TITLE

Drivers of municipal solid waste management cost based on cost models inherent to sorted and unsorted waste

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ABSTRACT

After having divided waste management cost in its cost items, we focus on how well-known exogenous and endogenous drivers impact on such cost items. To this end, we collected empirical data of 6,616 Italian municipalities for a two-year period. We develop four regression-based models to analyze the data according to cost items. Models are also reiterated using different data normalization: cost per ton of waste or waste per capita. Besides exogenous determiners of cost, such as altitude, population density, and coastal zone, results refer to both unsorted and sorted waste management cost items. In this respect economies of scale are confirmed along with the critical role of adequate waste facilities that play a remarkable role in cost minimization.

Policymakers and regulators may benefit from such results when it comes to define allowed revenues and design the scope of municipal solid waste regulation.

KEYWORDS: Municipal solid waste, waste management, sorted and unsorted waste, waste treatment, waste disposal, waste tax

1. INTRODUCTION

Scholars have identified a positive and linear relationship between economic growth and waste production, where a 1% increase in the gross domestic product increases the quantity of waste produced by 0.69% (Johnstone and Labonne, 2004). Given that socio-economic trends go hand in hand with environment implications, waste management has also became central to the sustainability policy agenda (Mani and Singh, 2016) and circular economy targets (Zeller et al., 2019) especially in Europe.

No wonder that within the waste management industry, what above mentioned clarify the reason municipal solid waste (MSW) has become one of the most important municipal services (Hoornweg and Bhada-Tata, 2012). Therefore, an improvement in the efficiency of this service is recognized as an opportunity for creating jobs, incentivizing responsible consumption, and protecting the environment (Beccarello and Di Foggia, 2018). Given that fees paid by various taxpayers and subsidies from local authorities' budget (World Bank, 2018) finance the service, efficient MSW management reduce the effective tax pressure and increase social welfare (Fuss et al., 2018). This aspect indicates the growing concern about its financial sustainability (Debnath and Bose, 2014; Jacobsen et al., 2013; Lombrano, 2009).

Previous literature has recurrently investigated drivers of the MSW management cost (MC), however, given that MSW collection and disposal chain encompasses different phases, we believe that an analysis and breakdown of the components of the MSW management cost may provide a better insight into how and why the identified cost drivers affect specifically cost items that make up the total cost.

To perform the analyses we conducted a clustered regression-based analysis using different cost items presented in the models as dependent variables. We modeled data obtained from a sample of 6,616 Italian municipalities; data were extrapolated for a two-year period.

From the results both general consideration could be drawn especially with regards to the impact of exogenous variables and specific insight obtained from models related to unsorted and sorted waste.

For example, in our analysis, some exogenous drivers such as urban density, altitude, waste production or coastal characteristics, are found to be persistent cost drivers. Instead, concerning the cost drivers of unsorted waste, our results show that the impact of MSW treatment facilities, particularly waste-to-energy plants, significantly affect the cost. An increase in the share of the waste sent to waste-to-energy plants tends to decrease the average cost. Although with worse impact on the environment, similar effect emerged considering the relationship between the share of waste sent to landfills and MC. Nevertheless it is recognized that waste sent to landfills shall be minimized. With regard to sorted waste, result confirm, e.g. the positive impact of the percentage of sorted waste on materials treatment and recycling. Similar to unsorted waste, the higher the share of sorted waste sent to the specific treatment facilities, the lower the cost. The letter point is crucial in today' waste management regulation context in many European countries, ad worldwide in general. To this extent previous literature has been analyzed the expected costs of transferring municipalities to solid waste source separation in order to minimize the waste sent to landfills and increasing the efficiency and amount of recycled waste (Lavee and Nardiya, 2013).

Our contribution to the existing literature is twofold. We provide information on how previously analyzed and typical waste management cost drivers influence specific cost items hardly considered before. This is an essential information for supporting regulators of solid waste management as per the identification of allowed revenues and the definition regulation scope. This is particularly important for many European country where the waste regulation is being updated in light of circular economy objective. For example, a recent study highlighted that tendency of productivity decline in the urban waste utilities calling for more efforts to design efficient economic regulation (Simões and Marques, 2012a). In addition, our results show that the unit of measure, costs per ton of waste and costs per capita, may lead to different results in the impact of cost drivers on cost.

Based on the foregoing findings, our research has the following policy implications. Industrial policymakers may benefit from our results to identify policy instruments aimed at overcoming critical issues such as the social stigma against the establishment of waste treatment facilities, which hinders their allocation, prevents self-sufficiency in waste management, increases costs, and, eventually, leads to negative environment externalities. Our results may provide and regulators with insights useful to design asymmetric regulations as per the definition of allowed revenues in each of the cost items analyzed in this paper. Local administrators may take advantage of these results for benchmarking purposes, e.g. to better understand the structure of the cost they pay to companies in both phased of the waste treatment chain: collection and disposal.

The remainder of the paper is organized as follows. Section 2 provides a literature review of related research. Section 3 presents the research design, the information pertaining to the sample, the variables generated for analyses, the cost definition relevant to this research, and the models used. Section 4 provides the results of the analyses. These results are discussed in Section 5, which is followed by conclusion in Section 6.

2. LITERATURE

In the study of MSWM efficiency, the identification and significance of cost drivers have been well-documented and they arguably represent some of the most thought-provoking current topics in light of the ongoing debate on optimal cost definition (Kinnaman, 2009). The number of relevant studies on MSW cost has increased (Bohm et al., 2010; Da Cruz et al., 2014; Gullì and Zazzi, 2011; Pérez-López et al., 2016; Sarra et al., 2017), despite the complexity anticipated from scattered and limited data (Tsilemou and Panagiotakopoulos, 2006). These studies have also been prompted by legislations on waste management (Buclet and Godard, 2001); they emerged in Europe and started to grow after the introduction of the 1994 European Directive on packaging waste. On the one hand, the economic literature has been primarily concerned with demand-side issues and the associated policy implications (Goddard, 1995); on the other hand, scholars have analyzed multiple output cost structures for waste management (Callan and Thomas, 2001). For example, research has concentrated on costs related to separate waste and recycling; scholars have also proposed tools to calculate the full collection costs of different types of waste (D'Onza et al., 2016) or econometric models to predict where the potential for economically efficient recycling is the highest (Lavee and Khatib, 2010). Moreover, literature has investigated the economic efficiency of MSW collection companies for verifying the drivers for efficiency, finding that these drivers differ for different types of waste (UNEP, 2012). Different approaches have been proposed in an effort to shed some light on this issue. For example, previous literature has summarized the results of studies examining different cost drivers of waste management: market structure where a consensus regarding the economies of scale, scope and density was identified, ownership where the period of analysis was identified as an important variable, incentives where differently from economies of scale the paper found low agreement in their effect of performance, and benchmarking. (Simões and Marques, 2012b). In fact, besides public firms, private operators have emerged to run the service given the rising pressure in terms of cost efficiency that has pushed governments to transfer a part of waste services to the private companies (Jacobsen et al., 2013). This has given rise to an important question related to market provision—whether profit-seeking firms will generate socially acceptable outcomes (Kinnaman, 2009). In this context, the open-ended debate on productivity enhancements in public versus private service production has yielded mixed results (Bel and Fageda, 2010; Simões et al., 2012). In this regard, empirical evidence based on the MSWM business model shows that economic and political factors exert varied impacts on the MSWM of private and public companies (Plata-Díaz et al., 2014).

Apart from this, it can be argued that firm dimension, inter-firm relationships, alternative technologies, and landfill capacity also exert significant impacts (Lombrano, 2009), similar to the economies of scale and scope. Based on the population of municipalities, some evidence about the economies of scale indicate that private MSWM operators do not outperform the public entities (Bel and Fageda, 2010). The aforementioned works have made considerable progress in explaining the statistically significant drivers of MSW cost by using robust approaches and providing information from different geographies. While the quantity of waste generated has been one of the most widely investigated drivers, , the important waste management methods, such as curbside or street bin (Guerrini et al., 2017) or door-to-door service, have received limited attention; these methods are crucial as they exert a significant impact on work organization in light of the fact that many factors may play a role regardless of the assessment methods (Allesch and Brunner, 2014) and that both controllable and non-controllable factors can significantly impact the cost (De Jaeger and Rogge, 2013).

The methods employed to perform the service and the population size and density also impact the cost because of the economies of scale (De Jaeger et al., 2011). In fact, the percentage of sorted waste has been found to exert varied impacts on the cost (Chifari et al., 2017; Greco et al., 2015) since sorted waste can both positively and negatively impact the cost by increasing collection and processing efficiency. In this regards an empirical simulation indicated that by adopting recycling, municipalities would be able to reduce waste management direct costs by 11% (Lavee, 2007). It has traditionally been argued that recycling municipal solid waste (MSW) is usually not economically viable Morphological and geographical drivers, such as surface and altitude and latitude of territories (Passarini et al., 2011), and socioeconomic drivers, such as available income (Mazzanti et al., 2008), political orientation of the governing party at municipal levels and above (Benito-López et al., 2011), and environmental targets (Beccarello and Di Foggia, 2016), have also been investigated. Production technologies (Swart and Groot, 2015; Tisserant et al., 2017) and the use of waste management facilities (Chu et al., 2019; Tsilemou and Panagiotakopoulos, 2006) have also been identified as worth noting. Some studies have approximated cost functions, highlighting the evolution of and the differences in organizational, financial, management, and technological schemes (Bohm et al., 2010); another study analyzing cost functions has proposed an approach to select different MSW strategies according to the waste recovery technology and the utility functional specification (Swart and Groot, 2015).

Having said that, although the number of studies has increased over the past, most of the mentioned studies have focused on the drivers of MSWM cost. However, this study contributes to the literature by breaking down its various components. The study discusses the cost items incurred during different phases of the service, from waste collection to waste disposal.

3. RESEARCH DESIGN

In order to evaluate how and to what extent some MSW-related cost drivers influence specific cost items that add to the MC we conducted a clustered regression analysis based on a two-year period. We developed two models inherent to unsorted and sorted waste cost items: each model is formalized using both costs per ton of waste, and costs per capita.

3.1. Population and sample

According to ISTAT, 60.432 million people lived in 7,978 municipalities in 2018. Our sample contained 6,616 municipalities, that is, 82.9% of all the Italian municipalities, covering 91.5% of the population. The variables were generated by querying official data published by the Public finance department of the Internal Minister, the Italian National Institute for Environmental Protection and Research (ISPRA), and the Italian National Institute for Statistics (ISTAT) based on economic, waste, and territorial data, respectively. We collected the data for a two-years period; specifically 2017 and 2018. The economic variables were constructed using official information, such as waste tax revenues, indicated in the environmental declaration model (MUD), which is updated annually by municipalities, their consortia, or delegated entities. The computation of costs per ton of waste is based on the data published by ISPRA, while the demographic and morphological data were extrapolated from ISTAT.

3.2. Variables and labels

Our variable can be classified labelled as exogenous e.g. morphological variables, cost-related and endogenous e.g. plants and waste. We identified the following exogenous drivers to perform our analyses: *alt:* meters above sea level, *axr*: km^2 per km of road, *coast*: coastal municipality, *density*: people or waste per square kilometer, *scale*: scale of service. Endogenous drivers were: *adig*: the share of waste sent to anaerobic digestion plants, *wet*: the share of wet fraction in sorted waste, *compo*: the share of waste sent to composting plants in total waste, *glass*: the share of glass in sorted waste, *integ*: the share of waste sent to integrated treatment plants, *landfill*: the share of waste to landfill in total waste, *mbt*: the share of waste sent to mechanical biological treatment plants, *metal*: the share of metal, *rev*: municipal revenues, *kg*: per capita waste produced, *paper*: the share of paper, *plastic*: the share of plastic, *perso:* the percentage of sorted waste, *wte*: the share of waste sent to incinerator and waste-to-energy plants.

Considering the cost items-related variables we identified: *ctc*: collection and transport cost, *MC*: municipal solid waste management cost, *msc*: material sorted waste cost, *ouc*: other unsorted waste cost, *SOMC*: sorted waste management cost, *swc*: the street sweeping and washing cost, tdc: the treatment and disposal cost, *trc*: the treatment and recycling cost, net of material and energy sales, *UNMC*: unsorted waste management cost.

As previously introduced, the aforementioned variables were normalized according to the unit of measure: costs per ton of waste and costs per capita. Table 1 presents descriptive statistics.

Table 1: descriptive statistics

Variable	Measure	Obs	Mean	Std. Dev.	Min	Max
alt	log	13,152	5.305	1.315	0.000	7.618
axr	km2	12,646	0.715	1.090	0.011	23.343
coast	dummy	13,156	0.073	0.260	0.000	1.000
scale	log	12,646	21.904	4.127	9.496	45.330
ctc	per capita	12,788	27.239	26.329	1.140	433.630
den	per capita	13,156	4.810	1.422	-0.266	9.380
msc	per capita	12,758	37.431	26.134	1.020	598.680
kg	per capita	13,139	450.632	152.694	121.240	1494.640
MC	per capita	13,232	144.094	65.635	19.040	1186.300
rev	per capita	12,910	7.286	0.603	5.998	11.295
SOMC	per capita	13,129	47.877	31.184	2.730	620.610
swc	per capita	10,716	16.217	17.977	1.400	319.980
tdc	per capita	12,627	25.499	17.761	1.030	199.890
trc	per capita	10,649	13.570	10.298	1.830	180.580
UNMC	per capita	13,102	54.916	37.535	9.380	582.270
adig	percent	13,232	2.600	3.770	0.000	23.444
bio	percent	11,799	37.777	14.472	0.007	100.000
compo	percent	13,232	14.221	7.148	0.000	34.971
glass	percent	12,537	16.145	8.931	0.005	63.726
integ	percent	13,232	10.644	12.445	0.000	55.531
land	percent	12,966	22.523	20.860	3.316	92.767
mbt	percent	13,232	29.677	20.797	0.000	86.199
metal	percent	11,754	2.780	2.769	0.000	53.991
paper	percent	12,629	18.587	7.605	0.115	69.968
plastic	percent	12,584	9.651	5.831	0.005	75.000
perso	percent	13,174	59.696	20.655	0.002	98.193
textile	percent	9,464	1.266	1.178	0.003	10.364
weee	percent	11,449	2.040	1.523	0.000	20.343
wte	percent	13,232	21.798	15.398	0.000	73.527
ctc	per ton	12,789	172.534	149.692	10.100	1342.000
den	per ton	13,098	3.970	1.472	-0.853	8.458
msc	per ton	12,649	161.334	138.931	10.000	2794.000
MC	per ton	13,232	331.683	117.026	65.800	1002.400
rev	per ton	12,910	8.127	0.660	6.657	11.759
SOMC	per ton	13,011	195.520	143.217	5.900	1213.300
swc	per ton	9,594	40.891	38.032	10.000	413.900
tdc	per ton	12,649	152.547	72.679	10.400	1133.900
trc	per ton	10,721	56.503	97.034	10.000	4866.900
UNMC	per ton	13,100	343.099	191.268	1.600	2214.500

Source: Own elaboration.

3.3. Cost definition

The identification of drivers of MC must consider the different cost items making up the cost as equation 1 formalizes.

(1) $$MC = UNMC + SOMC + AC + CK$$

In which UNMC can also be decomposed as in equation 2.

(2) $$UNMC = ctc + swc + tdc + CC_{unsorted}$$

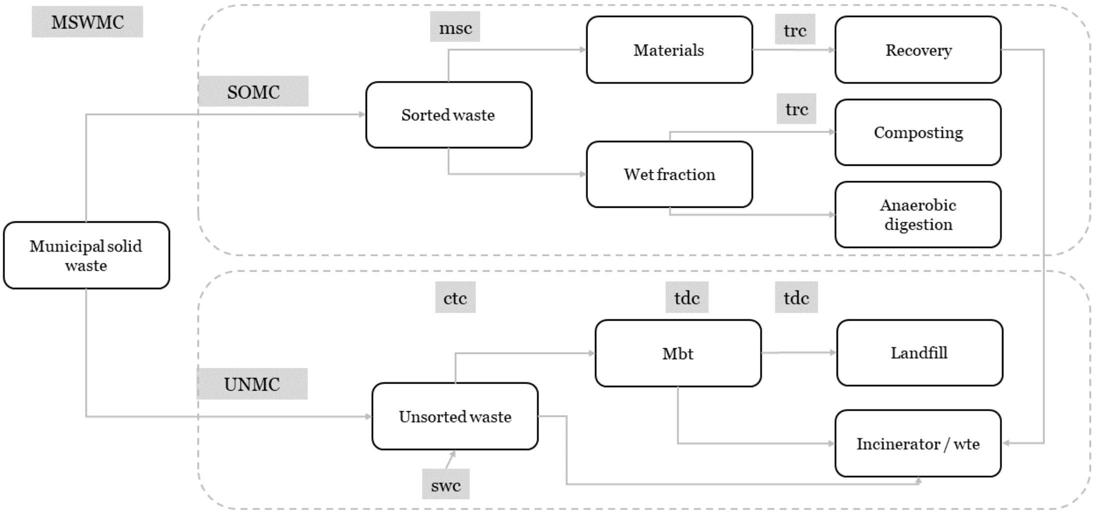
Similarly SOMC can be decomposed as equation 3.

(3) $$SOMC = msc + trc + CC_{sorted}$$

For the purposes of our analyses common costs and capital costs were excluded because of two reasons: first they could not be allocated to UNMC or SOMR respectively, marginal amounts, on average less than 4% of MC.

Figure 1 describes the phases in with the cost under examination in this paper occur. This is particularly important since the costs that the regulation should consider are those related to all the activities aimed at optimizing waste management, i.e. collection, transport, treatment, recovery and disposal of waste, including the control of these operations, sweeping and street cleaning, and the management of fees and user relations (Di Foggia and Beccarello, 2020).

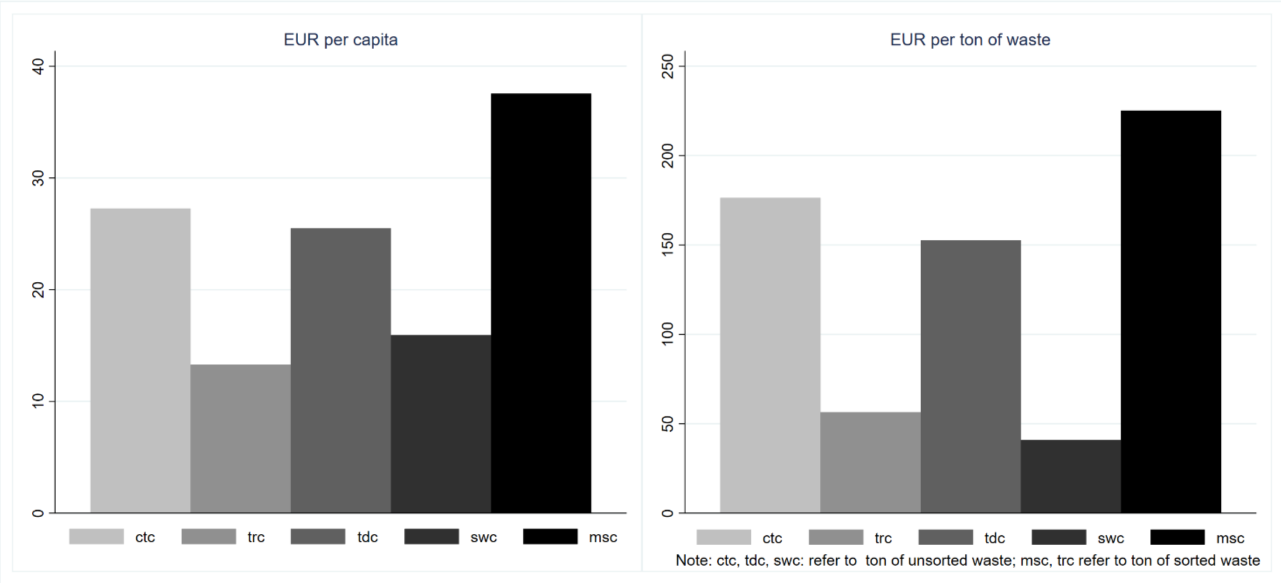
Figure 1: Typologies of municipal solid waste management cost



Source: own elaboration

Although the MSWM cost can be divided into unsorted and sorted waste management, it must be noted that several indivisible common costs are incurred for managing both types of waste; these costs are embedded in the analysis. Specifically, common costs could be included in the unsorted and sorted costs or embedded as independent variable within the models considered in this study. Figure 2 contains information regarding the average cost per typology of cost and per unit of measure, such figures stem from the breakdown of the MSWM cost.

Figure 2: Average cost per cost items



Source: own elaboration based on ISPRA. Common costs excluded as not allocated to waste typologies.

3.4. The model

This study hypothesizes that different cost drivers influence the components of the MSWM cost with different intensity. In order to ascertain the relationship and the influence of drivers on waste management costs, it is appropriate to perform an econometric analysis using regression models. Hence, we analyzed the data using separate models according to the typologies of costs and the units of measure, that is, per ton of waste or per capita waste. We performed a clustered regression that given the two-years period and the number of observations outperformed conventional cross-section regression, which could missed the specific effects of each municipality and potential changes overtime. In such a way the standard errors allowed for intragroup correlation. Properties of the following model justify its implementation. Equation 4 formalizes the model related to unsorted waste

$$COST = \propto + \beta_1 axr + \beta_2 coast + \beta_3 alt + \beta_4 perso + \beta_5 kg + \beta_6 rev + \beta_7 density + \beta_8 scale + \text{PLANTS} + \varepsilon \quad (4)$$

In equation 4 the dependent variable *COST* resamples the following cost items: *swc, ctc, tfc, UNMC, MC*. Independent variables follow together with the set of independent variables embracing the share of waste sent to waste treatment facilities as in equation 5.

$$PLANTS = \beta_9 wte + \beta_{10} landfill + \beta_{11} mbt \quad (5)$$

Similarly, Equation 6 formalizes the model related to unsorted waste:

$$COST = \propto + \beta_1 axr + \beta_2 coast + \beta_3 alt + \beta_4 perso + \beta_5 kg + \beta_6 rev + \beta_7 density + \beta_8 scale + \text{PLANTS} + \text{MATERIALS} + \varepsilon \quad (6)$$

In equation 6 the dependent variable *COST* resamples the following cost items: *msc, trc, SOMC, MC*. Again*,* independent variable follow where the set of independent variables embracing the share of waste sent to waste treatment facilities are summarized in equation 7.

$$PLANTS = \beta_9 mbt + \beta_{10} integ + \beta_{11} compo + \beta_{12} adig \quad (7)$$

In addition, the set of independent variables representing the share of materials types MATERIALS is formalized in equation 7.

$$\text{MATERIALS} = \beta_{13} plastic + \beta_{14} paper + \beta_{15} metal + \beta_{16} glass + \beta_{17} bio \quad (8)$$

Annex 1 presents a correlation matrix of all the variables used in the models inherent to unsorted waste while annex 2 presents a correlation matrix of all the variables used in the models inherent to sorted waste.

4. RESULTS

Consistently with research design our results are presented both in costs per ton of waste, i.e. table 2 and table 3, see annex 3 for variance inflation factors (VIFs), and costs per capita as in table 4 and table 5, see annex 4 for VIFs. Additionally, table 6 presents a synthesis of prominent evidences emerged from a cross reading of the tables.

4.1. Per ton of MSW

By considering table 2, and specifically the column that refers to UNMC, it is possible to infer that municipalities with higher density tend to show lower unsorted waste management costs. On the contrary, there is a significant increase in cost due to the coastal character of the municipality. The percent of sorted waste seems is associated with a tiny increase in cost, probably because of scale economies the impact on SOMC. As far as waste treatment and disposal facilities' equipment are concerned, there is a noticeable impact on UNMC reduction correlated with the use of waste management facilities: waste-to-energy plants and landfills. The same cannot be said for mechanical-biological treatment despite their recognized role in achieving circular economy objectives.

Table 2: Regression analysis of unsorted waste as in Equation 4 – cost per ton of waste

VARIABLES	(1) ut1 swc	(2) ut2 ctc	(3) ut3 tdc	(4) ut4 UNMC	(5) ut5 MC
axr	0.00850	-0.0167***	-0.0177***	-0.0114***	-0.000584
	(0.00609)	(0.00579)	(0.00466)	(0.00402)	(0.000405)
coast	0.343***	0.174***	0.0569***	0.146***	0.0274***
	(0.0333)	(0.0363)	(0.0181)	(0.0233)	(0.00235)
alt	0.0343***	-0.0156***	-0.0263***	-0.0232***	-0.000580
	(0.00583)	(0.00603)	(0.00332)	(0.00395)	(0.000437)
perso	-0.00192***	0.00949***	0.00393***	0.00790***	1.18e-06
	(0.000435)	(0.000405)	(0.000244)	(0.000284)	(2.87e-05)
kg	-0.0508*	-0.165***	-0.0527***	-0.109***	-0.0198***
	(0.0269)	(0.0255)	(0.0154)	(0.0171)	(0.00196)
rev	0.258***	0.133***	0.0516***	0.0887***	0.0252***

	(0.0164)	(0.0148)	(0.00884)	(0.00988)	(0.00104)
den	0.0546***	-0.0567***	-0.0363***	-0.0467***	-0.00103**
	(0.00724)	(0.00679)	(0.00380)	(0.00445)	(0.000455)
scale	0.00109	-0.0285***	-0.000121	-0.0128***	9.66e-05
	(0.00194)	(0.00182)	(0.00111)	(0.00131)	(0.000133)
wte	0.000275	-0.000191	-0.00183***	-0.00102***	-0.000451***
	(0.000517)	(0.000473)	(0.000322)	(0.000363)	(3.42e-05)
land	-0.00400***	-0.00303***	-0.00345***	-0.00345***	-0.000501***
	(0.000520)	(0.000494)	(0.000301)	(0.000346)	(3.16e-05)
mbt	0.00746***	0.00557***	0.00392***	0.00417***	0.00108***
	(0.000485)	(0.000504)	(0.000307)	(0.000360)	(3.33e-05)
Constant	1.177***	5.063***	4.896***	5.742***	1.654***
	(0.244)	(0.230)	(0.138)	(0.155)	(0.0172)
Observations	8,976	11,984	11,800	12,230	12,350
R-squared	0.156	0.142	0.083	0.154	0.344

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration

The results concerning the drivers of SOMC report similarities in the information pertaining to the analysis of undifferentiated collection. A coastal municipality is associated with an increase in cost and a higher altitude corresponds to a lower cost even if the percentage of sorted collection is negatively correlated with the altitude. The waste production density, i.e. waste produced per square kilometer, contributes significantly to cost reduction as expected. Result also confirms the role of the use of waste management facilities as a significant cost reduction driver, with the exception of mechanical biological treatment. Concerning the characteristic of the service, a prominent factor is the percentage of separate waste collection. There are no noteworthy results regarding the percentage of different materials that make up the sorted waste, with the exception of glass, wet faction and paper.

Table 3: Regression analysis of sorted waste, as in Equation 6 – cost per ton of waste

	(1)	(2)	(3)	(4)
	st1	st2	st3	st4
VARIABLES	msc	trc	SOMC	MC
axr	0.0167**	0.00930	0.0273***	-6.25e-05

	(0.00695)	(0.00691)	(0.00616)	(0.000505)
coast	0.0860**	0.0857**	0.0872**	0.0164***
	(0.0376)	(0.0359)	(0.0359)	(0.00225)
alt	-0.0208***	-0.00811	-0.0178***	-0.00444***
	(0.00664)	(0.00594)	(0.00631)	(0.000456)
perso	-0.00374***	-0.00101*	-0.00229***	0.000159***
	(0.000588)	(0.000543)	(0.000580)	(3.86e-05)
kg	-0.271***	-0.122***	-0.223***	-0.0185***
	(0.0310)	(0.0273)	(0.0310)	(0.00214)
rev	0.111***	0.183***	0.167***	0.0222***
	(0.0171)	(0.0150)	(0.0167)	(0.00119)
den	-0.0146**	0.0272***	-6.79e-05	-0.00104**
	(0.00738)	(0.00638)	(0.00658)	(0.000459)
scale	0.0115***	4.31e-05	0.0155***	0.000630***
	(0.00217)	(0.00194)	(0.00207)	(0.000141)
plastic	0.0161***	0.00205	0.0139***	0.000204*
	(0.00170)	(0.00149)	(0.00161)	(0.000115)
paper	0.00215	-0.0110***	-0.00416***	-0.000620***
	(0.00144)	(0.00133)	(0.00146)	(9.85e-05)
metal	-0.0103**	-0.00689*	-0.0187***	0.000279
	(0.00416)	(0.00379)	(0.00423)	(0.000224)
glass	0.00489***	0.00124	0.000789	0.000627***
	(0.00162)	(0.00145)	(0.00162)	(9.68e-05)
wet	0.00759***	0.000453	0.00706***	-0.000107*
	(0.000964)	(0.000825)	(0.000925)	(5.91e-05)
mbt	0.00850***	0.00704***	0.00577***	0.000930***
	(0.000582)	(0.000556)	(0.000553)	(3.73e-05)
integ	0.00300***	-0.00746***	0.00123***	-0.000520***
	(0.000513)	(0.000498)	(0.000474)	(3.95e-05)
adig	-0.00456*	0.0153***	-0.000776	-0.00210***
	(0.00252)	(0.00264)	(0.00281)	(0.000157)
compo	-2.12e-05	-0.00954***	0.00164	-0.000655***
	(0.00121)	(0.00101)	(0.00107)	(7.28e-05)
Constant	4.861***	3.150***	4.395***	1.677***
	(0.295)	(0.259)	(0.293)	(0.0204)
Observations	10,045	8,801	10,323	10,451
R-squared	0.172	0.199	0.141	0.404

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration

4.2. Per capita

Similar to the per ton analysis, the cost determinants can be analyzed reading the column that refer to UNMC of table 4. Considering exogenous drivers, it can be seen that the density plays an important role and also in this case, the cost reduction resulting from altitude is also significant as it is the fact of being a coastal municipality that is associated with higher cost. Concerning the use of waste management facilities, there is a noticeable impact of waste-to-energy plants and landfills in the territory on cost reduction. An assessment of some of the characteristics of the service shows that the waste produced per capita is significant and increases the cost, while the percentage of sorted waste decreases the cost. Similar to the earlier case, economies of scale are also noted in this version.

Table 4: Regression analysis of unsorted waste, as in Equation 4 – cost per capita

	(1)	(2)	(3)	(4)	(5)
	up1	up2	up3	up4	up5
VARIABLES	swc	ctc	tdc	UNMC	MC
axr	0.00242	-0.0166***	-0.0169***	-0.0138***	-0.00555*
	(0.00830)	(0.00644)	(0.00618)	(0.00485)	(0.00317)
coast	0.419***	0.296***	0.176***	0.252***	0.230***
	(0.0395)	(0.0365)	(0.0209)	(0.0228)	(0.0145)
alt	0.0426***	0.0101*	-2.35e-05	0.00224	-0.00552**
	(0.00755)	(0.00592)	(0.00376)	(0.00378)	(0.00257)
perso	-0.00208***	-0.0106***	-0.0168***	-0.0127***	-0.000198
	(0.000520)	(0.000410)	(0.000295)	(0.000271)	(0.000167)
kg	0.442***	0.360***	0.622***	0.470***	0.497***
	(0.0338)	(0.0250)	(0.0193)	(0.0179)	(0.0131)
rev	0.315***	0.133***	0.0403***	0.0888***	0.125***
	(0.0190)	(0.0151)	(0.0106)	(0.0101)	(0.00680)
den	0.0782***	-0.0406***	-0.0271***	-0.0312***	-0.00340
	(0.00876)	(0.00684)	(0.00464)	(0.00451)	(0.00283)
scale	0.00920***	-0.0306***	-0.00158	-0.0134***	0.000568
	(0.00240)	(0.00184)	(0.00130)	(0.00123)	(0.000812)
wte	-0.000964	-0.00184***	-0.00349***	-0.00256***	-0.00272***
	(0.000607)	(0.000477)	(0.000378)	(0.000318)	(0.000199)
land	-0.00358***	-0.00241***	-0.00276***	-0.00288***	-0.00228***
	(0.000607)	(0.000502)	(0.000374)	(0.000331)	(0.000196)
mbt	0.00794***	0.00509***	0.00296***	0.00370***	0.00479***
	(0.000590)	(0.000511)	(0.000380)	(0.000349)	(0.000210)
Constant	-3.428***	1.215***	0.193	1.522***	0.974***
	(0.250)	(0.188)	(0.142)	(0.135)	(0.0989)
Observations	10,043	11,979	11,779	12,229	12,350
R-squared	0.152	0.243	0.471	0.402	0.367

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: own elaboration

Results concerning the determinants of the cost of sorted waste per capita report similarities in information pertaining to the analysis of undifferentiated collection. Population density contributes significantly to cost reduction even if its effect is found to be controversial (Di Foggia and Beccarello, 2018; Dijkgraaf and Gradus, 2015). Similar to the previous case, the use of waste management facilities within the territory is a significant cost reduction driver, with the exception of mechanical biological treatment. Concerning the characteristic of the service, the most important factor is the production of waste per capita that concur to a higher cost. Concerning the percentage of different materials that make up separate waste collection, the only significant materials are glass, wet fraction and paper.

Table 5: Regression analysis of sorted waste, as in Equation 6 – cost per capita

	(1)	(2)	(3)	(4)
	sp1	sp2	sp3	sp4
VARIABLES	msc	trc	SOMC	MC
axr	0.0155**	0.0157**	0.0197***	-0.00349
	(0.00700)	(0.00737)	(0.00612)	(0.00357)
coast	0.159***	0.0749**	0.134***	0.156***
	(0.0400)	(0.0374)	(0.0346)	(0.0140)
alt	-0.0158**	-0.00578	-0.0174***	-0.0305***
	(0.00714)	(0.00673)	(0.00608)	(0.00265)
perso	0.0113***	0.0123***	0.0120***	0.000491**
	(0.000623)	(0.000530)	(0.000563)	(0.000225)
kg	0.384***	0.500***	0.385***	0.517***
	(0.0323)	(0.0285)	(0.0308)	(0.0153)
rev	0.106***	0.132***	0.148***	0.104***
	(0.0179)	(0.0155)	(0.0162)	(0.00737)
den	-0.0185**	0.0385***	-0.00479	-0.00641**
	(0.00781)	(0.00660)	(0.00635)	(0.00278)
scale	0.0128***	0.00327	0.0130***	0.00309***
	(0.00222)	(0.00204)	(0.00202)	(0.000839)
plastic	0.0204***	0.00621***	0.0133***	0.000684
	(0.00176)	(0.00149)	(0.00155)	(0.000715)
paper	0.00157	-0.0126***	-0.00468***	-0.00290***

	(0.00150)	(0.00132)	(0.00135)	(0.000553)
metal	-0.0144***	-0.0184***	-0.0239***	5.97e-05
	(0.00402)	(0.00362)	(0.00408)	(0.00146)
glass	0.00410**	0.00387***	-0.000212	0.00273***
	(0.00166)	(0.00143)	(0.00157)	(0.000641)
wet	0.00774***	-0.000382	0.00658***	-0.00108***
	(0.000984)	(0.000839)	(0.000871)	(0.000354)
mbt	0.00591***	0.00542***	0.00407***	0.00460***
	(0.000610)	(0.000570)	(0.000526)	(0.000215)
integ	0.00319***	-0.00705***	0.000623	-0.00367***
	(0.000557)	(0.000529)	(0.000466)	(0.000224)
adig	-0.00777***	0.00764***	-0.00138	-0.0111***
	(0.00283)	(0.00296)	(0.00262)	(0.000891)
compo	-0.000641	-0.0104***	-7.30e-06	-0.00370***
	(0.00126)	(0.00105)	(0.00104)	(0.000420)
Constant	-1.246***	-2.392***	-1.033***	1.117***
	(0.275)	(0.237)	(0.257)	(0.125)
Observations	10,114	8,813	10,371	10,451
R-squared	0.126	0.179	0.173	0.443

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: own elaboration

To conclude this section, table 6 presents prominent cost drivers that according to our models deserve special attention being them used in both models and resulted significant in influencing specific cost items under investigation in this paper.

Table 6: focus of cost drivers for unsorted and sorted waste cost items

variable	Impact	ctc	tdc	msc	trc
axr	Less urbanized municipalities are associated with lower costs taking into account the cost items of the unsorted waste; the same cannot be said for the cost items related to the sorted waste. This is partially explained by increased sorting and management costs of the sorted fraction where waste production is dispersed; e.g. increased mileage to optimize vehicle loading and deliver waste to recovery and recycling plants.	-	-	+	(+)
alt	At mountain and hill municipalities corresponds a lower waste management cost. This is do to the morphological characteristics of Italy with plenty of hillside villages with no o a few economic activities.	-	-	-	-
coast	Coastal municipalities have higher costs in all cost items considered. This paper does not go into the subject in depth but a potential explanation is related to tourism flows.	+	+	+	+
perso	The impact of the separate collection rate is ambiguous as the literature suggests. There are economies of scale for both cost	+	+	-	-

	items related to the sorted waste. The opposite is true for the items related to the unsorted waste.				
kg	As waste per capita increases, the cost of management decreases. Although circular economy objectives require waste generation to be reduced, it is clear that the cost of management decreases as waste generation per capita increases, other things being equal. One possible explanation, for example, is the optimization of collection for the same number of kilometers travelled.	-	-	-	-
rev	There is a correlation between the cost of waste management and the municipality' revenues. Municipalities with higher budget per waste produced have a higher percentage of manufacturing and tertiary activities. The type of waste produced increases and some of it is assimilated to municipal waste.	(+)	(+)	(+)	(+
den	The production of waste per kilometre is correlated to the reduction in the cost of management of the unsorted waste while for the sorted waste there is a reduction in the cost of sorting and management of materials.	-	-	-	(+)
scale	Economies of scale related to the size of the service are especially noticeable in the management of the unsorted waste. This is also due to the presence of treatment and disposal plants.	-	(-)	(+)	(+)
mbt	Mechanical biological treatment plants, although useful for achieving circular economy objectives, tend to increase costs.	+	+	+	+
Landfill	Despite negative externalities this solution generates it is still widely used because of its low cost.	-	-		
wte	Incinerator with energy recovery play a remarkable role in reducing cost.	-	-	NA	NA
adig	Cost reduction observed in material sorting cost items; the opposite as long as treatment and recycling is concerned.	NA	NA	-	+
compo	Cost reduction observed in both cost items but significant only as long as treatment and recycling is concerned.	NA	NA	(-)	-
integ	Cost reduction observed regarding treatment and recycling. the opposite as long as material sorting and collection is concerned.	NA	NA	+	-

Source elaboration. Non-significant values in parentheses.

5. DISCUSSION

The results of the analysis of our models show that the impact of determinants varies according to the sub-cost items and the units of measure—cost per capita and cost per ton. We go one step further by cross-referencing the results concerning the cost drivers of unsorted waste and using the total cost as a comparison variable. As a result of this cross-referencing, we confirm significant relationships in the case of the variables used, regardless of the unit of analysis, per capita or per ton. Specifically, we believe that it is useful to underline some aspects not considered in the literature.

We begin our considerations by emphasizing the role of the use of waste management facilities; waste-to-energy plants and landfills play a remarkable role (Liu et al., 2019; Makarichi et al., 2018; Swart and Groot, 2015) in cost determination, highlighting the significance of making self-sufficiency in waste management capacity a common policy objective. Although our results show that both waste disposal options lower the MSWM cost, the significance of waste-to-energy parts is widely recognized in the context of a circular economy (Malinauskaite et al., 2017). Concerning modern waste legislation, it aims to reduce landfill through regulations, landfill tax, and landfill bans (Scharff, 2014). In this regard, estimates show that Italy alone would require an additional treatment capacity of 6.3 million tons per year of waste-to-energy plants. In order to solve the dilemma of energy demand, waste management, and greenhouse gas emission simultaneously and to achieve a circular industrial economy, it would be viable to establish waste-to-energy supply chains (Pan et al., 2015). Similarly, the selection of different waste management strategies based on waste recovery technologies and the utility functional specification (Swart and Groot, 2015) would be crucial. This is because, among the waste treatment technologies, certain technologies, such as the mechanical biological treatment, do not act in the same way as that of waste-to-energy plants. It has been found that mechanical biological treatment facilities contribute to cost increase. Therefore, it is accepted that, in many types of facilities, an increase in capacity lowers costs.

The role of the economies of scale in reducing the cost of MSWM has also been confirmed—an increase in the size of the service leads to a reduction in costs (Bel and Fageda, 2010; Callan and Thomas, 2001). Although circular economy targets require upgradation of the endowment of waste treatment facilities, the realization of economies of scale through the development of new waste management facilities is subject to legislative factors, such as prescriptive or enabling legislation; international, national, regional, and municipal legislations, and technical legislation.

Our results also indicate that a higher degree of density corresponds to a lower cost of service (Bartolacci et al., 2019; Greco et al., 2015; Mani and Singh, 2016) that fosters MSWM operations. This result gains importance in light of recent World Bank forecasts as per which the annual waste generation is projected to increase by 70% from 2016 levels (which accounted for 2.01 billion tons of MSW generated globally in cities) to 3.40 billion tons in 2050. The results also indicate that coastal municipalities incur higher cost. This may attributed to tourist activities (Arbulú et al., 2015; Greco et al., 2018); however, limited attention has been paid to how and to what extent tourism increases the costs of solid waste collection (Greco et al., 2018). It has also been noted that the cost of service is related with the municipality' budget.

Deductions, as the ones outlined above, can be drawn for sorted waste. From our analyses, the impact of separate collection, and in turn of the recycling targets, on cost is not unambiguous. In fact, it depends on many factors including, as the Italian system is set up, the revenues from the sale of materials obtained from separate collection (there is also an agreement between municipalities and the national packaging consortium). Since these prices in recent years have shown fluctuating trends its impact is not easily measurable through an econometric model that includes a two-year period. Among the various materials that make up separate waste, the percentage of glass tends to increase costs, while paper reduces costs. In the case of paper, the lower prices may be attributed to a significant reduction in pulping prices consequent to new international customs barriers on imports. For glass, the increase in prices can be attributed to the surprising increase in the collection rates and the disbursements made alongside the simultaneous fall in the auction value of scrap due to the saturation of treatment plants. For plastic, in southern regions, a significant increase in the amount of packaging waste due to its poor quality has generated additional costs for material sorting and waste management.

The use of waste management facilities for the treatment of sorted waste contributes to cost reduction, with the exception of mechanical biological treatment. In this case, therefore, plant capacity plays a fundamental role in achieving the objectives of circular economy. Consistent with findings related to unsorted waste, the study confirms the role of the economies of scale in the total cost. Since our findings are based on Italian municipalities, the results from such analyses should be treated with caution, especially for comparative purposes. For example, one potential concern about our findings is the possibility of alternative scope of cost items. However, our results are reliable, given the internal validity and the consistency of our findings with those in mainstream literature, especially regarding the role of the economies of scale and other widely considered cost drivers.

6. CONCLUSION

We have given an account of how cost drivers impact on waste management cost according to different cost items. After having divided waste management cost in its cost items we have focuses on how exogenous and endogenous drivers impact on such cost items. We have performed four regression-based models to analyze the data according to cost items. Models have also been reiterated using different data normalization: cost per ton of waste or waste per capita. Besides exogenous determiners of cost, such as altitude, population density, and coastal zone, results refer to both unsorted and sorted waste management cost items. In this respect economies of scale are confirmed along with the critical role of adequate waste facilities that play a remarkable role in cost minimization.

Results have also confirmed that they differ according to the unit of the selected measures. From the results we can also draw two conclusions for unsorted and sorted waste, respectively.

As regards cost drivers of unsorted waste, consistently with previous literature our results confirm the role of the economies of scale, the role of density and the role of geographical variables. Our results add to the exiting knowledge the role of being a coastal municipality Results also highlight the impact of the use of treatment or disposal facilities, such as waste-to-energy plants, in the transition towards a circular economy. Similarly, results concerning the cost drivers of sorted waste have suggested that the use of facilities for the treatment of sorted waste reduces costs, with the exception of mechanical biological treatment. Concerning sorted waste materials, a higher percentage of glass contributes toward increasing costs, while a higher share of paper lowers costs. Our research suggests that the policymakers should identify policy measures to overcome critical issues, such as the social stigma against the establishment of waste treatment facilities that hinders their allocation; for example, the policymakers can refer to the European legislation when designing the policy instruments. This would also guarantee consistency between the cost of the service and the level of quality.

Besides benefits for industrial policymakers, our results may provide and regulators with insights useful to design asymmetric regulations as per the definition of allowed revenues in each of the cost items and local administrators may take advantage of these results for benchmarking purposes. In order to move toward a circular economy, it would be important to upgrade the endowment of waste treatment facilities; it is widely recognized as a prominent step for realizing the economies of scale.

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Annex 1. correlation matrix of all the variables used in the models inherent to unsorted waste

	axr	coast	alt	perso	kg	rev	density	scale	wte	land	mbt
axr	1,000	-0,042	0,141	-0,071	0,066	0,175	-0,340	-0,170	-0,057	0,063	-0,040
coast	-0,042	1,000	-0,362	-0,193	0,214	-0,002	0,210	0,278	-0,227	0,219	0,260
alt	0,141	-0,362	1,000	-0,228	-0,210	0,434	-0,507	-0,354	0,007	0,178	0,097
perso	-0,071	-0,193	-0,228	1,000	-0,085	-0,213	0,266	0,018	0,150	-0,447	-0,466
kg	0,066	0,214	-0,210	-0,085	1,000	-0,414	0,252	0,185	0,110	-0,181	-0,243
rev	0,225	0,105	0,371	-0,276	0,050	1,000	-0,604	-0,292	-0,237	0,295	0,338
den	-0,365	0,171	-0,479	0,292	0,047	-0,564	1,000	0,454	0,189	-0,263	-0,162
scale	-0,170	0,278	-0,354	0,018	0,185	-0,227	0,429	1,000	-0,167	0,110	0,163
wte	-0,057	-0,227	0,007	0,150	0,110	-0,204	0,172	-0,167	1,000	-0,427	-0,377
land	0,063	0,219	0,178	-0,447	-0,181	0,232	-0,233	0,110	-0,427	1,000	0,675
mbt	-0,040	0,260	0,097	-0,466	-0,243	0,248	-0,115	0,163	-0,377	0,675	1,000

Annex 2. correlation matrix of all the variables used in the models inherent to sorted waste

	axr	coast	alt	perso	kg	rev	density	scale	plastic	paper	metal	glass	wet	mbt	Integ	Adig	compo
axr	1,000	-0,042	0,117	-0,074	0,052	0,153	-0,346	-0,161	0,059	0,046	0,084	0,101	-0,081	-0,017	0,036	-0,047	-0,011
coast	-0,042	1,000	-0,370	-0,221	0,239	0,016	0,201	0,280	-0,062	0,069	-0,084	-0,007	0,052	0,273	-0,187	-0,150	-0,074
alt	0,117	-0,370	1,000	-0,168	-0,219	0,401	-0,460	-0,338	0,143	0,111	0,156	0,288	-0,338	0,089	-0,210	-0,167	-0,012
perso	-0,074	-0,221	-0,168	1,000	-0,179	-0,130	0,174	-0,045	-0,174	-0,371	-0,014	-0,352	0,459	-0,404	0,350	0,177	0,085
kg	0,052	0,239	-0,219	-0,179	1,000	-0,413	0,257	0,209	-0,129	0,092	0,057	-0,152	-0,096	-0,211	0,026	0,154	0,044
rev	0,194	0,142	0,326	-0,235	0,065	1,000	-0,566	-0,249	0,162	0,012	0,073	0,320	-0,064	0,340	-0,229	-0,281	-0,206
den	-0,368	0,156	-0,429	0,218	0,051	-0,517	1,000	0,435	-0,218	-0,050	-0,184	-0,403	0,252	-0,150	0,035	0,120	0,026
scale	-0,161	0,280	-0,338	-0,045	0,209	-0,164	0,405	1,000	-0,184	0,150	-0,151	-0,348	0,251	0,194	-0,088	0,057	-0,011
plastic	0,059	-0,062	0,143	-0,174	-0,129	0,111	-0,197	-0,184	1,000	0,083	0,009	-0,027	-0,311	0,104	-0,056	-0,115	-0,202
paper	0,046	0,069	0,111	-0,371	0,092	0,061	-0,071	0,150	0,083	1,000	-0,052	0,077	-0,470	0,154	-0,145	-0,109	0,077
metal	0,084	-0,084	0,156	-0,014	0,057	0,110	-0,202	-0,151	0,009	-0,052	1,000	0,069	-0,308	-0,219	0,202	0,089	-0,051
glass	0,101	-0,007	0,288	-0,352	-0,152	0,272	-0,383	-0,348	-0,027	0,077	0,069	1,000	-0,478	0,112	-0,074	-0,088	-0,005
wet	-0,081	0,052	-0,338	0,459	-0,096	-0,120	0,282	0,251	-0,311	-0,470	-0,308	-0,478	1,000	0,102	0,021	0,006	-0,042

mbt	-0,017	0,273	0,089	-0,404	-0,211	0,263	-0,110	0,194	0,104	0,154	-0,219	0,112	0,102	1,000	-0,488	-0,335	-0,072
integ	0,036	-0,187	-0,210	0,350	0,026	-0,237	0,030	-0,088	-0,056	-0,145	0,202	-0,074	0,021	-0,488	1,000	0,207	-0,007
adig	-0,047	-0,150	-0,167	0,177	0,154	-0,228	0,092	0,057	-0,115	-0,109	0,089	-0,088	0,006	-0,335	0,207	1,000	0,156
compo	-0,011	-0,074	-0,012	0,085	0,044	-0,203	0,017	-0,011	-0,202	0,077	-0,051	-0,005	-0,042	-0,072	-0,007	0,156	1,000

Annex 3. VIFs for per ton models as in table 2 and table 3

	swc	ctc	tdc	UNMC	MC	msc	trc	SOMC	MC
			Table 2						
den	2.38	2.36	2.32	2.35	2.35				
mbt	2.25	2.32	2.29	2.33	2.33				
land	2.11	2.16	2.17	2.17	2.17				
rev	2.03	2.1	2.1	2.11	2.1				
alt	1.77	1.69	1.67	1.69	1.7				
perso	1.58	1.59	1.58	1.59	1.58				
coast	1.53	1.5	1.5	1.49	1.53				
scale	1.5	1.5	1.49	1.49	1.5				
kg	1.47	1.46	1.48	1.47	1.48				
wte	1.33	1.38	1.4	1.37	1.37				
axr	1.16	1.18	1.17	1.18	1.18				
Mean VIF	1.74	1.75	1.74	1.75	1.75				
							Table 3		
bio						3.23	3.14	3.29	3.28
den						2.23	2.24	2.24	2.24
rev						2.17	2.19	2.16	2.16
mbt						2.14	2.15	2.15	2.14
glass						2.07	1.97	2.07	2.08
perso						2.07	1.97	2.06	2.06
alt						1.86	1.86	1.85	1.86
paper						1.68	1.68	1.68	1.69
scale						1.63	1.61	1.64	1.65
kg						1.57	1.6	1.57	1.58
coast						1.54	1.56	1.54	1.57
integ						1.54	1.54	1.53	1.54
plastic						1.51	1.53	1.5	1.5
metal						1.35	1.51	1.35	1.35
adig						1.27	1.34	1.27	1.25
axr						1.18	1.21	1.18	1.18
compo						1.17	1.17	1.17	1.17
Mean VIF						1.78	1.78	1.78	1.78

Annex 4. VIFs for per capita models as in table 4 and table 5

	swc	ctc	tdc	UNMC	MC	msc	trc	SOMC	MC
f			a. Table 4						
mbt	2.28	2.31	2.3	2.32	2.33				
den	2.18	2.22	2.17	2.21	2.21				
land	2.14	2.16	2.17	2.16	2.17				
rev	1.74	1.75	1.73	1.75	1.75				
alt	1.73	1.69	1.67	1.69	1.7				
perso	1.59	1.59	1.59	1.58	1.58				
coast	1.52	1.5	1.5	1.5	1.53				
scale	1.48	1.5	1.5	1.5	1.5				

kg	1.37	1.38	1.4	1.37	1.37				
wte	1.35	1.35	1.35	1.36	1.36				
axr	1.18	1.18	1.17	1.18	1.18				
Mean VIF	1.69	1.69	1.68	1.69	1.7				
						b. Table 5			
bio						3.23	3.1	3.3	3.28
mbt						2.15	2.23	2.15	2.14
den						2.1	2.04	2.1	2.09
perso						2.08	1.94	2.07	2.08
glass						2.06	1.93	2.06	2.06
alt						1.85	1.85	1.85	1.86
rev						1.81	1.81	1.8	1.8
paper						1.68	1.67	1.69	1.69
scale						1.64	1.62	1.64	1.65
coast						1.54	1.6	1.55	1.58
kg						1.54	1.54	1.54	1.54
integ						1.54	1.53	1.53	1.53
plastic						1.51	1.51	1.5	1.5
metal						1.36	1.5	1.35	1.35
adig						1.27	1.35	1.26	1.25
axr						1.18	1.21	1.18	1.18
compo						1.17	1.16	1.17	1.17
Mean VIF						1.75	1.74	1.75	1.75