Economic benefits from food recovery at the retail stage: An application to Italian food chains

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A B S T R A C T

The food supply chain is affected by losses of products near to their expiry date or damaged by improper transportation or production defects. Such products are usually poorly attractive for the consumer in the target market even if they maintain their nutritional properties. On the other hand undernourished people face every day the problem of fulfilling their nutritional needs usually relying on non-profit organizations. In this field the food recovery enabling economic benefits for donors is nowadays seen as a coherent way to manage food products unsalable in the target market for various causes and thus destined to be discarded and disposed to landfill thus representing only a cost. Despite its obvious affordability the food recovery is today not always practiced because the economic benefits that could be achieved are barely known. The paper aims at presenting a deterministic mathematical model for the optimization of the supply chain composed by retailers and potential recipients that practice the food recovery, taking into account the benefits recognized to donors and the management costs of the food recovery. The model determines the optimal time to withdraw the products from the shelves as well as the quantities to be donated to the non-profit organizations and those to be sent to the livestock market maximizing the retailer profit. The results show that the optimal conditions ensuring the affordability of the food recovery strategy including the tax reliefs and cost saving for the retailers outperforms the profit achievable in absence of such a system.

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1. Introduction and literature review

Recent studies highlight that the food losses represent a significant issue affecting food supply chains. In particular the attention is focused on the economic, social and environmental impact of food losses. This is due to the awareness that a significant part of the food managed along the supply chain is wasted even if it can be still suitable for human consumption. A study conducted by Gustavsson et al. (2011), highlighted that in 2011 the per capita food loss in Europe and North-America was 280–300 kg/year, while in Sub-Saharan Africa and South/Southeast Asia it was 120–170 kg/year. Nellman et al. (2009), reported that a percentage which ranges between the 25% and the 50% of food produced is wasted through the supply chain. Beretta et al. (2013), conducted an analysis for the quantification of food losses in Switzerland by dividing them into avoidable, partially avoidable and unavoidable and calculating the percentage of losses for each type of food. They found that about the 48% of animal and agricultural food produced

is lost and in particular the 13% of food loss is avoidable and nearly half of it is in perfect quality, another 13% is potentially avoidable and the 21% is not avoidable.

The need to improve food quality and reduce food waste along the supply chains is hence an emerging challenge for researchers and practitioners, who must develop and implement new concepts for planning and controlling the supply chain. New advanced technologies for food traceability, as well as innovative shelf-life based management policies are an example of the recent efforts aiming at increasing the sustainability of food supply chains.

Food losses are generally not further salable to the consumer in the target market for different reasons such as visual or quality defects, behavior consumer changes, and the reaching of the end of Shelf Life (SL), (see Kantor et al., 1997, Alexander and Smaje, 2008, Prado et al., 2010, Parfitt and Barthel, 2010, Gustavsson et al., 2011, Mena et al., 2011, Garrone et al., 2012, Barilla, 2012). On the other hand if properly recovered, such products could ameliorate the diet of undernourished people of the local country sustained by non-profit organizations. However the food recovery is not always extensively practiced due to the risk that an improper handling of the products donated can affect the firm reputation especially for products that are closer to the expiration date (see

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Garrone et al., 2012). In fact the main destination of food losses is today the landfill whereas the supply to livestock market as raw materials for animal feeding production, or for direct animal feeding, or for free donation to non-profit organizations could be a more effective way to manage such products under the economic environmental and social standpoint. In this context the literature does not report attempts of modeling of the economic profitability of food recovery while the importance of such practice is more and more advocated. In this paper, by following the definition done by Griffin et al. (2009), food waste is referred to the products wasted along the supply chain without distinction between edible or not, while other definitions such as the one given by Kantor et al. (1997) and Betts and Burnett (2007), refer to the food still suitable for human consumption but not sold to or consumed by people for which it had been produced. In this sense the food losses result in food which has lost its value in the target market even if it is still suitable for human (European Commission, 2010) or animal consumption. The present study focuses on a better management of food losses produced through their recovery for human consumption or recycling for animal feeding. The recovery relates to the proper withdrawal of food for direct human consumption, while the animal recycling refers to the use of the food recovered for animal feed production. The food losses in the retail sector generally comprise products close to their expiration date (or SL or sell by date), or products affected by visual or quality defects (errors during the manufacturing process, or transport or packaging mistakes), or unsold products resulting from poor forecasting, demand variability, promotions, pricing policies. For such reasons they result not attractive for the consumer in the target market, even if they still comply with safety and nutritional standards. If such food is not properly recovered for human consumption or recycled for animal feeding it represents an inefficiency in the supply chain. Such inefficiencies consist of lost sales, increased production costs, and costs related to the management and disposal of surplus products. As specified by Binyong (2007), one of the most critical aspects of food losses is that their costs are usually underestimated. In such context food losses hinder the minimization of supply chain costs and the achievement of its efficiency (Alexander and Smaje, 2008). Prado et al. (2010), state that a good management of such food represents a "differential to achieve better profit margin".

Besides mere economic implications food losses also have a strong social and environmental impact (Hall et al., 2009). From a social standpoint food losses recovery can support non-profit organizations, which are crucial for undernourished people to get sufficient food. Today an alternative use of such losses is expected to be particularly appreciated, since the economic crisis increased the number of people that cannot afford the cost of a buying sufficient food. The estimates determined by Gabe (2012), for the Congressional Research Service reveal that the poverty rate in the USA reached 15% in 2011 compared to 12.3% in 2006, while the European Commission (2011), reports that in Europe the poverty rate reached the 23% in the 2010.

The problem of food losses is linked to the characteristics of the supply chain: in responsive supply chains more food losses are expected than in efficient ones since generally the improvement of responsiveness leads to an excess of buffer capacity and inventories to face demand variability, while in an efficient supply chain the members manage their activities in order to meet predictable demand at the lowest cost (Minnich and Maier, 2006). On the other hand Mena et al. (2011), underline that even efficient supply chains can be prone to increase the potential of food loss generation, because of strategic decisions encouraging the use of cheaper transportation channels, making the products travel longer distances and requiring more handling when locking for full truckloads thus increasing risk of damage. In such context, the

possibilities of an alternative employment of surplus food refer to the redistribution of such products in markets with less stringent standards related to the expiring date where they are sold at discounted prices (Thang, 2009), or in the livestock market where they can be supplied at no cost. Generally speaking the alternative use of surplus food is dependent on the type of the managed product, the stage of the supply chain in which the surplus has been generated, and its quality. For example dry food is more properly salable in the livestock market compared to liquid food while very ripe are suitable for the transformation industries. On the other hand moving from the top stages (Supplier) to the bottom stages (Distribution and Retailing) of the supply chain the quantity and variety of the food surplus switch from high quantity of a scarce variety of products to low quantity of a wide variety. On the basis of the products characteristics, selling to an alternative market can represent only a cost rather than a true source of gain. In fact, as reported by Garrone et al. (2012), usually Italian firms producing animal feeds are willing to pay a discounted price to receive dry food and cereals while they require a fee to accept fish food; however such a fee is less than the disposal cost sustained by the retailer. The effective implementation of food loss reduction strategies and policies therefore strongly depends on the possibility of recognizing a true affordability (Singer, 1979 and Kantor et al., 1997) deriving from the prevention and recovery of food loss. The ability to rely on food donation strongly depends on the possibility to highlight an economical benefit from the donation, originating from the tax relief allowed by the law and the reduction of the management costs. However food donation is a very sensitive operation with both positive and negative consequences. It can contribute to ameliorate the firm's reputation and to increment the consumer fidelity and sales, but it can have a negative impact as it can highlight the difficulty of the firm in selling the products in the target market (Prado et al., 2010).

The food waste and losses recovery problem has attracted the interest of researchers in the last thirty years (see Youngs et al., 1983, Kantor et al., 1997, Hyde et al., 2001, Al Seadi and Holm-Nielsen, 2004, Parfitt et al., 2010, Gustavsson and Stage, 2011, Garrone et al., 2012, Prado et al., 2010, Smil, 2004, Kummu et al., 2012, Kosseva, 2009, Nahman et al., 2012,). Regardless of the noticeable interest arisen about the problem, the effective sustainability of food loss reduction policies strongly depends on the evidence of the economic benefits achievable. However, this topic has barely been discussed in literature.

The present paper aims at overcoming this lack by proposing a mathematical model showing the economic advantage arising from food recovery for the operators of the supply chain and in particular for the retailers who can have additional benefits from tax reliefs. Potential benefits achievable from other parties such as non-profit organizations or livestock market are also taken into account. The model determines the optimal conditions which maximize the profit in case of the recovery and redistribution of the surplus practiced through alternative delivery channels such as the livestock and taking into account the free supply to non-profit organizations. The focus is on food loss management at the retailing stage because most of the food managed at this stage can always be considered "ready to eat" for the human consumption (Garrone et al., 2011) and thus more simply distributable to non-profit organizations. Alexander and Smaje (2008), reported that "retail food waste discarded to landfill only represents about a third of the total food waste generated in the sector", in the UK, "since on-going efficiency measures have sought to maximize the rate of re-use as far as possible", while a study conducted by Jones (2004), reported that 0.76% of the total food products offered by Commercial Food Store in the USA is wasted. The model determines the optimal profit achievable in presence of food losses recovery compared to the profit in absence of such strategy. The