food; Food waste; Redistribution; Manufacturing; Food waste hierarchy

*Final version published as: Garrone, P., Melacini, M., Perego, A., & Sert, S. (2016).
Reducing food waste in food manufacturing companies. Journal of cleaner production, 137,
1076-1085.*

1 **1. Introduction**

2 After the shocking report of the United Nations' Food and Agriculture Organization (FAO),
3 which stated that, every year, one third of the food produced for human consumption is lost or
4 wasted globally - 1.3 billion tons (Gustavsson et al., 2011) - the world has become more aware
5 of the issue of food waste. Wasting food also means wasting resources such as water, cropland
6 and energy. Indeed, food is wasted throughout the whole supply chain, from agriculture and
7 fishing to the end household consumption (Kummu et al, 2012).

8 On the other hand, according to FAO statistics, almost 800 million people are undernourished
9 globally (FAO, 2015). Food insecurity is an important issue even in developed countries; in
10 Europe, nearly 43.6 million people were estimated to be food-insecure (Gentilini, 2013) and, at
11 the same time, European countries are reported to generate 179 kg per capita of food waste per
12 year (O'Connor, 2013).

13 Although different approaches are followed to achieve food security, such as increasing
14 efficiency in production and distribution, the figures on wasted food speak loudly in favour of
15 reducing food waste, seen as one of the possible options to address this problem. Reducing food
16 waste is a global priority not only to conserve natural resources, but also to deal with food
17 insecurity (Evans et al., 2012; Evans et al., 2013; Garnett, 2014). Waste reduction is connected,
18 in part, with the effective management of surplus food, where surplus food can be defined as
19 "the edible food that is produced, manufactured, retailed or served but for various reasons is
20 not sold to or consumed by the intended customer" (Garrone et al., 2014a). Preventing the
21 generation of surplus food whenever possible and managing it wherever it is created are critical
22 options to reduce food waste degradation.

23 Surplus food management and its role in the model known as "food waste hierarchy" are
24 discussed in a few articles (Papargyropoulou et al, 2014), but we know relatively little about
25 the operational processes, structural antecedents and intentional strategies that make it both
26 feasible and cost-effective within companies. Redistributing surplus food to food banks and
27 other food aid organizations is highly recommended from a social perspective, but there are
28 very few studies examining the critical factors behind this management channel.

29 It is now, therefore, necessary to provide companies with innovative operational instruments
30 that can be used to manage surplus food efficiently and effectively, once it is generated. The
31 main aim of this paper is to combine the objectives of reducing waste and enhancing food

1 security in an integrated way. The first contribution of this paper is to adapt the food waste
2 hierarchy to food manufacturing companies, refining it by including more pertinent options.
3 The second contribution is to identify in a clear manner the main critical factors that enable
4 food manufacturing companies to set in place an efficient and effective process for managing
5 surplus food and, more particularly, for supplying it to the food assistance sector.

6 The remainder of this paper is structured as follows. The research background is explained in
7 Section 2 and the research methodology is summarized in Section 3. Section 4 contains the
8 main results of the study. Section 5 includes the discussion of the main conclusions, together
9 with a potential route for future studies.

10 **2. Background**

11 Over the past years, the literature on food waste has increased significantly. The issue has been
12 investigated from various angles, including sociological (Evans et al., 2014), policy
13 development (Thyberg & Tonjes, 2016) and ethical (Edwards & Mercer, 2008) perspectives. In
14 most studies, food waste is explained by dividing it into different categories (Kantor, et al.,
15 1997; Kummu, et al., 2012) or by directly assessing the value of waste along the food supply
16 chain (Buzby & Hyman, 2012; Katajajuuri, et al., 2014).

17 According to the definition given by FAO, food waste “refers to the removal from the food
18 supply chain of food which is fit for consumption, by choice, or which has been left to spoil or
19 expire as a result of negligence by the actor—predominantly, but not exclusively the final
20 consumer at household level” (FAO, 2014, p. 4). On the other hand, we believe that including
21 food fit for consumption within the definition of food waste can hinder the opportunities for
22 reducing food waste degradation. Therefore, we formulated our research by starting from the
23 definition of surplus food, which is explained as “the edible food that is produced,
24 manufactured, retailed or served but for various reasons is not sold to or consumed by the
25 intended customer” (Garrone et al., 2014a).

26 The European Union Directive 2008/98/EC on waste management laid the foundations for the
27 food waste hierarchy (Papargyropoulou et al, 2014) and set priorities, by suggesting that
28 companies should first of all prevent surplus food from being generated. If feasible, this is
29 clearly the best option.

30 Although companies do all they can to avoid generating surplus food, in some cases it is
31 unavoidable (Mena et al., 2011; Garrone et al. 2014b; Buzby et al., 2015).

1 For instance, products that have reached their sell-by date cannot be sold to their intended
2 customers at full price even though they are perfectly edible (Aleksandar & Smaje, 2008;
3 Garrone et al., 2014a). Processing errors, poor handling and packaging failures, such as wrong
4 labels and damaged boxes (Kantor et al., 1997), are other common reasons for surplus food
5 generated at the manufacturing stage (Richter & Bokelmann, 2015).

6 Once generated, surplus food should be “reused” for human consumption (Schneider, 2013).
7 Many scholars associate reusing to donations made to non-profit organizations. Donated
8 surplus food is redistributed to disadvantaged people in different ways that include providing
9 food and grocery products to be prepared and consumed at home or serving meals to be
10 consumed on-site. Apart from a few special cases, the donor (company) cannot reach the
11 persons in need of food aid directly itself and so non-profit organizations are needed to connect
12 both sides of the “supplier” and “receiver” chain (Santini & Cavicchi, 2014).

13 If the reuse option is not possible, then the food is no longer suitable for human consumption
14 and should be recycled (Papargyropoulou et al, 2014). Recycling food waste can be defined as
15 “reducing the amount of food waste entering waste stream” (Griffin et al., 2009), for instance,
16 into animal feed or compost (Papargyropoulou et al, 2014). Food waste can also be transformed
17 into valuable materials that can be used in some sectors, especially in the nutraceutical and
18 pharmaceutical industries (Mirabella et al, 2013). Finally, before resorting to its disposal, the
19 suggestion it to recover energy from food waste and reduce any negative environmental impact
20 (Papargyropoulou et al, 2014).

21 Obviously, sending valuable materials to landfill, incineration or disposal is not a sustainable
22 option for society, the environment and the economy, and consequently is at the bottom of the
23 food waste hierarchy. Some empirical studies, in fact, demonstrate that a reduction of disposed
24 waste may lead to substantial cost savings for companies (Lundie & Peters, 2004; Darlington
25 et al., 2009).

26 Although the food waste hierarchy proposes a hierarchical guideline to manage surplus food in
27 the supply chain, from prevention to disposal, applying this framework can follow very
28 different avenues across the product and supply chain stages, depending upon the companies’
29 strategies and capabilities. In other words, applying this policy may not be as straightforward
30 as expected. A second under-studied issue concerns the internal barriers and enablers for surplus
31 food management, looking in particular at the drivers that can increase the amount of food saved
32 for human consumption

1 The aim of this research is to fill these gaps, i.e. to adopt and enhance the food waste hierarchy
2 and identify the critical factors that affect its implementation, by studying the process of
3 managing surplus food in food manufacturing companies.

4 Based on literature review, two broad and preliminary questions can be formulated:

- 5 – How can food manufacturers implement the food waste hierarchy?
- 6 – How can food manufacturers prevent surplus food degrading into food waste?

7 In order to extrapolate the research questions with greatest potential in terms of management
8 and policy implications, insights from literature reviews are not sufficient and have to be
9 combined with a bottom-up exploration of food manufacturers' strategies and operations
10 concerning surplus food.

11 **3. Formulation of research questions and research design**

12 Qualitative research methodologies, such as case studies, can be particularly suitable during the
13 early stages of the investigation of a phenomenon (Eisenhardt, 1989; Yin, 2003). This paper
14 draws on case studies to obtain a conceptual framework of surplus food management in food,
15 that is to refine, corroborate and adapt the very general insights gained through the literature
16 review to the complex reality of food manufacturing. Moreover, a multiple-case study approach
17 is used since the outcomes of multiple-case studies are commonly better grounded than results
18 from single-case studies (Eisenhardt & Graebner, 2007).

19 In order to formulate our research questions and design descriptive case studies, we conducted
20 a few exploratory case studies. The literature review proved, in fact, not to be sufficient for
21 elaborating hypotheses on the process used by manufacturers to manage surplus food. In
22 addition, the extant studies could not offer any clear or detailed predictions on the internal
23 barriers and enablers for recovering and redistributing surplus food. We, therefore, combined
24 insights from the literature review with the results from exploratory cases, following
25 Eisenhardt's argument (1989) whereby case studies can be a starting point in developing a
26 theory.

27 **3.1. Interview protocols**

28 For both the exploratory and descriptive cases, a confidentiality agreement was offered to all
29 participating companies, since, for many organizations, information on surplus food

1 management is highly sensitive. In the description of the sample and the empirical analysis, the
2 companies will be named and referred to with numbers and alphabetical letters. Interviews were
3 not recorded for the same reason, which helped to reduce the response bias of the interviewees.

4 Each interview lasted around two hours and was conducted by a group of three researchers to
5 reduce personal biases (Voss et al, 2002). Visits and company reports were used as secondary
6 methods for collecting data (Yin, 2003). In general, company tours were a good opportunity to
7 verify and clarify responses given in the interviews and also gave researchers a feel for how the
8 company deals with overall surplus food and waste.

9 Results from each interview were analyzed, coded and put into a standard template. Each
10 question was formulated as a variable, reducing the data collected through the interviews into
11 categories. By comparing each incident, we set out the properties for each category and the
12 dimensions of these properties (Voss et al., 2002).

13 **3.2. Exploratory case studies**

14 Four exploratory cases were conducted to identify the main elements of the conceptual
15 framework, and as the basis for defining the sample and designing the questionnaire for the
16 descriptive cases.

17 We asked the supply manager and the director of the leading food bank in Italy - the Fondazione
18 Banco Alimentare - to provide a shortlist of five best and five worst cases in surplus food
19 management. At the end of this process, we were able to conduct interviews with four
20 companies willing to be studied (Table 1). Two of them turned out to be long-lasting and regular
21 donors. Another makes donations from time to time and the last is a company that used to
22 supply the food bank, but has recently decided to stop making donations. Therefore, the study
23 involves both active donors and those lagging behind. Looking at the sample's characteristics,
24 it contains producers of fresh food, ambient (or shelf-stable) food and frozen food.

25

26

Table 1 – Exploratory cases

Case	Main stream products	Domestic Turnover [m €]
C1	Fresh food	220
C2	Frozen and ambient food	1100
C3	Ambient food	190
C4	Ambient food	2000

1
2 Unstructured interviews were conducted with the managers responsible for surplus and waste
3 management in order to distinguish the key elements of the conceptual framework from the
4 extreme cases, (Fontana & Frey, 1994). Although we did not use a questionnaire, the following
5 questions were given beforehand to guide the conversation.

- 6 ▪ What are the main causes for surplus food generation in your company?
- 7 ▪ How do you manage surplus food? Could you describe the operational process and
8 preferred options?
- 9 ▪ In your opinion, what are the key factors to be considered for managing surplus food,
10 once generated, in an efficient and effective way? Which factors prevent degradation of
11 surplus food into food waste?
- 12 ▪ What are the internal and external barriers to the redistribution of surplus food for social
13 purposes? And the enablers?

14 **3.3. Results of exploratory cases and definition of the research questions**

15 The exploratory cases were analyzed on a case-by-case basis. They revealed that, consistently
16 with the food waste hierarchy, companies start to consider actions for surplus food reuse and
17 redistribution when they detect that there is the risk of generating surplus food. Depending or
18 not on whether it is suitable for human consumption, surplus food is managed according to
19 different approaches.

20 - *Surplus food reuse.* Surplus food can still be offered by manufacturers to their intended
21 primary customers via different methods i.e. remanufacturing (C2), repackaging (C2),
22 discounts (C3) and promotions (C3).

23 - *Surplus food redistribution.* Surplus food can still be targeted to human consumption
24 even outside the primary markets in many ways, for social or commercial purposes, such as
25 through secondary markets (C3) or by donating to food aid organizations (C2, C3).

1 - *Food waste management.* Not all surplus food is reused or redistributed. In these cases,
2 surplus food becomes waste that needs to be managed (C1). Apart from recycling it into animal
3 feed and fertilizers, recovery can take the forms of energy or material recovery (C4).

4 Based on these preliminary insights, we can specify a research question concerning the
5 application of food waste hierarchy in manufacturing.

6 *Research question 1: How do food manufacturers implement the food waste hierarchy?*

7 *Research question 1a: What are the potential options for reusing and redistributing*
8 *surplus food?*

9 *Research question 1b: What are the main decision-making factors in managing surplus*
10 *food?*

11 Exploratory case studies and, more specifically, the comparison between the two manufacturers
12 that donate regularly and the two that lag behind, clarified several factors behind the effective
13 and efficient management of surplus food in manufacturing, once it is generated.

14 - *Measurement.* Surplus food is managed more effectively if it is measured regularly and
15 communicated to different functions as a key performance indicator (Case C3), otherwise
16 surplus food is not managed and degradation probability increases (Case C1).

17 - *Coordination.* Coordination among different company functions regarding surplus food
18 management makes it easier to select the best option, by taking economic, environmental and
19 social perspectives into account (Case C3).

20 - *Organization.* Various causes can generate surplus food (Case C2), and making
21 decisions in a timely manner requires designing a process around each of these causes (Case
22 C3).

23 As far as redistribution to food aid organizations is concerned, the exploratory interviews
24 highlighted the variables that describe a company's relationship with food banks.

25 - *Pro-activism.* The company can manage the process proactively (Case C3) or only be
26 reactive when answering the request of non-profit organizations (Case C4).

27 - *Regularity.* Donation to food aid organizations can be regular, with the company
28 defining the frequency of its donations jointly with the non-profit organizations (Case C3) or

1 irregular when the donation is triggered by the detection of surplus food or by a call from the
2 non-profit organization (Case C4).

3 The research question concerning the drivers of surplus food management was specified as
4 follows.

5 *Research question 2: How do food manufacturers prevent surplus food degrading into food*
6 *waste?*

7 *Research question 2.a: What is the relationship between the prevention of food waste*
8 *and the management of surplus food; what is the coordination mechanism among the*
9 *interested functions; and how are surplus food processes managed?*

10 *Research question 2.b: What is the relationship between the redistribution of surplus*
11 *food and partnerships with food aid organizations?*

12 **3.4. Design of descriptive case studies**

13 The core of our empirical analysis is a cross-case analysis of descriptive case studies. To this
14 purpose, the descriptive case study methodology was designed on the basis of both the literature
15 review and the exploratory stage. A case study protocol was prepared to ensure the reliability
16 of the results by standardizing the investigation (Yin, 2003).

17 First of all, we adopted the interview protocol described in Section 3.1. Secondly, a semi-
18 structured interview questionnaire was developed in three stages. A first draft was prepared on
19 the basis of the literature review and our research questions. This draft was revised by a panel
20 of nine academics and four practitioners operating in food manufacturers and food banks. The
21 first draft was then adapted following their feedback and was piloted in two interviews, after
22 which, a few additional questions were added and others adapted. The final questionnaire
23 covered five key areas:

24 *1. Contact details and characteristics of the company:* The first section was designed to collect
25 general information about the company being interviewed. The logistics network and planning
26 process were investigated for each company.

27 *2. Quantitative and qualitative assessment of surplus food generated:* This involved collecting
28 information relating to the amount of surplus food generated in the companies and how surplus
29 food is measured.

1 *3. Main reasons for surplus food generation and main management alternatives:* The reasons
2 for surplus food generation and the options used to manage surplus food were discussed in the
3 third section.

4 *4. Surplus food management process:* The fourth section was designed to understand the
5 process of surplus food management. Internal processes and relationships with third parties
6 were discussed in this section.

7 *5. Main motivations, constraints and drivers towards surplus food management:* In this section,
8 the focus was on surplus food redistributed for social purposes. The primary motivations, the
9 main internal and external constraints and drivers relating to management and redistribution of
10 surplus were discussed in this section.

11 More precisely, the first research question is answered by analyzing sections 2, 3 and 4, while
12 the second research question is answered by analyzing sections 4 and 5.

13 Finally, we identified the case sample. We followed Eisenhardt's argument (1989) suggesting
14 that a cross-case analysis involving four to ten case studies can be a good basis for analytical
15 generalization and to ensure external validity, and performed a cross-case analysis on ten food
16 manufacturing companies operating in a single region in Northern Italy (Table 2). This helped
17 to reduce the potential impact of environmental factors on the cross-case analysis, e.g.
18 differences in the quality of infrastructure or the different distribution of food aid organizations
19 in the area.

20 Taking into account the sample characteristics, it is possible to note that our sample contains
21 small, medium and large companies with diverse product ranges. However, all the companies
22 have a relationship with food banks or food aid organizations and all donate different amounts
23 of products according to different schedules. This is consistent with the aim of this research
24 (more particularly, with research question 2). Nonetheless, we are aware that reliance on the
25 food bank as the main source may create a sample selection bias, with a greater incidence of
26 good practice than in the overall industry environment, and we will discuss the results
27 accordingly

28 Table 2 - Description of the sample

Case	Main stream products	Domestic turnover [m €]
A	Dairy products	14
B	Meat products	180
C	Beverages	300
D	Dairy products	220
E	Conserved food products	1300
F	Fresh products	100
G	Dairy products	860
H	Conserved food products	6
I	Confectionary products	320
J	Confectionary products	1000

1

2 Following the suggestions of Voss et al (2002), the outline of the questionnaire was sent in
3 advance to help the interviewees be properly prepared. Interviewees were middle or senior
4 managers responsible for logistics and/or surplus food management within their organizations.
5 In some instances, the Corporate Social Responsibility (CSR) manager also took part together
6 with the manager responsible for surplus food. It is known that multiple sources of evidence
7 help to improve the construct's validity (Yin, 2003).

8 **4. Findings and discussion**

9 In this section, the research questions are answered, based upon the descriptive cases.

10 **4.1. Food Waste Hierarchy in food manufacturing**

11 The main findings relating to the first research question are described in detail in the following
12 paragraphs.

13 *Surplus food reuse - Remaking (Remanufacturing and repackaging)*. Based on the product type
14 and the reason why surplus food is generated, companies can opt for its remanufacturing in the
15 case of production errors, or repackaging in the case of packaging and labelling errors. In both
16 cases, the remaking must follow control instructions given by the quality department, for safety
17 purposes, and surplus food is reworked and fed back to the primary market. Remanufacturing
18 is used in meat, chocolate and pasta production (Cases B, I and H respectively); it is also true
19 that remanufacturing processes are not feasible or efficient in some of the other sectors
20 analyzed. We, in fact, found that repackaging is a minor option, due to the additional cost of
21 removing the package from the product and repackaging it. As a consequence, it is used by the

1 chocolate producer only (Case I), something that can be explained by the higher value of the
2 product. The main functions involved in the remaking process are production and quality.

3 *Surplus food reuse - Sales with promotions and discounts.* Despite surplus food being
4 generated, sales on primary markets can still be profitable for companies, especially for
5 chocolate (Case I). When it is clear that there is a risk of reaching the internal sell-by date, the
6 manufacturer can try to sell surplus food to its customers on the primary market at a discounted
7 price (Cases B, C, D, F, G, I and J). Coordination between the sales, marketing and planning
8 departments is crucial for making a timely decision and to sell surplus food to the company's
9 intended customers (Case I). The option of selling on primary markets tends to expire rapidly,
10 and only a few customers will accept the trade-off between short shelf life and reduced price
11 (Case D).

12 *Surplus food redistribution - Sales in secondary markets.* When the surplus food can no longer
13 be sold on the primary channels, some companies will use secondary channels, i.e. alternative
14 markets like distributors specializing in surplus products (Cases B, C, D, F, and G) or special
15 points of sale managed directly by the company (Case I). Revenue from secondary markets was
16 found to be substantial in only one of our cases (Case F). The main functions involved here are
17 sales, marketing, planning and finance.

18 *Surplus food redistribution - Marketing actions and sponsorships.* Companies can also utilize
19 surplus food by sponsoring specific organizations or arranging product tasting events. In Case
20 I, the company department responsible for surplus food management checks whether
21 employees have submitted any sponsorship requests to the CSR department/officer. The
22 company allows its employees to sponsor and to suggest events to be sponsored. These can be
23 charitable events or sports competitions where surplus food is offered to participants.

24 *Surplus food redistribution - Internal distribution.* Companies can also choose to distribute
25 surplus products within their organization. In general, they set up a dedicated area stocked with
26 "free to take" products available to their employees. For instance, in Case A, the company
27 produces yogurt. When production changes from one flavour to another, the set-up batch will
28 be mixed (e.g. a combined banana and strawberry flavour). Products from this batch are
29 absolutely edible but cannot be sold. Instead of disposing of them, the company will pack and
30 gift these products to their employees. The main functions involved here are quality control,
31 planning and operations.

1 *Surplus food redistribution - Donation:* Surplus food can be given for free to non-profit
2 organizations that assist the poor. The beneficiaries can be front-end aid organizations that serve
3 food to people with insecure residency status or other people in need (organizations can be
4 social supermarkets, food pantries or soup kitchens, social coffee shops and social restaurants),
5 or a back-end, wholesale organization that supplies to front-end aid organizations (such as food
6 banks). Given the approach followed in selecting the sample (Section 3), all the companies
7 interviewed use this channel. In many cases, food manufacturers prefer to work with a single
8 established food aid organization (Cases A, C, E, F, G, and H). In some cases, however, a
9 second food aid organization becomes involved, because the first organization's collection
10 capacity or demand for certain types of goods can be limited (Case B, D, I, and J). If food aid
11 organizations arrange product transport, the donation is easier from the company's perspective.
12 However, in Case E, the company uses its own transport methods to help the non-profit
13 organization with the collection of goods. The main functions involved in the donation
14 decisions here are supply chain and logistics, planning and operations and CSR.

15 *Food waste management - Conferment to processing companies.* Depending on the product
16 type, surplus food can be sold to companies that produce animal feed or fertilizers. In some
17 cases, the company can earn a small revenue from this channel. In Case D, most of the
18 company's surplus food is sold to produce animal feed. The company has a close relationship
19 with an animal feed producer and the product is suitable (i.e. yogurt and milk). This is not an
20 option for meat producers, because of safety regulations on animal feed processing (Case B).

21 *Food waste management - Conferment to waste management companies.* At the bottom of the
22 hierarchy, conferment of food waste to third parties for disposal, with or without recovering
23 energy, is the final option (Cases B, C, E, G, I, and J). Typically, a specialized waste
24 management utility or company collects and treats waste produced by food manufacturers. In
25 all cases, waste management is a cost for the company. Cost control implies that this waste has
26 to be held at the minimum level.

27 **4.2. Critical factors for surplus food management**

28 **4.2.1. Management control system for surplus food: methods and functions**

29 The main findings relating to research question (2a) are summarized as follows.

30 *Measurement.* Three levels of measurement were detected:

- 1 - Ad hoc measurement: Some companies measure surplus food only if the amount
2 generated is extremely high due to extraordinary events like failed promotions or
3 unsuccessful new product introductions (Cases B, D, and G).
- 4 - Periodic and fragmented measurement: Some companies measure and monitor surplus
5 food regularly, where different corporate functions are involved depending on the types
6 of surplus food. For instance, the marketing department can manage commercial
7 returns, while management control monitors the products sent to landfill (Cases E and
8 J).
- 9 - Periodic and structured measurement: Some companies measure and monitor surplus
10 food regularly, with standard surplus food measurement indicators in all departments
11 (A, C, F, H, and I).

12 *Coordination.* The process for managing surplus food involves various business functions, i.e.
13 quality control, production, planning and operations, supply chain and logistics, marketing,
14 external relations and CSR. In the exploratory cases, the companies with a formal surplus food
15 management process stated that different company functions interact with each other regularly
16 to decide how to manage surplus food. Three levels of coordination were detected:

- 17 - No coordination: no joint decisions made among the various departments, and the whole
18 process is managed by a single department without consulting the others (Cases B, D,
19 and G).
- 20 - Informal coordination: the departments are in contact by email, phone and meet
21 informally when necessary to make decisions (Cases C, E, and J).
- 22 - Formal coordination: surplus food is managed through regular meetings involving
23 different departments (Cases A, F, H, and I).

24 *Organization.* There are different reasons behind the generation of surplus food and the
25 different methods for managing it depend upon these reasons. For instance, if surplus food is
26 generated as the result of error, the company can decide to go along the route of
27 remanufacturing. Similarly, repackaging may be used for labelling and packaging errors. When
28 surplus food is the result of imminent internal sell-by dates, the company can try to sell the food
29 to its customers on the primary market at a discounted price. It can then follow the various
30 routes described previously. Three levels of process organization were detected:

- 1 - Process not organized: Some companies have no procedure in place for the different
- 2 causes of surplus food generation (Case D).
- 3 - Process organized for some causes: Some companies have a formal approach for some
- 4 causes of surplus food generation, such as exceeding the internal sell-by date (Cases B,
- 5 C, E, G, H, and I)
- 6 - Process organized for all causes: Some companies have a formal approach for all causes
- 7 of surplus food generation (Cases A, F, and J).

8 Table 3 compares cases for the three components of the management control system

9 Table 3- Degree of adoption of management control systems

		A	B	C	D	E	F	G	H	I	J
Measurement	Ad hoc measurement		X		X			X		X	
	Periodic and fragmented measurement					X					X
	Periodic and structured measurement	X		X			X		X		
Coordination	No coordination		X		X			X		X	
	Informal coordination			X		X			X		X
	Formal coordination	X					X				
Organization	Process not organized				X						
	Process organized for some causes		X	X		X		X		X	
	Process organized for all causes	X					X		X		X

10

11 In order to perform the cross case analysis, we used an ordinal scale with three options, Low

12 (L), Medium (M) and High (H), to indicate how strongly each factor is implemented by the

13 individual manufacturers. (Example: Companies using ad hoc measurement systems are

14 classified as Low (L) for the measurement parameter.) Then, in order to compare the cases, the

15 three components used to assess “management control” were reduced to a single parameter.

16 The logic applied here is as follows. An overall High level of management control was assigned

17 if the entire management control system contained at least two components assessed as High

18 and none assessed as Low. An overall Low level of management control was assigned if the

19 entire management control system contained at least two components assessed as Low and none

20 assessed as High. All the remaining cases were labelled as Medium (Table 4).

1 The effectiveness of surplus food management is measured, in each case, through the proportion
 2 of surplus food recovered for human consumption, i.e. reused or redistributed, out of the total
 3 surplus food generated. The cross-case analysis allows us to deduce how surplus food savings
 4 vary according to how committed manufacturers are to managing the problem. A clear
 5 correlation is found between the commitment to surplus food management and the adoption of
 6 management control systems for surplus food, as summarized in Table 4.

7 Table 4 – Cross case analysis for management control system variables

	A	F	H	I	C	E	J	B	G	D
Measurement	H	H	H	H	H	M	M	L	L	L
Coordination	H	H	H	H	M	M	M	L	L	L
Organization	H	H	M	M	M	M	H	M	M	L
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Management Control System	High	High	High	High	Med	Med	Med	Low	Low	Low
Reuse and redistribute	100 %	100 %	100 %	80 %	85 %	50 %	45 %	32 %	15 %	8 %

8

9 Table 4 shows an apparent exception for some cases. Case C is a company that produces
 10 alcoholic and alcohol-free beverages and soft drinks. Glass bottles are generally used to pack
 11 the product. Ruined packaging means, in many cases, that the bottle is broken and the product
 12 is no longer fit for human consumption and is thrown away, so there is no surplus. In addition,
 13 the products have a relatively long shelf life and this simplifies management, despite there being
 14 no well-structured process.

15 **4.2.2. Partnership with food aid organizations: methods and functions**

16 In this part, we focused on the organizational and operational drivers, although we do
 17 acknowledge that higher level incentives come into play whereby making donations to food aid
 18 organizations and acting in partnership with them becomes a valuable option, in the light of
 19 corporate social responsibility. Descriptive case studies offered empirical evidence on the
 20 internal drivers of surplus food redistribution through donations to food aid organizations
 21 (research question (2b)).

1 *Pro-activism.* The company can manage the process proactively or may remain reactive to the
 2 demand from food aid organizations.

- 3 - Reactive: The food aid organization contacts the company to check if something is
 4 available for donation and organizes transport of surplus food (Cases B, D and G).
- 5 - Pro-active: The company contacts the food aid organization when there is surplus food
 6 to donate (Cases A, C, E, F, H, I and J).

7 *Regularity.* The process of making a donation can be regular or variable.

- 8 - Sporadic: In most of the cases, when the company detects surplus food to be donated, it
 9 contacts the food aid organization for conferment and no formal agreement exists (Cases
 10 A, B, C, D, F, G and J)
- 11 - Regular: In some cases, there is an agreement between the company and the food aid
 12 organization, regulating the process of collecting surplus food, which is defined in
 13 advance (Cases E, H and I).

14 Table 5 compares cases along the two components of the degree of partnership with food aid
 15 organizations.

16 Table 5- Degree of partnership with food aid organizations

		A	B	C	D	E	F	G	H	I	J
Pro-activism	Reactive		X		X			X			
	Pro-active	X		X		X	X		X	X	X
Regularity	Sporadic	X	X	X	X		X	X			X
	Regular					X			X	X	

17
 18 The same method used in Section 4.2.1 was also applied to the remaining two variables that
 19 identify the company's partnership with food aid organizations (Table 6). In this case, the
 20 comparison was performed by using the percentage of donation to food aid organizations as a
 21 measure of effectiveness. In order to perform the cross case analysis, we used the same ordinal
 22 scale with three options, Low (L), Medium (M), High (H), to indicate how intensely each factor
 23 is implemented by the individual manufacturers. More precisely, we assigned H if this

1 relationship is proactive and regular, M if the relationship is proactive and sporadic and L if the
 2 relationship is reactive and sporadic. By definition, a reactive and regular relationship cannot
 3 exist.

4 Table 6 – Cross case analysis for partnerships with food aid organizations

	H	I	A	F	E	J	C	B	G	D
Pro-activity	P	P	P	P	P	P	P	R	R	R
Regularity	R	R	S	S	R	S	S	S	S	S
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Partnership with food aid organization	High	High	Med	Med	Med	Med	Med	Low	Low	Low
Donation	100 %	80 %	80 %	75 %	50 %	45 %	10 %	12 %	7 %	5 %

5
 6 Apart from Case C, the exception here is for Case A. Because of its highly structured
 7 management control system, Case A is able to save 100% of its surplus food and donates 80%
 8 of it. Its relationship with food aid organizations is not regular or formal. However, due its small
 9 size, the company is able to manage its surplus food without a regular donation process.

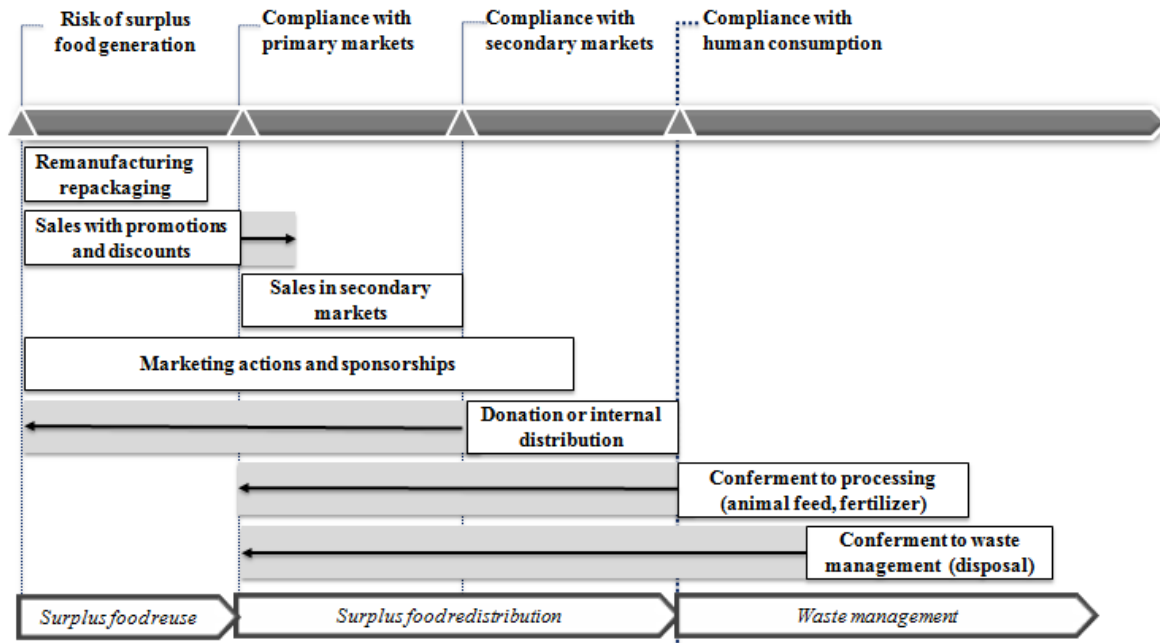
10 **4.3. Discussion**

11 The descriptive cases allowed us to adapt the food waste hierarchy to manufacturing, i.e. to
 12 address research question 1. First of all, the cross-case analysis highlighted that reuse of surplus
 13 food in primary markets can take different forms, these being remanufacturing, repackaging,
 14 promotional sales through discounts and other pricing techniques. In addition to reusing the
 15 product, redistribution is also widely practiced, by selling surplus food to secondary markets,
 16 distributing it at sponsored events and to employees and, above all, by donating it to food aid
 17 organizations. Secondly, the descriptive cases also revealed that the choice among the various
 18 management options varies over time, depending upon the feasibility of each single option (the
 19 state of the surplus food), but in any case it is moderated by the general attitude of the company
 20 towards each option.

21 Figure 1 shows how the options for managing surplus food and food waste - those available to
 22 food manufacturing companies (y axis) - vary depending on the state of the surplus food, i.e.
 23 whether it is suitable for human consumption (x axis). First of all, not all the surplus food

1 management options are available simultaneously. Considering products about to reach their
2 internal sell-by date, in principle the company has a wide portfolio of options when it becomes
3 aware that surplus food is going to be generated (*risk identification*), as long as it is still fit for
4 human consumption, i.e. it has gone past its use-by date (*compliance for human consumption*).
5 However, the shelf life requirements included in commercial agreements limit access to primary
6 and secondary markets. Only if surplus food has not exceeded the internal sell-by date accepted
7 by the retail trade and other primary markets (*compliance for primary markets*), can it be reused,
8 e.g. through special discounts and promotions, or by remanufacturing. Alternatively, it can be
9 redistributed for human consumption in a different form, e.g. donation to non-profit
10 organizations, through internal distribution and product tasting, by sponsoring events or selling
11 to secondary markets. Reuse options cease to be available after the internal sell-by date has
12 expired, but selling to secondary markets may still be a possibility, provided that the surplus
13 food has not gone past the sell-by date accepted by secondary markets (*compliance for*
14 *secondary markets*). Other redistribution options remain open for even longer, i.e. until the use-
15 by date.

16 However, Figure 1 highlights that technical and economic feasibility is not the only factor
17 driving choice among the various options. Activating one or another option also depends on the
18 company's overall strategy and its managers' individual motivations. Moreover, if companies
19 work in close partnership with food aid organizations, they are likely to inform food aid
20 organizations about its surplus food distribution plans before it has to comply with secondary
21 markets. For instance, a company may prefer to donate its surplus food for reasons of social
22 responsibility, without considering other reuse and redistribution options, and even without
23 waiting for the surplus food to go over the threshold for secondary markets. Other companies
24 may prioritize economic efficiency and always use commercial options, until the expiration of
25 the sell-by threshold date.



1

2

Figure 1 – Surplus food management in food manufacturing companies

3 The cross case analysis also helped in refining the research question 2 concepts and how they
 4 can be adapted to food manufacturing.

5 The descriptive cases showed that the amount of surplus food reused or redistributed can
 6 increase by designing and implementing a structured control system, which includes the
 7 measurement of surplus food, coordination among the main officers/departments that have a
 8 say on surplus food (from CSR to logistics) and organized management processes. There are
 9 differences among the companies, starting from whether there is a system to measure surplus
 10 food. While some companies consider surplus food as an important variable in their
 11 management control system, and measure it periodically and systematically, other companies
 12 are not aware of the issue, and so do not measure surplus food, or do so casually, with negative
 13 implications for surplus food uses. Coordination among departments is another factor that
 14 reveals how important surplus food management is to the organization. Not only does it focus
 15 its employees' attention on the process of managing surplus food, but it also ensures that the
 16 process of reusing and redistributing surplus food is more efficient. Finally, the organization of
 17 surplus food management entails making a clear distinction between different surplus food
 18 types. In order to exploit the different options fully, all the various reasons for why surplus food
 19 is generated have to be taken into account; different causes trigger different reuse and
 20 redistribution routes.

1 Donations to food aid organizations are a high-priority channel for redistributing surplus food,
2 and, as such, deserve a more focused analysis. The cases analysed demonstrated that donations
3 risk being sporadic and mainly at the behest of non-profit organizations. A certain amount of
4 activism is demanded of the company, which has to plan its interaction with food banks and
5 charities and give them a clear timescale.

6 Figure 2 summarizes key factors in surplus food management, grouping them together under
7 “Management Control System”, which supports both reuse and redistribution, and “Partnership
8 with food aid organizations”, whereby redistribution through donations is more efficient.



9

10

Figure 2 - Critical factors for surplus food reuse and redistribution

11 **5. Conclusions**

12 Food waste is a critical issue for the economy, the environment and society. Managing surplus
13 food efficiently and effectively is increasingly recommended when preventing surplus food at
14 the onset is not economically feasible, since it is believed to have huge potential for reducing
15 both food insecurity and food waste. Despite the progressive diffusion of the food waste
16 hierarchy and related guidelines, the management of surplus food in food manufacturing
17 companies is not as straightforward as expected. We, therefore, studied both the various food
18 waste hierarchy options and their feasibility, and the internal barriers and enablers for surplus
19 food management, in particular regarding redistribution for social purposes.

20 First of all, we found that, once the risk of surplus food is detected, the company can choose
21 among a set of reuse options, depending on the product type and the reason why surplus food
22 is generated. Other channels are remanufacturing, repacking and selling on the primary markets
23 with promotions and discounts. When those options are not viable or are operationally
24 expensive, redistribution options are considered, namely surplus food used for marketing
25 purposes, such as product tasting, sponsorship and distribution to employees. Companies can
26 also make use of the option to donate surplus food to aid organizations.

1 Secondly, in order to implement the food waste hierarchy fully, the company should plan for
2 the above mentioned process. As a first precondition, it should be aware that surplus food is
3 generated through its own processes. In other words, it should measure the amount of surplus
4 food it generates periodically and in a structured way. At the same time, its decision-making
5 system should be organized to take into account all relevant causes and be coordinated formally.
6 Finally, partnerships with non-profit organizations are necessary to build a formal and regular
7 donation process and increase the amount of surplus food saved for human consumption.

8 Coming to the limitations of the study, we recognize that our findings may be specific, because
9 they relate to practices observed in one Northern Italian region. Contributions from other
10 countries would allow us to extend the empirical setting, and to understand whether our results
11 can be generalised. We see our current focus on companies that have already donated surplus
12 food - albeit at very different degrees - as necessary at this stage for eliciting best practice.
13 However, we acknowledge that investigating non-donating players and carrying out a
14 quantitative test of our framework on a larger scale could also serve our objective of
15 generalizing the results. Finally, understanding the perspectives of players at different stages in
16 the food supply chain, such as retailers and food service operators, would help in providing a
17 bigger picture.

18 This research can have implications for other players, besides food manufacturers. For example,
19 non-profit food aid organizations can identify ways for collaborating more easily with donors.
20 They can design solutions to improve their relationship with food manufacturers. Moreover,
21 our results could be the starting point for further research. Policy-makers could evaluate the
22 current incentive system concerning food donations and offer tax incentives to companies that
23 demonstrate to have set up a surplus food management control system, and provide financial
24 support to food aid organizations that give higher priority to the compliant manufacturers
25 among their suppliers.

26 **Acknowledgements**

27 The authors would like to express their gratitude to the interviewees and colleagues for their
28 contribution to this research, as well as to the Foodsaving project, funded by Cariplo Foundation
29 and Lombardy Region.

30 **References**

- 1 Aleksandar, C., Smaje, C., 2008. Surplus Food Redistribution: An Analysis of a Third Sector
2 Model. *Resource, Conservation and Recycling* 52 (11), 1290-1298.
- 3 Buzby, J., Hyman, J., 2012. Total and Per Capita Value of Food Loss in the United States. *Food*
4 *Policy* 37, 561-570.
- 5 Buzby, J.C.; Bentley, J.T.; Padera, B.; Ammon, C.; Campuzano, J., 2015. Estimated Fresh
6 Produce Shrink and Food Loss in U.S. Supermarkets. *Agriculture*, 5, 626-648.
- 7 Darlington, R., Staikos, T., Rahimifard, S, 2009. Analytical Method for Waste Minimization in
8 the Convenience Food Industry. *Waste Management* 29 (4), 1274-1281.
- 9 Edwards, F., Mercer, D., 2007. Gleaning from Gluttony: an Australian youth subculture
10 confronts the ethics of waste. *Aust. Geogr.* 38, 279-296.
- 11 Eisenhardt, K. M., 1989. Building Theories from Case Study Research. *The Academy of*
12 *Management Review* 14 (4), 532-550.
- 13 Eisenhardt, K. M., Graebner, M. E., 2007. Theory Building from Cases: Opportunities and
14 Challenges, *Academy of Management Journal* 50 (1), 25–32.
- 15 Evans, D., 2014. *Food Waste. Home Consumption, Material Culture and Everyday Life.*
16 London: Bloomsbury Academic.
- 17 Evans, D., Campbell, H. & Murcott, A. 2012. A Brief Pre-History of Food Waste and the Social
18 Sciences. *Sociological Review*, 60, 5-26.
- 19 Evans, D., Campbell, H. & Murcott, A., 2013. *Waste Matters: New Perspectives on Food and*
20 *Society* (D. Evans, H. Campbell, and A. Murcott, Eds.). Oxford: Wiley-Blackwell/ *The*
21 *Sociological Review*.
- 22 FAO, 2014. *Definitional Framework of Food Loss, SAVE FOOD: Global Initiative on Food*
23 *Loss and Waste Reduction; Food and Agriculture Organization (FAO), Rome.*
- 24 FAO, 2015. <http://faostat3.fao.org/browse/D/FS/E> (accessed 25 May 2015).
- 25 Fontana, A., Frey, J.H. 1994. *Interviewing: The Art of Science. The Handbook of Qualitative*
26 *Research.* Sage Publications, Thousand Oaks.

- 1 Garnett, T., 2014. Three perspectives on sustainable food security: efficiency, demand restraint,
2 food system transformation. What role for life cycle assessment? *Journal of Cleaner Production*
3 73, 10 – 18.
- 4 Garrone, P., Melacini, M., Perego, A., 2014a. Opening the Black Box of Food Waste Reduction.
5 *Food Policy* 46, 129-139.
- 6 Garrone, P., Melacini, M., Perego, A., 2014b. Surplus Food Recovery and Donation: The
7 Upstream Process. *British Food Journal* 116 (9), 1460-1477.
- 8 Gentilini, U., 2013. *Banking on Food: The State of Food Banks in High-income Countries.*
9 Institute of Development Studies, Brighton.
- 10 Griffin, M., Sobal, J., Lyson, T., 2009. An Analysis of a Community Food Waste Stream.
11 *Agriculture and Human Values* 26, 67-81.
- 12 Gustavsson, J., Cederberg, C., Sonesson, U., 2011. *Global Food Losses and Food Waste.* Food
13 and Agriculture Organization of United Nations, Rome.
- 14 Kantor, L., Lipton, K., Manchester, A., Oliviera, V., 1997. Estimating and Addressing
15 America's Food Losses. *Food Review*, 2-12.
- 16 Katajajuuri, J., Silvennoinen, K., Hartikainen, H., Heikkilä, L., 2014. Food Waste in the Finnish
17 Food Chain. *Journal of Cleaner Production* 73, 322–329.
- 18 Kummu, M., De Moel, H., Porkka, M., Siebert, S., Varis, O., Ward, P.J., 2012. Lost Food,
19 Wasted Resources: Global Food Supply Chain Losses and Their Impacts on Freshwater,
20 Cropland, and Fertiliser Use. *Science of Total Environment* , 477-489.
- 21 Lundie, S., Peters, G. M, 2004. Life Cycle Assessment of Food Waste Management Options.
22 *Journal of Cleaner Production* 13 (3), 275-286.
- 23 Mena, C., Adenso-Diaz, B., Yurt, O., 2011. The Causes of Food Waste in the Supplier - Retailer
24 Interface: Evidences from the UK and Spain. *Resources, Conservation and Recycling* 55 (6),
25 648-658.
- 26 Mirabella, N., Castellani, V., Sala, S., 2013. Current Options for the Valorization of Food
27 Manufacturing Waste: A Review. *Journal of Cleaner Production* 65 (15), 28-41.

- 1 O'Connor. C. 2013. Quantification of Food Waste in the EU. OECD Food Chain Network.
2 http://www.oecd.org/site/agrfcn/Session%201_ClementineOConnor.pdf (accessed 25 May
3 2015).
- 4 Papargyropoulou, E., Lozano, R., Steinberger, J. K., Wright, N., 2014. The Food Waste
5 Hierarchy as a Framework for the Management of Food Surplus and Food Waste. *Journal of*
6 *Cleaner Production* 76, 106 – 115.
- 7 Richter, B., Bokelmann, W., 2016. Approaches of the German food industry for addressing the
8 issue of food losses. *Waste Manag.* 48, 423-429.
- 9 Santini, C., Cavicchi, A., 2014. The Adaptive Change of the Italian Food Bank Foundation: A
10 Case Study. *British Food Journal*, 116 (9), 1446 – 1459.
- 11 Schneider, F., 2013. The evolution of food donation with respect to waste prevention. *Waste*
12 *Manag.* 33, 755-763.
- 13 Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable
14 policy development. *Resour. Conserv. Recycl.* 106, 110-123.
- 15 Voss, C., Tsiriktsis, N., Frohlich, M., 2002. Case Research in Operations Management,
16 *International Journal of Operations & Production Management*, 22 (2), 195-217.
- 17 Yin, R., 2003. *Case Study Research Design and Methods*. Sage Publications, London.