Business innovation and waste management sustainability: the case of door-to-door collection

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Abstract

The paper analyses the economic sustainability of advanced recycling programs based on door-to-door collection service, estimating their impact on the costs and profits of firms entrusted with waste collection. By using a panel of around 70 Italian firms specialized in waste management observed in the period 2008-2011, we estimate a short-run cost and profit function system, where recycling rate depends on the adopted collection schemes. Results show that costs increase following the implementation of environmentally friendly programs while they decrease when recycling rates increase, possibly due to savings from the disposal side. Notable increase in profit level emerges just after the implementation of greener collection techniques as a result of enhanced mark-up. The interpretation of this effect invokes a process of social legitimacy by the firms, theorized in the context of the institutional theory.

***Key words**: waste management; sustainability; triple-bottom-line paradigm; profitability*

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1. Introduction

With the increasing awareness of environmental sustainability, legislative and regulatory efforts are being made to encourage practices that allow keeping up with ecological standards. These pressures have led the European Council to adopt rules on waste management (Directive2008/98/EC) expected to promote recycling priority by Member States as well as an effective limitation of the reliance on landfills. The declared strategy sets a 50% recycling target at the European level by 2020, while leaving discretion to the States on the achievement of this objective.

New trends in solid waste management emerged as a result of the efforts to reduce quantities to be landfilled and increase recyclates. These systems lie along a spectrum of trade-off between users' convenience and government ease and essentially comprise residential kerbside recycling and drop-off-based programs. The first refers to a more innovative model of collection directly from households and cadenced over time and by type of waste, while the second requires the waste producer to carry it to local stations provided of sorting facilities. This distinction is however not rigid. Mixed arrangements are, in fact, not uncommon either combining capillary door-to-door collection in some neighbourhoods to more concentrated delivery stations in others or pursuing pervasive collection only for a set of materials.

The introduction of kerbside collection schemes may be regarded as a primary motivator in encouraging recycling activities as they contribute to make recycling less burdensome and time consuming for households (Woodard *et al*., 2005). However, the more extensive and comprehensive the collection scheme, the larger is the expected impact on costs. In this vein, Jenkins *et al*. (2003) find that less expensive drop-off programs may be considered as viable alternatives to kerbside recycling programs especially for budget-constrained municipalities since they also proved effective in increasing recycling, although not at the level of kerbside schemes.

In Italy, an attempt to enhance recycling practices was made in 2006 with the *Environmental Code* that introduced the challenging target of 65% recycling rate by 2012. This has prompted local public authorities throughout Italy to revise their recycling strategies through a gradual corporatization of the service and the introduction of pervasive collection schemes. In this respect, while the use of in-house practices has dramatically shrunk (Utilitatis, 2014), recycling rates generally failed to attain the predetermined standards (ISPRA, 2013) and the ambitious target of 65% has been recently postponed to 2020 (Law n. 137/2013, so called "Budget Law 2014"). Moreover, the ongoing process shows wide differences within the national territory, with the Northern areas being more virtuous.

Early studies have investigated the role of economies of scale and other cost determinants in municipal solid waste industry, showing that small municipalities and collection based on more concentrated delivery stations may attain lower unit costs (Stevens, 1978; Tickner and McDavid, 1986; Dubin and Navarro, 1988).

Subsequent studies, specifically addressing the combination between recycling and disposal programs, do not support univocal results on the effects on costs of recycling programs (Lund, 1990; Jacobs and Everett, 1992; Ready and Ready, 1995; Highfill and McAsey, 1997; Huhtala, 1997; Tanskanen and Kaila, 2001; Larsen *et al*., 2010; Lavee, 2007). While acknowledging the existence of a body of literature on the impact on costs, no study has addressed, at least to the best of our knowledge, the less evident nexus between recycling programs and firms' profits. Firms entrusted with collection services actually play an instrumental role for municipalities in pursuing challenging goals otherwise hardly achievable. By devoting resources and organizational efforts to the assigned environmental commitment, they may reap reputational benefits and social legitimacy (Hart, 1995). In this case, due to a favourable disposition towards green services, also

fostered by external institutional pressures as well as a mounting public opinion, extra costs are more likely to be transferred to users (Ambec and Lanoie, 2008), thus leaving room for greater bargaining power by firms and therefore higher rewards.

Such arguments fall within the *institutional approach to legitimacy* (Suchman, 1995). He describes the process through which the external audiences grant a degree of approval to organizations and, in particular, he defines legitimacy as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions" (Suchman 1995: 574). An implication of this theory is that when there is an institutional pressure from various stakeholders, firm's ability to respond to such instances allows achieving legitimacy in the eyes of its stakeholders, also giving the possibility of leveraging on this social merit to pursue an economic advantage (Oliver, 1991; Ambec and Lanoie, 2008). Furthermore, we believe the links between the environmental and economic dimension on the one hand and the economic and social one on the other (through the increasingly adopted full-cost pricing principle) can fit into the emerging Elkington (1998)'s triple-bottom-line pattern, whose sustainability concept relies on a balance among planet, profit and people (the triple P) pillars (Coffman and Umemoto, 2010).

The aim of this paper is twofold. First, drawing on the above-mentioned theoretical paradigms, we develop a conceptual framework for analysing the context of waste management. Secondly, we assess the economic sustainability of some environmental friendly characteristics of the service organization. In particular, the paper estimates the impact of the introduction of advanced recycling systems based on door-to-door collection on costs and profits using a structural model.

The rest of the paper is organised as follows. First, we sketch our theoretical framework, where institutional theory's view is embedded into a triple-bottom-line framework, informing the hypotheses for the empirical application. Second, we describe the dataset and the empirical method. Third, we present the results and discuss them in the light of the formulated hypotheses. Conclusions and some strategic remarks close the paper.

2. Literature framework and definition of the hypotheses

The principle of sustainability has undergone an evolution that led it to take on different meanings. As outlined by Coffman and Umemoto (2010), the original ecological characterization, mainly focused on the well-being of the natural system, gradually shifted towards the more anthropocentric sustainable development concept, encompassing attributes like growth and social equity other than ecosystem protection. As sustainability concept has been popularized and migrated to the sphere of business, a new paradigm called "triple-bottom-line" or "triple-P" (Planet, Profit, People) emerged (Elkington, 1998), stemming on a threefold notion of corporate responsibility involving environmental and social other than strictly economic factors. Although this approach has been basically designed to provide a system for measuring the level of sustainability of an enterprise, allowing for the establishment of a corporate reporting based on environmental, social and economic parameters (Siano, 2012), it has hence transcended this framework, taking on a broader meaning, allowing to embrace the plot of relationships between these different dimensions, including their

complementary but also contradictory aspects. In this regard, the idea of harmonic firm suggested by Baccarani (1991) represents a useful antecedent.

This paradigm is well suited to be used in our research context (see Fig. 1), since institutional and stakeholders pressures on environmental issues (Planet side) have encouraged local municipalities to adopt new collection schemes suitable to cope with more challenging targets. Once implemented and operationalized, these innovative collection methods may be expected to impact on firm costs and, possibly, on firm profits (Profit side). In the context of a taxation system increasingly oriented to a full-cost pricing principle, the sum of costs and profits makes up the total revenues that companies may charge on served communities (People side). The conceptual framework in Fig. 1 illustrates the system of relations linking implementation/operation of environmentally friendly collection programs to cost and profit levels.

Some pioneering attempts to explore the link between cost and recycling programs may be found in Stevens (1978), Tickner and McDavid (1986) and Dubin and Navarro (1988), who consistently highlighted the importance of factors like collection frequency and capillarity. More recent studies assessed the relation between enforcement of recycling programs, service cost and exhausting landfill risk (Lund, 1990; Jacobs and Everett, 1992; Ready and Ready, 1995; Highfill and McAsey, 1997; Huhtala, 1997). They argue that, despite a general opinion that recycling programs are more burdensome than landfill-based systems, the cost of investing in new landfills, once the existing ones had arrived at exhaustion, would tip the balance in favour of environmentally friendly alternatives. Also, this effect would be even more pronounced in countries with limited territorial capacity (Larsen *et al*., 2010). Tanskanen and Kaila (2001) and Leeve (2007) finally emphasized the potential cost savings from the disposal stage by a reduction of reliance on landfills.

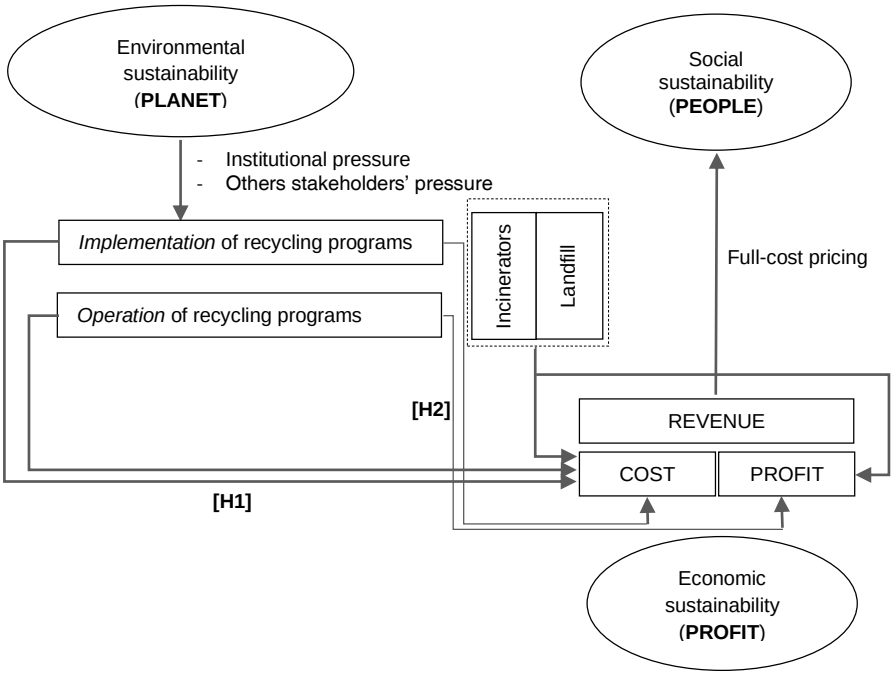
As a result, implementing recycling programs is likely to increase organizational efforts and hence costs, although the reduction of reliance on landfills subsequent to the increase of recycling rates may entail cost savings. Thus, we hypothesise the following:

H1: Firm costs are positively related to the implementation of recycling programs and negatively related to the increase of recycling rates and these relations are more substantial in more advanced recycling systems.

According to the dictates of the *Institutional Theory*, and specifically of the legitimacy-based view, we can infer some predictions about the impact of recycling programs on profitability. Institutional Theory posits that institutions are a critical component as they induce the structure of norms, rules and beliefs that characterize the environment wherein organizations move (Sonpar *et al*., 2009). When organizations subject to institutional pressure conform to the system of acceptable norms, they may earn increasing legitimacy (Suchman, 1995; Oliver, 1997). Suchman (1995) grounded the concept of legitimacy on the generalized perception that actions of an entity are desirable for the collectivity. In particular, we share the view that "efforts to conform to the dictates of pre-existing audiences within the organization's current environment" (Suchman, 1995: 587) may be regarded as a way to build legitimacy. Given that the provision of green services can be regarded as a behaviour that reflects desirability standards, this approach helps to address the question of whether it pays to be green (Ambec and Lanoie, 2008; Dixon-Fowler *et al*., 2013). Indeed, it seems plausible to assume that better environmental performance through greener services may allow firms to take advantage from higher margins. In other words, firms might be able to transfer extra costs to users due to the increased willingness to pay of the latter for services more oriented to environment protection. Thus, we offer the following hypothesis:

H2: Firm profits are positively related to the implementation/operation of advanced recycling programs and this relation is more substantial in more advanced recycling systems.

Fig. 1. Conceptual framework



Finally, we believe that the above relations may be better investigated by considering whether firms directly manage disposal facilities like landfills or incinerators. Although in this case we do not pose a specific hypothesis, we think that these characteristics may interact with cost and profit levels.

3. Methodology

3.1 Cost and profit functions

The cost function approach constitutes a consolidate practice in the waste management literature. In this work we propose a short-run cost function, with the capital stock acting as a quasi-fixed input. The function can be expressed as:

$$VC = f(y, p_x, k, z) \qquad (1)$$

where *VC* indicates the variable cost, *y* is a vector of output quantities, p_x is a vector of variable input prices, *k* represents the (quasi-fixed) capital stock and, finally, *z* represents a vector of environmental or firms' characteristics which are likely to affect the *VC*.

In this model, the underlying assumption is that firms minimize the variable cost by choosing the optimal quantity and combination of variable inputs given the exogenous variables, i.e. the amount of output to be produced, the variable input prices and the available stock of capital.

As a counterpart for the short-run cost function, the restricted profit function, in its standard formulation, takes the following form:

$$PR = g\,(p_y\,,\, p_x\,,\, k,\, z) \qquad (2)$$

where PR represents the gross operating profit, computed as total revenues minus the variable costs, p_y is the vector of output prices, while p_x, k and z are defined as in (1).

This formulation holds under the assumption of perfect competition. We believe that price-taking behavior in purchasing inputs constitutes a realistic hypothesis, but we have doubts the same applies to the output market. In our opinion it is possible that firms enjoy some degree of market power in price negotiation. For this reason, we have chosen to employ an "alternative" specification of the profit function, introduced by Humphrey and Pulley (1997). This model allows to relax the hypothesis of perfect competition on the output side by substituting the output prices with the output quantities as explanatory variables. The alternative restricted profit function takes the form:

$$PR = h\,(y,\, p_x,\, k,\, z) \qquad (3)$$

This formulation is fully comparable with equation (1), as it employs the same set of explanatory variables. Moreover, it relies on less restrictive assumption in terms of competition. Finally, a further advantage is linked to the fact that output quantity measures, in this industry, are easily available and reliable, while prices are not, especially because we want to differentiate among different types of outputs, as we will explain in more detail in the following sections.

After its introduction, the alternative profit function has been employed mainly in works related to the banking sector, for efficiency estimation purposes. In some cases it is used in comparison with cost and standard profit function models. Some interesting example are provided, among the others, by Berger and Mester (2000), Akhavein et al. (1997), Lozano-Vivas (1997), Kasman and Yildirim (2006), Chou et al. (1999), De Young and Hasan (1998), Casu and Girardone (2004).

3.2 Data and variables

Our dataset contains 290 observations, structured as an unbalanced panel covering 73 Italian firms specialized in waste management over 4 years. As 9 observations show negative variable profit, they have been automatically deleted. The model is run by pooling 281 observations.

The annual reports of the firms, provided by the Chambers of Commerce, are the main data source, integrated by information directly collected from the firms by means of questionnaires, and by public data available on the websites of the Chambers of Commerce.

Table 1 lists the variables and contains some descriptive statistics.

With respect to the dependent variables, we define the variable cost, *VC*, as the sum of the expenditure related to variable factors, i.e. labor and material and services consumption. The dependent variable in the alternative restricted profit function, *PR*, is the difference between total revenues and variable costs and corresponds to the gross operating profit (EBITDA)[5].

As mentioned in the previous section, we consider a multi-output technology, with two output categories: y_D is the variable capturing the quantity of solid waste collected for disposal, while y_R refers to the waste collected for recycling. Both the quantities are expressed in tons; they sum to the total quantity of waste managed.

We consider two variable input prices. The labor price, p_L, is obtained dividing the total labor expenditure by the average number of employees. The other price relates to materials and services consumption, p_C. As the cost of this aggregated category mainly refers to fuel expenditure, we proxy the related price with the average fuel price registered in a given year in the Province where the firms operates. This information is available on the Chambers of Commerce's websites.

Tab. 1: Descriptive statistics

Variable	Mean	St. Dev.	Min.	Max.
VC (000€)	30,100	697,000	883,564	558,000
PR (000€)	8,139	21,400	26	154,000
y_R (t)	45,709.3	61,649.52	1,864	443,031
y_D (t)	74,867.72	177,204.5	466	1,430,680
p_L (€)	42,931.27	6,962.681	23,700.96	77,309.25
p_C (€)	1.119	0.127	0.85	1.41
k (000€)	24,900	86,600	169	762,000
z_{DTD}	0.203	0.403	0	1
z_{MIX}	0.651	0.477	0	1
z_{INC}	0.128	0.335	0	1
z_{LAND}	0.274	0.447	0	1
z_{NW}	0.327	0.470	0	1
z_{NE}	0.186	0.390	0	1
z_C	0.324	0.469	0	1
z_S	0.157	0.364	0	1

The quasi-fixed input, *k*, is a monetary variable and reflects the net value of fixed assets.

We also considered the following set of dummy variables:

- z_{DTD} is equal to 1 when the door-to-door service is prevailing with respect to drop-off waste collection.
- z_{MIX} is equal to 1 when the door-to-door service is present but limited.
- z_{INC} and z_{LAND} are equal to 1 if the firm is vertically integrated downstream and manages respectively an incinerator or a landfill.
- z_{NW} is equal to 1 when the firm operates in the North-Western part of the Country
- z_{NE} is equal to 1 when the firm operates in the North-East part of the Country[6]

[5] In order to provide a robustness check we tested a model based on EBIT as measure of profit (we thank an anonymous referee for having raised this point). This also implied a change in the cost measure, defined as the sum of variable and capital costs. The system of equations (4) was then re-estimated. The results (available upon request) support our main findings.

[6] The variable referring to North-East has not been included in the estimation to avoid multi-collinearity.

- z_C is equal to 1 when the firm operates in the Central part of the Country
- z_S is equal to 1 when the firm operated in the Southern part of the Country.

From Table 1 we can notice that about 85% of the firms in our sample has implemented at least partially the door-to-door service. Moreover, vertical integration is not the most common management choice, since 27% of the firms manages a landfill and less than 13% owns an incinerator.

3.3 Estimation strategy

We believe it is relevant to consider waste management as a multi-output technology: even when firms are specialized on the waste sector, waste disposal and waste recycling are distinct activities involving different processes. Therefore, we consider them as two distinct outputs, expressed by the respective waste quantities (y_D and y_R).

We have chosen to employ identical functional forms for both the cost and profit function, starting from a simple Cobb-Douglas specification, enriched with squared and interaction terms of the output variables, in order to improve the model flexibility in terms of scale and substitution elasticity.

Equations (1) and (3) may thus be written as:

$$\ln VC = \beta_0 + \sum_{i\in(D,R)} \beta_{yi} \ln y_i + \frac{1}{2} \sum_{i\in(D,R)} \sum_{j\in(D,R)} \beta_{yij} \ln y_i \ln y_j + \sum_{i\in(L.C)} \beta_{pi} \ln p_i + \beta_k \ln k + \sum_{i\in q} \beta_i z_i + \varepsilon \qquad (4)$$

and

$$\ln PR = \gamma_0 + \sum_{i\in(D,R)} \gamma_{yi} \ln y_i + \frac{1}{2} \sum_{i\in(D,R)} \sum_{j\in(D,R)} \gamma_{yij} \ln y_i \ln y_j + \sum_{i\in(L.C)} \gamma_{pi} \ln p_i + \gamma_k \ln k + \sum_{i\in q} \gamma_i z_i + \eta \qquad (5)$$

where q equals to {*DTD*, *MIX*, *INC*, *LAND*} and the terms ε and η represent the normally-distributed random noise.

The two dummy variables capturing the prevailing (z_{DTD}) or partial (z_{MIX}) implementation of the door-to-door service appear in both the equations (4) and (5), allowing us to measure their direct effect.

It is, however, important to keep in mind that output quantities complement each other, summing to the total waste quantity. The distribution of the total quantity between the two outputs depends, in turn, on different factors. Among these factors, the waste collection method plays an important role, since door-to-door service is considered as a crucial tool to improve the recycling share. For this reason we estimate, in addition to equation (4) and (5), a further equation modeling the recycling share as a percentage of the total waste quantity:

$$\frac{y_R}{y_R + y_D} = \delta_0 + \sum_{i\in s}^{s} \delta_i z_i + \psi \qquad (6)$$

where *s* equals to {*DTD*, *MIX*, *NW*, *C*, *S*} and the term ψ represents the normally-distributed random noise.

The non-linear system of equations (4)-(5)-(6) is estimated simultaneously[7].

Notice that the dummy variables referring to the implementation of the door-to-door service (z_{DTD} and z_{MIX}) appear in both the sets *q* and *s*. In fact we assume that not only they directly affect the cost and the profit, but also contribute in determining the share of waste recycling.

To ensure linear homogeneity with respect to input prices in the variable cost function (4), the following restriction has been imposed:

$$\sum_{i\in(L,C)} \beta_{pi} = 1 \qquad (7)$$

The alternative profit function, instead, does not require price homogeneity (Humphrey and Pulley, 1997; Khumbhakar, 2006).

In running the estimates, all the variables, except the dummies contained in the sets *q* and *s*, are standardized on their sample (geometric) mean.

4. Results and discussion

The system of equations described in Section 3 was estimated using a non-linear seemingly unrelated regression (NLSUR), which can be viewed as a non-linear version of Zellner's model (Zellner, 1962; Green, 2012, p. 305-306). The model accounts for any cross-equation error correlation (e.g. the error of the fit obtained for a firm when estimating a cost function might be correlated to the error of the fit in the profit function for the same firm), thus improving the efficiency of estimates with respect to separated single-equation models. Estimates are obtained by feasible generalized non-linear least squares (FGNLS), using the statistical package STATA (Version 12.0).

Table 2 reports the estimated parameters for both the cost and the profit function, as well as the determinants of the share of waste sent to recycling. The R-squared indicates that all the equations of the empirical model can fit the data very well, with the highest value associated to the equation explaining the share of waste sent to recycling (0.96) and slightly lower values for the cost function (0.90) and the profit function (0.80).

Tab. 2: Results

	Equation 1 Dep. Var: ln*VC*		Equation2 Dep. Var: ln*PR*		Equation 3 Dep. Var.: $y_R / (y_R + y_D)$	
Explanatory variables		*Coefficient (standard error)*		*Coefficient (standard error)*		*Coefficient (standard error)*
Constant	β_0	-0.223 *** (0.062)	γ_0	-0.313 ** (0.157)	δ_0	0.458 *** (0.024)
lny_D	β_{yd}	0.642 ***	γ_{yd}	0.317 ***		

[7] In addition to the three main equations, the system includes also the cost and profit shares of inputs, in order to improve the efficiency of the price parameter estimates. The cost share of material consumption is omitted to avoid multi-collinearity.

		(0.038)		(0.097)		
$(\ln y_D)^2$	β_{yd2}	0.341 *** (0.065)	γ_{yd2}	0.149 (0.166)		
$\ln y_R$	β_{yr}	0.272 *** (0.038)	γ_{yr}	0.277 *** (0.098)		
$(\ln y_R)^2$	β_{yr2}	0.146 ** (0.057)	γ_{yr2}	0.194 (0.147)		
$\ln y_D \ln y_R$	β_{ydr}	-0.241 *** (0.059)	γ_{ydr}	-0.158 (0.151)		
$\ln p_L$	β_{pl}	0.438 *** (0.010)	γ_{pl}	-0.858 *** (0.226)		
$\ln p_C$			γ_{pc}	-0.886 ** (0.355)		
$\ln k$	β_k	0.041 * (0.024)	γ_k	0.363 *** (0.061)		
z_{INC}	β_{inc}	0.010 (0.069)	γ_{inc}	0.349 ** (0.047)		
z_{LAND}	β_{land}	0.093 * (0.048)	γ_{land}	0.147 (0.228)		
z_{DTD}	β_{dtd}	0.212 *** (0.082)	γ_{dtd}	0.426 ** (0.209)	δ_{dtd}	0.324 *** (0.027)
z_{MIX}	β_{mix}	0.091 (0.060)	γ_{mix}	0.241 (0.153)	δ_{mix}	0.078 *** (0.008)
z_{NW}					δ_{nw}	-0.167 *** (0.024)
z_C					δ_c	-0.243 *** (0.023)
z_S					δ_s	-0.266 *** (0.038)
	R-squared 0.9073		R-squared 0.8022		R-squared 0.9608	

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Overall, the signs of parameters related to outputs and input prices in both the cost and profit functions meet the theoretical conditions: an increase in outputs leads to an increase of both costs and profits, while an increase in input prices increases costs and decreases profit. The elasticities with respect to the outputs are not constant, although the second order coefficients - associated to the terms $(\ln y_D)^2$, $(\ln y_R)^2$ and $\ln y_D \ln y_R$ - are statistically significant only in the case of the cost function. Interestingly, the negative sign of the interaction between the two types of collected waste suggests the presence of cost complementarities between disposal and recycling, in line with previous research in the field (Callan and Thomas, 2001; Abrate *et al.*, 2014). However, these cost savings do not seem to convert to profit gains; counter-intuitively, the sign of γ_{ydr} in the profit function is even negative, though the parameter is not significant at any statistical level.

The net value of fixed assets (k) should act as a constraint to the economic performances. Our findings show that, on average, increasing the capital stock by 10% would lead to slightly higher variable costs (+0,41%) and to significantly higher earnings (+3,6%). The interpretation of these results is not straightforward, especially from the cost perspective. The micro-economic theory predicts a reduction of variable costs as k increases, by raising the set of production choices thanks to input substitutability and giving a potential boost to variable factors' productivity. However, in practice, when estimating variable cost functions it is not unusual to find such a positive relation (e.g. Antonioli and Filippini, 2002), which can be justified in terms of firms' inefficient behavior or because of capital stock capturing to a certain extent some omitted (and unavailable) measures of service quality (such, for example, the average frequency of collection service).[8] The boost on profit is instead more intuitive, also because it is worth remarking that our measure of profit is the EBITDA (operating gross profit) which does not include the amortizations.

[8] A further explanation is the practical difficulty to disentangle variable and fixed costs. In particular, a large part of labor costs can be considered as fixed, especially for this type of firms often operating under a public ownership.

When a firm is directly involved in landfill or incinerator activities, we find on average an increase in both costs and profits, though not always significant. In particular, the business model based on vertical integration with incinerators - adopted by 12% of firms in our sample - is able to improve significantly firms' profits and cash flow. Incineration can be seen as a possible way of recovering value from non-separated waste (waste-to-energy) and avoid the recourse to landfill, but several criticisms have been raised in terms of pollution and possible threats to the health of people living nearby. Thus, a trade-off between the three dimension of sustainability (profit, planet and people) can emerge, also because incineration competes with the recycling option.

Finally, we examine in detail the results concerning the adoption of door-to-door kerbside collection schemes. For a given level of outputs, the value of β_{dtd} and γ_{dtd} yields, approximately, the percentage impact of adopting door-to-door collection schemes on costs and profits. Both effects are positive and significant, while in the case of mixed scheme the coefficients, while still positive, do not reach the statistical significance region. This result is in line with our expectations and provides a first support to both H1 and H2, but offers only a partial view of the question. In fact:

- first, it is rather unrealistic to assume that the adoption of door-to-door does not change the patterns of waste collected. Indeed, the main objective of door-to-door is to improve share of recycling, and the results of Equation 3 confirm this tendency in the data. On average, moving from absence of door-to-door service to its partial adoption ($z_{MIX} = 1$) increases the portion of waste sent to recycling by about 8%, while following its full application ($z_{DTD} = 1$) the upward shift is 30%;
- second, since a percentage increase in profits cannot be directly compared with a percentage increase in costs we need absolute measures for the economic impact of recycling programs.

For the above reasons we run a simulation allowing to better understand the overall economic impact. Assuming an hypothetical "average" firm of our sample in terms of total waste, input prices and fixed assets,[9] we predict the impact on costs and profits of z_{DTD} (and z_{MIX}) while changing the relative level of outputs, in order to account for the expected increase in the share of recycling (according to Equation 3 estimates). Given the widespread heterogeneity of Italian regions, specific simulations were run according to the different average share of recycling of each area (North-West, North-East, Center, South), again predicted according to Equation 3. The results are summarized in Table 3 and the reported values represent the average impact on cost and profit per inhabitants served by the firm. These values are particularly meaningful since the sum of cost and profit reflect the overall charge that final users have to pay, usually in form of tax to the municipality. The transformation to cost (profit) per inhabitant is based on the average per-capita total waste production, equal to 533 kilograms per year.

Table 3 splits up the impact on the economic performance into a *direct* effect, which measures the one-off impact of implementing the new system of waste collection, and an *indirect* (*quota*) effect, due to increasing share of recycling that can be reached thanks to the (partial or full) application of door-to-door service. The overall effect is the sum of both the direct and indirect effect.

For example, the partial adoption of door-to-door ($z_{MIX} = 1$) would produce a one-off increase in the cost per inhabitant of at least 9.5 € (and up to 11.1 €), but this effect is partially compensated (up to 7.1 € of cost savings) thanks to a higher portion of waste recycled - and thus to a lower share of waste sent to landfill. The result is confirmed to a larger extent

[9] All these variable were imposed equal to the geometric mean of the sample.

when looking at the case of full application of door-to-door (z_{DTD} = 1), for both the direct and indirect effect. Overall, these results fully supports H1.

As to the effect on profit, the overall effect approximately corresponds to the direct effect, since the impact of the increasing share of recycling is almost zero. This implies that firms take market power advantage when adopting the new collection scheme, independently of the recycling target. Overall, the green attitude of firms given by the implementation of more advanced recycling schemes seems to legitimate a higher level of profit, even if this happens independently from the actual level of *"green target"* (i.e. the share of recycling) reached. Therefore, we may say that H2 is partially supported.

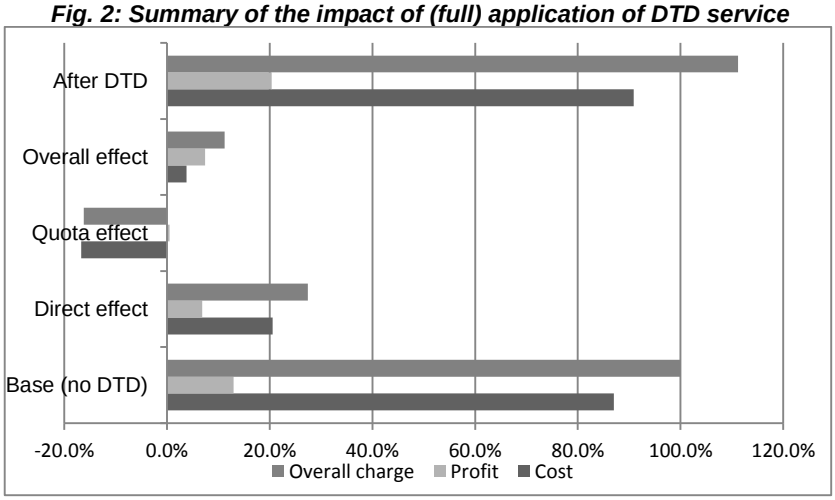
Tab. 3: Simulation of the economic impact of door-to-door service.

	Impact (+/-) on the average **cost** per inhabitant with respect to the base case (d_{MIX}=0; d_{DTD} =0)			Impact (+/-) on the average **profit** per inhabitant with respect to the base case (d_{MIX}=0; d_{DTD} =0)		
	Direct effect	*Quota effect*	*Overall effect*	*Direct effect*	*Quota effect*	*Overall effect*
d_{MIX} =1	[+9.5 ; +11.1]	[-7.1; -4.1]	[+4.0; +5.3]	[+4.4; +4.5]	[–0.2;+0.2]	[+4.3; +4.7]
d_{DTD} =1	[+23.4; +27.0]	[-25.1; -14.7]	[+2.4; +8.7]	[+8.6; +8.7]	[+0.2; +1.4]	[+8.9; +10.1]

(*) For each case, the interval indicates the minimum and the maximum value obtained in the different simulations.

Figure 1 depicts the impact of full application of door-to-door service, detailed in percentage with respect to the actual total charge to the final user. On average, in absence of door-to-door, we register a cost of about 110 Euros per inhabitant and a profit of about 16 Euros per inhabitant. Thus, the base charge is composed of 87% costs and 13% profits. Due to the introduction of door-to-door, the impact on total charge is around 11%, largely due to the increase in firm profits. Thus, while door-to-door can be regarded as sustainable from the point of profit (better economic performance for the firms) and planet (better achievements in terms of recycling share), some risks are placed at the "people" dimension (increase in taxation). Municipal contracts should probably try to rebalance the profit-people trade off.

Fig. 2: Summary of the impact of (full) application of DTD service



5. Conclusions

The issue of sustainability in solid waste management has emerged as topical for citizens, firms and institutions and

can be well declined according to the so-called triple P paradigm (People, Profit, Planet). Building on this strand of literature, in this paper we provide a conceptual framework that may help to evaluate the trade-offs along the three dimensions, while focusing especially on the economic relationships. Specifically, we devote our attention to the impact emerging waste management services, such as the door-to-door collection system. We argue that, while benefits for planet derives from inducing more recycling and thus less waste of resources, the economic implications in terms of firm performances and citizens' acceptability of such programs are not straightforward and might be in conflict.

The research strategy was based on data collection at firm level, including public available information (such as balance sheets) and specific questionnaires. The empirical model involves the attempt of estimating both cost and profit determinants, among which there are measures of environmental performance such as the amount of waste sent to recycling as well as to the degree of implementation of door-to-door services. In our view, the comparison of the impact of recycling program on costs and profits can yield important strategic and policy indications for the stakeholders.

First, we find that the adoption of more innovative kerbside collection programs tends to increase costs, but this impact can be, at least partially, compensated by the reduction of disposal. Disentangling these two effects may help also to reconcile some conflicting evidence in the literature. Second, we find firms showing more green attitudes, by adopting advanced recycling schemes, attain higher level of profit, providing some support to the legitimacy-based view. Strategically, firms are rewarded from innovative collection systems, because they are able to more than compensate the increase in costs, exploiting the institution attention to environmental goals. However, the economic burden to the end users may increase significantly, largely because of an increase of firm margins. Thus, institutions should put an increasing attention also to the social sustainability of environmental policies.

There are several limitations in this study, which leave broad room for further research. For example the set of variable explaining the firm's economic performance could be enlarged. One particularly interesting issue may be a more detailed analysis of the issue of vertical integration with landfill and incinerators.

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