EE
E u r o E c o n o m i c a
Issue 5(31)/2012 *ISSN: 1582-8859*

Multi-Tasking in the Waste Realm.
Theoretical and Empirical Insights on Management and Disposal Performances

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Abstract. We investigate waste management and disposal performances through the lens of the multi-tasking model (Holmstrom and Milgrom, 1991) to analyse the conversion that occurred in the Italian municipal waste management system, which is of interest due to its idiosyncratic and extensive decentralisation of waste management and policy decisions. We empirically root the research on a large panel dataset that covers 103 provinces over a decade. Waste management and waste policy incentives are tested. Main results are that increasing the price of landfill taxes promotes the primarily technological substitute to disposal, i.e. recycling, and consequently is able to promote separate collection. With regard to the new tariff, it constitutes an economic incentive to promote separate collection, because its structure includes tax breaks for those people who reach a certain amount of separate collection. More negative outcomes – but coherent with the multi-tasking model – emerge when assessing the determinants of waste generation: neither the tariff nor the landfill tax is statistically significant drivers of waste generation.

Keywords: multi-tasking, principal agent model, waste disposal, waste management, waste tariffs

1 Waste Management Systems: economic and policy issues

This work makes an extensive use of the multi-tasking model (Holmstrom, Milgrom, 1991) to interpret the conversion that has occurred in the Italian municipal waste management system in the last decade. As shown in recent studies (Nicolli, 2012) both in Europe and in Italy specifically, there has been a radical transformation at all levels of waste management, thanks to which traditional waste disposal technologies, such as landfilling, have been replaced by recycling and, to some extent, incineration. However, as shown in Mazzanti, Montini and Zoboli (2008) evidence of decoupling[1] of the total amount of waste produced is rather scarce and limited to some northern provinces. This transformation is well highlighted in the graphs below.

Figure 1 illustrates the trends in municipal waste generation per inhabitant from 1999 to 2008. We can see that municipal waste production per capita increased constantly between 1999 and 2006, before undergoing a slow decrease. However, if the entire period is considered, per capita production of waste grew from 500 kg in 1999, to 540 kg in 2008. Nevertheless, when the first year is fixed as equal to 100, Figure 2 shows that, over the analyzed period, the amount of waste going to landfills decreased by more than 25 percent, from around 380 kg per inhabitant in 1999 to some 260 kg per inhabitant in 2008.

[1] A common approach to measuring environmental performance in Economic literature is through the use of 'absolute' and 'relative' indicators of delinking (Jacobsen et al., 2004), the former being a negative relationship between economic growth and environmental pressures; the latter positive but decreasing in terms of size and association, that is, a positive lower than unity elasticity in economic terms. Absolute and relative delinking trends are embedded in the more general Environmental Kuznets Curve (EKC) framework (Stern, 2004).

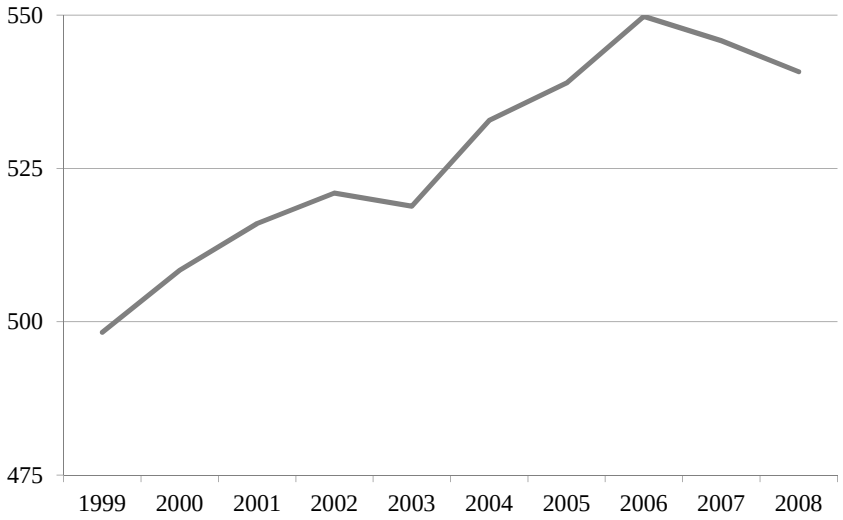

Figure 1 Municipal waste generated per inhabitant (kg) in Italy in 1999-2008

At the same time, recycling increased exponentially, and accounted for some 30 percent of total waste disposal in 2008 compared to only 13 percent in 1999. Incineration increased by more than 25 percent in the 1999-2008 period, and assumed an important role in the waste management system. Figures 3, 4 and 5 depict longitudinal comparisons that highlight the differences among waste management choices across Italian regions in 2008. They reveal a very complex and diverse picture. Figure 3 shows that the north of the country is less reliant on landfills than the central area and Sicily, where waste disposal is mostly by landfill. Figure 4 highlights differences across the north and south of the country in the adoption of separated waste collection. All regions in the north (with the exception of Liguria) show amounts of separated collection exceeding 179 kg per inhabitant in 2008, with particularly high levels in Piemonte, Emilia-Romagna, Trentino Alto-Adige, and Veneto. In southern Italy there is much less separated collection, with Sicily, Calabria, Puglia, Basilicata, and Molise in the lowest end of this distribution. Figure 5 shows incineration levels per province in 2008. In this figure the geographical unit is the province rather than the region because of the wide differences in incineration adoption, for which regional data would have shown a biased picture. Figure 5 demonstrates a concentration of incineration plants in the north of Italy, especially in Emilia Romagna and Lombardia. If we exclude these two regions, there is no clear pattern for the use of this technology.

According to Mazzanti and Zoboli (2009) and Mazzanti and Nicolli (2012), different policy levers played a fundamental role in diverting waste from the landfill and promoting recycling, but had no effect on waste generation. This work seeks to shed further light in this direction, by making use of the multitasking model in order to understand whether of not policy tools have been able to promote waste prevention and why.

The paper is structured as follows: the section immediately following introduces the multitasking model and its application to this specific case study, the third section introduces the data and the empirical model, the fourth presents the main results and the final section concludes.

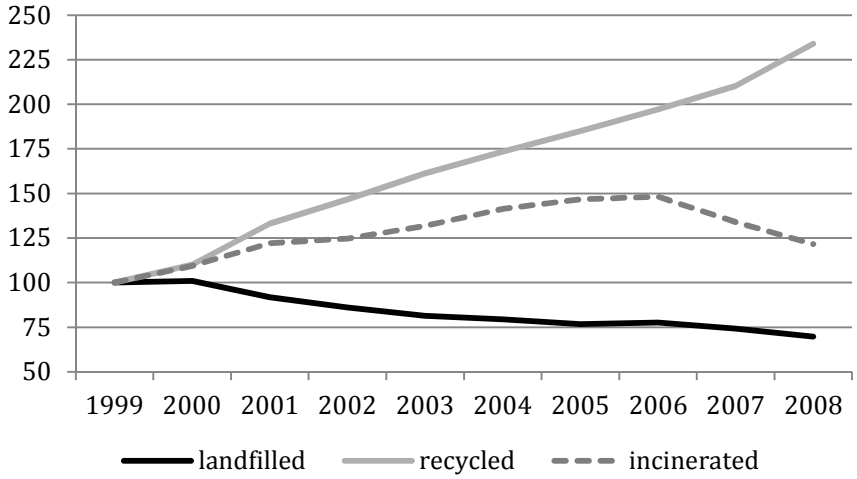

Figure 2 Italian waste disposal options trend, year 1999=100.

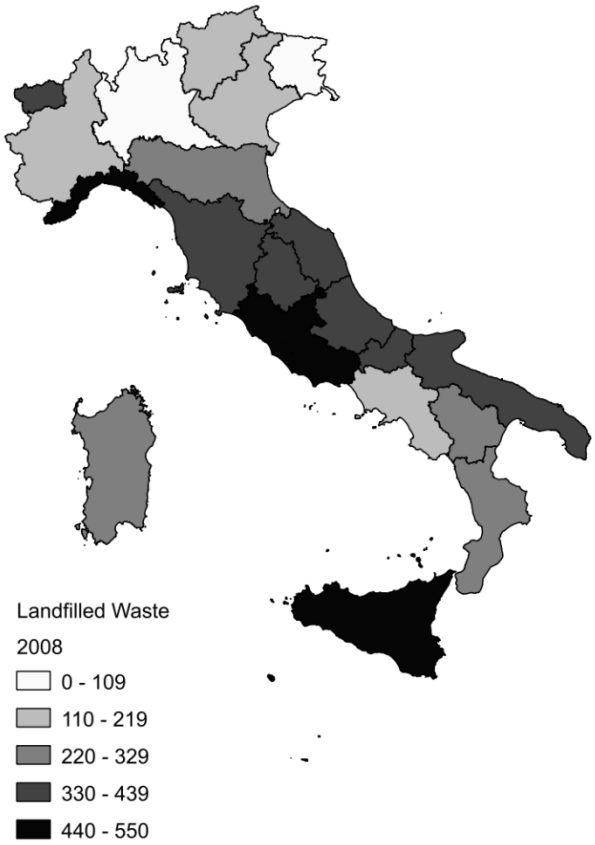

Figure 3 Landfilled waste – regional comparison (Kg) in 2008.

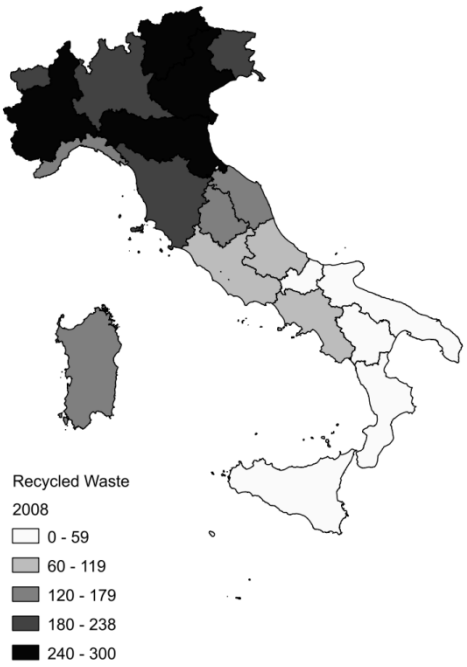

Figure 4 Recycled waste – regional comparison (Kg) in 2008.

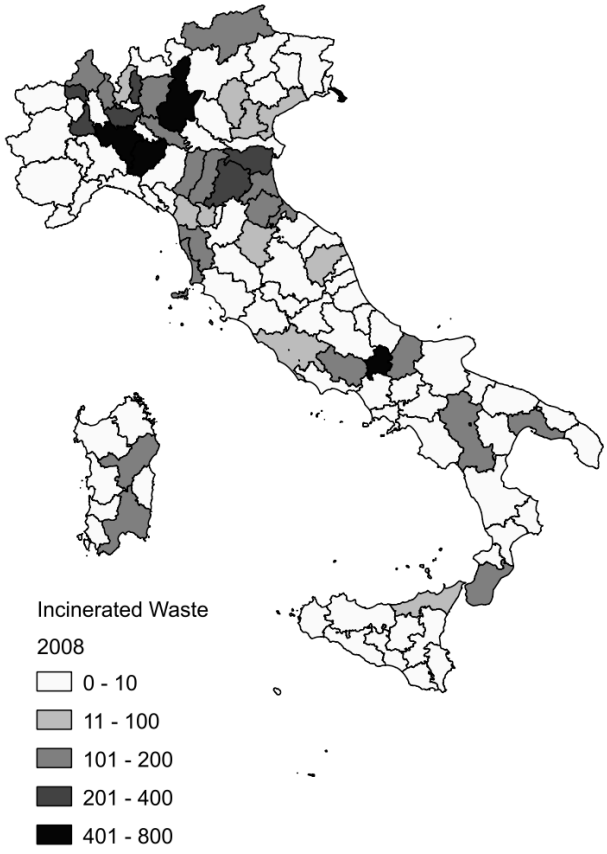

Figure 5 Incinerated Waste – provincial comparison (Kg) in 2008.

2 Multi-tasking Model

The multi-tasking model (Holmstrom and Milgrom, 1991), is an extension of the traditional principal-agent model, and it treats the case in which the principal assigns two tasks to the agent or the agent's task has different dimensions in which it can be executed (therefore, we overcome the classic dissertation where the agent has to execute only one task). The original model studies the employer-employees relationship, in a context of asymmetric information, in which the principal is not able to perfectly observe all the aspects of the performances carried out by the agent, who holds the majority of information. For this reason, the model introduces the concept of signaling, and assumes that the agent's effort generates information for the principal, who however is not able to perfectly observe the performances reached by the agent in every activity[2]. The multidimensionality in the agent's tasks is the most common one in the employment contracts; because either the final performance reached by the worker is composed of different aspects, or the worker has to carry out more than one task. With regard to this point, the authors give the example of teachers who has to teach both high-level and basic skills. If their incentive pay is determined by the student's test score that, in turn, is focused mainly on the basic skills, then teachers are encouraged to teach only these skills at the expense of high-level ones, which are however important in order to give a complete education. In this case, the signal captured by the principal (on which is based the economic incentive) is the score reached by students in their tests. Therefore, since that the test emphasizes the knowledge of basic skills, some dimensions of teaching (high-level skills), for which there are no incentive, are not observed by the principal.

The model demonstrates that providing incentives for only one activity assigned to the agent can entail a reallocation of the total effort and attention s/he devotes to all activities, because a piece-rate scheme directs agent's commitment towards only some activities (those more observable and therefore well-compensated). Therefore, when the agent has to choose the commitment's degree to devote to different activities, in his choice he will be affected by the measurability of these tasks by the principal.

We can see that if the agent has to carry out two tasks, but only one task is easy to measure, then fixing an incentive pay could lead to a situation where the agent will reach high performances only in the task more easily observable by the principal. In fact, providing incentives for reaching high performance levels only for observable tasks could induce the agent to dedicate effort and attention only to those tasks, and s/he will not be encouraged to reach high levels performance in other tasks. Moreover, the model also concludes that the principal should provide higher incentives for those agents whose performance are measurable with a higher degree of precision. In general, we can see that the lower is the ability to measure the performance in the other tasks of the agent, the lower is the desirability of fixing incentives for a certain activity.

Therefore, when the measured performance is not available for every task, an economic incentive could cause a distortion in the output reached by the agent. This is the most important aspect that makes multi-tasking model different from the traditional principal-agent relationship: in fact, in the traditional model, an incentive pay is only important in motivating agent's commitment and in distributing the risk between all the subjects involved in the production process; instead, in the multi-tasking model economic incentives fixed by the principal also are important in allocating the agent's effort and attention between the two tasks.

The model also concludes that it is advantageous not to provide incentives when the agent is able to reduce observed performance by the principal not bearing any cost, because in this way s/he will focus

[2] The model also assumes that the costs for the agent only depend on the total attention and effort that he has to devote to the different tasks In order to develop the model, it is also important to remark the fact that the two parties (agent and principal) set a wage that is a function of the measured performance, because the principal bases the amount of compensation to assign to the agent on observable outputs.

only on well-compensated activities. This is an important point, because highlights that even if output measures are available, it could be convenient not to fix incentives anyway. In fact, even if the principal set a good measurement process, then it could be distorted because of the opportunity of the agent to reduce the measured performance. Therefore in this way the measurement process will give partial results on actual performances and the final output reached by the agent will be affected by this opportunity that the agent has. The principal should prevent this eventuality making the agent's opportunity to reduce the performance onerous, for example fixing some kind of sanctions.

With the purpose to overcome problems generated by the economic incentives, the authors state that the job design could play an important role, and it becomes an effective tool in order to permit the achievement of high performances in every task assigned to the agents. In fact, we can divide and separate every activity (or every aspect of these activities) and group them according to their measurability. In this way, the principal can overcome problems regarding economic incentives, because s/he could assign the more observable tasks to a specific worker, whereas the other tasks are assigned to another one. Therefore, job design is not only affected by the worker's characteristics in terms of commitment, skills and experience, but it is also linked to the task's measurability and the effectiveness of the measurement process: even workers who has the same skills, could be carry out different tasks.

The situations discussed in the model also refer to the case of a teamwork, in which the performance of every agent is difficult to measure. In a situation where individuals has to carry out both single and group activities, and supposing that the individual contribution to an output reached by the team work is not effectively measureable, could be convenient not to provide incentives in order to avoid that the agent devotes his commitment only on the activity in which an individual performance emerges. This implication, as we will see, will have a direct application in the Italian waste management case and it could offer important insights in this sense.

We apply this model to Italian waste management, setting the principal as the "environmental authority", the agents as families and the tasks assigned to them as reducing waste and increasing separate collection of materials for recycling[3]. We can see that the asymmetric information also exists in a waste management context, because the environmental authority is not able to perfectly know all the people's waste management habits. In fact, the authority provides incentives for reaching the objectives in this field.

The main tools used by the principal in order to promote these objective tasks are the landfill tax and the Italian waste tariff (TIA, *Tariffa di Igiene Ambientale*), which, as we will see, should not constitute an effective incentive to reduce waste, but could be an effective incentive to increase separate collection. In this situation, in following the multi-tasking model we should see that users are encouraged to carry out separate collection but not to reduce waste. Firstly, the most important purpose of the landfill tax is to drive down 'landfill diversion', but it does not have any impact on waste reduction, because there is not any theoretical evidence in this sense. In fact, the main effect of landfill tax could be on recycling, because discouraging the landfill diversion it is possible to promote other methods of waste treatment, such as recycling. Second, TIA is an important economic incentive in increasing separated collection, but since here amount is not directly linked to waste generated, it cannot be considered an incentive to reduce waste.

In a situation where families have to execute two tasks (waste reduction and separate collection), and where only one task is encouraged by economic incentive and therefore more easily achieved in this sense (separate collection), the multi-tasking model concludes that the agents will be encouraged to reach high levels of performance in separate collection, but not in waste reduction. Also, we have seen that when the agent has the opportunity to reduce the measured performance without any cost, it could be desirable not to fix incentives. Since the amount of TIA to be paid is based on aggregate

[3] Hereafter referred to as 'separate collection'.

information, and therefore it does not determine the exact amount of waste generated by every family, agents can reduce their observed performances in waste reduction. For this reason as well a multi-tasking situation is likely. In fact, in a situation where the individual performance is hard to measure, we can interpret this situation using the example of the team work that derives from an application of multi-tasking model, which we have discussed above. In this situation, the user will be able to reduce his measured performance regarding waste reduction (because it is based on aggregate information), also increasing the amount of waste, devoting less care and attention to this task and focusing on the other well-compensated one, namely the increase of recycling. With regard to this point, setting negative incentives and economic sanctions to reduce the agent's performance (and therefore, avoiding that the user can increase the amount of waste without any cost) could be important, but it is realizable only with a punctual tariff, which is able to determine every quantity of waste generated by every family.

This issue will be further explored by way of an econometric analysis, which will be presented in the next paragraph. Following the theoretical dissertation regarding the multi-tasking model, we expect policy variables to positively affect separate collection, but not to be able to promote waste reduction. Such a result would demonstrate that in Italy there is a multi-tasking problem with regards to waste management policies, and, due to this, only one of the tasks (separate collection) is encouraged by economic tools.

3 Econometric analysis

3.1 The data and Model

The empirical analysis is based on a large panel dataset for the 20 Italian Regions for the 1999-2008 period, that merges environmental, economic and demographic data, such as added value, population density, separate collection, waste generation, landfilled and incinerated waste. Environmental data has been taken from the Italian Environmental Agency (ISPRA), while economic and demographic data has been taken from the Italian National Institute for Statistics (ISTAT). The two economic tools considered are:

1) landfill tax: In accordance with the 1999 Landfill Directive (EEA, 2009), Italian regions were required to implement landfill taxes under national Law 549/1995. However, the timing of their introduction varied from region to region. Some regions fulfilled the requirement of the national law to impose the new tax within 12 months, while it took seven years for Valle d'Aosta, Molise, and Puglia to implement the tax as regional law. Amendments to the national law were made concerning landfill tax adoption, the definition of waste, and the distribution of responsibilities among the different regional offices. In the empirical analysis we have used a new dataset containing information on the level of the landfill tax (in euro per ton of landfilled waste) across Italian provinces from the years 1999 to 2005. Given the absence of official data on the tax in Italy, we surveyed each specific regional implementation through the use of official regional web sites, complementing this step with telephone interviews to regional offices in order to fill gaps and verify web-related information.

2) TIA (*Tariffa di Igiene Ambientale*): in the last years Italy has undergone a transition from the old taxation system (TARSU, *Tassa sui Rifiuti Solidi Urbani*) to the new Italian waste tariff, TIA. The TARSU was simply related to the size of household living space, and did not follow any cost-recovery principle. For this reason we do not expect it to have any impact on waste reduction. Instead, TIA should move waste management towards a full-cost pricing/polluter pays principle (PPP) based system. The tariff is composed of two parts: a fixed part, which covers the fixed costs of waste management (such as costs of cleaning streets), and a variable part, which covers the variable costs of this service, such as the costs of waste collection and disposal. These parts are attributed to different users using four coefficients, which are based on the number of components of the family or on type

of economic and productive activity. We may note that TIA has more rigorous criteria than TARSU in order to measure the actual amount of waste generated, however it is based on aggregate information, so it is not possible to consider TIA as an economic incentive to reduce waste. In fact, we may state that TIA is not a real tariff, because there is no proportional relation between waste generated and waste management costs. Accordingly, with the verdict no. 238/2009, Italian Supreme Court definitively decreed that TIA is not a tariff, but a tax. At the same time, TIA sets important economic incentives to increase separate collection, because there are many tax breaks for those users who reach a certain amount of separate collection. Therefore, we expect TIA to have a positive impact on separate collection but not on waste reduction. We used the following two proxies in the empirical analysis: TAR-MUN and TAR-POP, which are the share of provincial municipalities and the provincial population affected by the new "waste tariff" regime respectively.

In summary, the variables used in the dataset are grouped into four categories:

- SET A, which contains economic variables such as value added (VA) and its square;
- SET B, which contains demographic variables such as tourist flows and population density;
- SET C, which contains waste management variables such as the amount of incinerated or landfilled waste, number of landfills and incinerators;
- SET D, which contains policy variables such as TAR-MUN, TAR-POP and the landfill tax.

Thanks to this data set an empirical analysis was conducted using Fixed effect panel estimation techniques. The main factors to be assessed were the impact of local specificities (infrastructure, habits, social norms) on the linkage between policy and dependent variables. The estimates were then repeated for geographic macro-area, dividing the Italian territory in two parts, north and south, in order to analyze possible differences between the two in terms of waste reduction and separate collection. Eventually, another set of estimates was carried out, including only Italian Provinces with an added value of more than € 23,000. This choice was made following Montini, Mazzanti, Zoboli (2008), who found weak evidence of a turning point (TP) around € 23,000 and therefore of Waste Kuznets Curves (WKC) /decoupling dynamics in Italy during the 1999-2005 period[4]. In this way, the study aimed to verify if the impact of TIA on waste reduction in a richer subset of provinces which are supposedly within the 'right' part of an WKC.

The research hypotheses are then the following. Firstly, we aim to test for the presence of delinking in waste generation, examining the statistical significance of added value and its square. We expect either a linear relationship with eventual relative delinking, or a (to our knowledge never-been-found) reasonable TP.

Secondly, we test the role of socio-economic and demographic variables like population density and tourism. In particular, we could expect that areas with high levels of population density and tourist flows produce more waste than other areas. We could also expect a positive linkage between recycling and tourist flows: since landfills could involve many problems for the landscape, local economies that are based on tourism are encouraged to discourage landfilling in favor of incineration or recycling, which are associated with higher amenity values. Population density, on the other hand, might control for the incidence of economic and environmental opportunity costs, which we expect to be higher and more critical in densely populated areas.

Waste management variables like the number of incinerating plants and landfill sites, represent a simple control for the technical composition of provincial waste management.

Finally, our main research hypothesis is that both the TIA and landfill tax do not have a real effect on waste reduction but they could have a positive impact on separate collection. If this last result holds, we might conclude that there is a multi-tasking problem in the country with regards to waste management policies.

[4] The range in which the authors found the TP was between € 22,586 and € 31,611. We chose € 23,000 because it permits us to work with a reasonable number of observations.

A comprehensive variable description and research hypothesis is offered in Table 1.

In line with literature on the Waste Kuznets Curve (WKC) (Mazzanti and Zoboli, 2009) we can formulate the following general specification:

$$\text{Log (waste generated)}_{it}$$
$$\text{or}$$
$$\text{Log (recycling)}_{it} = \alpha_{it} + \beta_1 \text{Log (TAR-MUN)}_{it}$$
$$\text{or}$$
$$\beta_2 \text{Log (TAR-POP)}_{it} + \beta_3 \text{Log (landfill tax)}_{it} + \beta_4 \text{Log (Z)}_{it} + \beta_5 \text{Log (VA)}_{it}\ \varepsilon_{it}$$

The first term is an intercept that controls for country fixed effects, the dependent variables are waste generated or recycling per capita, and the explanatory variables include TAR-MUN (β_1), TAR-POP (β_2), landfill tax (β_3) and a set of variables that control for regional waste management, demographic and economic characteristics based on the information summarised in Table 1. Z includes structural factors such population density. VA is the economic control which shapes the eventual WKC. All variables are expressed in logarithmic form in the analysis.

Table 1 Descriptive analysis and research hypothesis

Acronym	Variable Description	Mean	Min	Max	Research Hypothesis
MSW	Municipal solid waste generated per capita (kg/pop.) (log in the analysis)	524.7663	251.91	882.87	Dependent Variable
Recycling	Separate collection per capita (kg/ab.) (log in the analysis)	115.5637	0.1	378.35	Dependent Variable
VA	Value added (Euro) (log in the analysis)	18267.36	9386.47	30889.24	Positively correlated to both dependent variables
Tottourism	Total touristic flows (log in the analysis)	3398301	91033	3.36e+07	Positively correlated to both dependent variables
Popdens	Population density (log in the analysis)	246.8536	31.17	2646.92	Positively correlated to both dependent variables
Incinerated	Municipal Solid Waste incinerated (kg/ab.) (log in the analysis)	61.7722	0	766.77	Control for waste management characteristics
Nrinc	Number of incinerators (log in the analysis)	0.4621359	0	6	Positively correlated to waste generated
Landfilled	Municipal Solid Waste landfilled (kg/ab.) (log in the analysis)	318.4889	0	1898.47	Control for waste management characteristics
Nrdisc	Number of landfills (log in the analysis)	4.520388	0	77	Positively correlated to waste generated
TAR-MUN	Share of provincial municipalities affected by TIA	7.814825	0	100	No significant correlation with waste generated, positively correlated to recycling

Acronym	Variable Description	Mean	Min	Max	Research Hypothesis
TAR-POP	Share of provincial population affected by TIA	13.50073	0	104.24	No significant correlation with waste generated, positively correlated to recycling
Landfill tax	Landfill tax, euro per Kg (log in the analysis)	0.0573689	0.1	0.15	No significant correlation with waste generated, positively correlated to recycling

3.2 Regression Results - Waste Generation Drivers

Regression results are presented in Table 2 below. We perform fixed effect (FE) and random effect (RE) estimations, as is usual for panel data. In order to choose between RE and FE models, we perform the Hausman test, which shows a preference for the FE model, suggesting a possible bias in the RE coefficient. Therefore we present only FE estimations, which are however similar to the RE ones. With regards to waste generation drivers, firstly we may note that the WKC hypothesis is not verified, because the income-waste relationship appears to be linearly shaped. In fact, even if there is a positive and significant correlation between municipal solid waste generation per capita and added value, there is not any significant correlation with its square. Therefore, we may conclude that in Italy the turning point described by WKC has not occurred yet. At the same time, a relative delinking is present, because the elasticity between dependent variable and added value is less than one.

Moreover, these results confirm the research hypothesis with regards to demographic variables: population density and tourist flows exert a positive pressure on waste generation. Observing the results on waste management variables, we may note that the number of incinerators has the expected sign and neither incinerated nor landfilled waste affect waste generation. Therefore, an environmental policy focused on incinerators does not constitute a positive factor towards decreasing waste generation.

A different result emerges when we consider the number of landfill sites, which appears negatively linked to the dependent variable. Nevertheless, the most important result comes when we analyze policy variables. In fact, we can see that neither TIA (with its proxies) nor the landfill tax are statistically significant drivers of waste generation. Therefore, the most important environmental policy instruments applied in Italy on waste management do not have a significant impact on waste reduction, which should be the first objective for a waste management policy. With regard to TAR-MUN and TAR-POP, this result could be explained by the fact that TIA uses presumptive criteria to determine waste generation: in Italy there is not a “punctual tariff”, so amount is not computed (therefore, it is not proportional) for waste generated by every family and for this reason it cannot constitute an economic incentive to reduce waste.

Observing results regarding the estimates for geographic macro-area, we can see that the policy variables present the same results as the aggregated estimates. Therefore, the multi-tasking problem also emerges if we consider the local specificities of different Italian areas. Added value always remains positively linked to waste generation, even if in the second group the linkage is weaker than in the first group. Other key drivers present some different results. Tourist flows are not positively linked to waste generation in Northern and Central Italy, but they positively affect waste generated in the second geographic macro-area. Population density and the number of incinerators show an inverse trend, being positively correlated to the dependent variable in the first group. The number of landfills does not affect waste generation in Northern and Central Italy, but it negatively affects waste generated in Southern Italy. Finally, the main regression results are confirmed when restricting the sample to the richer provinces only (Table 4).

Table 2 Estimation results using waste generation as a dependent variable.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
lva	0.6782***	33.106	0.5965***	0.5672***	0.5558***	0.5646***	0.4798***	0.470***	0.4803***	0.4734***	0.4806***
lva2		-0.1354									
ltottourism			0.0955***	0.0850***	0.0819***	0.0844***	0.0759***	0.074***	0.0760***	0.0753***	0.0757***
lpopdens				0.3355**	0.3405**	0.3306**	0.3317**	0.312**	0.3341**	0.3027**	0.3355**
lincinerated					0.0049						
lnrinc						0.0277**	0.0282**	0.031***	0.0280**	0.0279**	0.0281**
lnrdisc							-0.025***	-0.025***	-0.026***	-0.025***	-0.026***
llandfilled								-0.003			
TAR-MUN									-0.0000		-0.0000
TAR-POP										0.0001	
llandfilltax											0.0012
N	1030	1030	1030	1030	1030	1030	1030	1030	1030	1030	1030
MODEL	FEM	FEM	FEM	FEM	FEM	FEM	FEM	FEM	FEM	FEM	FEM

*Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at 5% and 1% level respectively.*

Table 3 Estimation results for geographic macro-area using waste generation as a dependent variable

	I (NC)	II (NC)	III (NC)	IV (SI)	V (SI)	VI (SI)
lva	0.5549***	0.5507***	0.5563***	0.3446*	0.3398*	0.3426*
ltottourism	0.0284	0.0270	0.0245	0.1276**	0.1289**	0.1283**
lpopdens	0.4001***	0.3595***	0.4120***	0.2222	0.2084	0.2396
lnrinc	0.0315**	0.0332**	0.0322**	0.0250	0.0253	0.0269
lnrdisc	-0.0211	-0.0200	-0.0229	-0.0275**	-0.0259**	-0.0273**
TAR-MUN	-0.0001		-0.0001	0.0002		0.0002
TAR-POP		0.0000			0.0006	
llandfilltax			0.0084			-0.0188
N	670	670	670	360	360	360
MODEL	FEM	FEM	FEM	FEM	FEM	FEM

*Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at 5% and 1% level respectively.*

Table 4 Estimation results for those provinces that have an added value of more than € 23,000. Dependent variable: waste generation.

	I	II	III
ltottourism	-0.0394	-0.0396	-0.0403
lpopdens	0.6672**	0.5700**	0.6704**
lnrinc	0.0391**	0.0444	0.0390**
lnrdisc	-0.0152	-0.0140	-0.0153
TAR-MUN	-0.0004		-0.0004

	I	II	III
TAR-POP		-0.0001	
llandfilltax			-0.0034
N	159	159	159
MODEL	FEM	FEM	FEM

*Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at 5% and 1% level respectively.*

3.3 Recycling drivers

Firstly, we can see that added value is a statistically significant driver of recycling, but its effect is non linear, as confirmed by the statistical significance of the squared term of added value. Beyond a certain threshold the income effect is not enough to promote recycling, and other factors play a role.

Moreover, regression results confirm the effect of tourist flows and recycling; local systems relying on tourism tend to reduce landfilling, as additional opportunity costs may arise and negative externalities could affect the business. On the contrary, despite our expectations, population density does not seem to be a significant driver of recycling activity.

Policy variables have the expected sign, because we can see that both TIA and the landfill tax are positively linked to recycling. By increasing the price of using landfills the tax is able to promote its primarily technological substitute, i.e. recycling, and consequently it is able to promote separate collection. With regards to the TIA, we may conclude that this result confirms the research hypothesis in which the Italian tariff constitutes an economic incentive to promote separate collection, because its structure includes tax breaks for those people who reach a certain amount of separate collection.

Observing Table 5, which illustrates estimates for every geographic macro-area, we can see that the main results are confirmed. In fact, added value, its square and tourist flows present the same sign as the previous analysis. Policy variables positively affect separate collection in Northern and Central Italy, confirming previous results, but this relation does not exist in the Southern sub-sample. Moreover, as highlighted in Table 7, the main regression results are robust even when restricting the sample to rich provinces, where landfill tax and TIA confirm their role as a primary drive for separate collection.

Table 5 Estimation results using recycling as a dependent variable.

	I	II	III	IV	V	VI	VII
lva	8.208***	172.613***	179.542***	194.401***	184.767***	194.525***	184.313***
lva2		-8.459***	-8.868***	-9.646***	-9.154***	-9.674***	-9.126***
ltottourism			1.184***	1.101***	1.123***	1.087***	1.079***
lpopdens				2.944			
TAR-MUN					0.006***		0.007***
TAR-POP						0.007***	
llandfilltax							0.202***
N	1030	1030	1030	1030	1030	1030	1030
MODEL	FEM	FEM	FEM	FEM	FEM	FEM	FEM

*Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at 5% and 1% level respectively.*

Table 6 Estimation results for geographic macro-area using recycling as a dependent variable

	I (NC)	II (NC)	III (NC)	IV (SI)	V (SI)	VI (SI)
lva	74.528**	66.708*	79.802**	298.356***	309.604***	274.002**
lva2	-3.595**	-3.180*	-3.859**	-15.169**	-15.755***	-13.870**
ltottourism	0.734***	0.798***	0.678***	1.316**	1.316**	1.300***
TAR-MUN	0.007***		0.007***	0.006		0.006
TAR-POP		0.008***			0.001	
llandfilltax			0.149***			0.449*
N	670	670	670	360	360	360
MODEL	FEM	FEM	FEM	FEM	FEM	FEM

*Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at 5% and 1% level respectively.*

Table 7: Estimation results for those areas that have an added value of more than € 23,000. Dependent variable: Recycling.

	I	II	III
ltottourism	0.4260	0.7573	0.4406
copoptar	0.0088***		0.0091***
copcomtar		0.0092***	
llandfilltax			0.1729***
N	159	159	159
MODEL	FEM	FEM	FEM

*Cluster-robust standard error, Cluster unit: Region. **,*** indicate significance at 5% and 1% level respectively.*

4 Conclusions

In order to enrich the recent literature which has analyzed the role of waste management and policy instruments within the more specific realms of environmental and regional economics, we test implications that derive from the introduction of the multi-tasking principal agent model into the waste realm. We especially focus on waste generation, waste management (separated collection) and disposal issues.

We analyse the Italian environment given the richness of policy implications and data availability, by using the multi-tasking model which treats the case in which the principal assigns two tasks to the agent.

We demonstrate that providing incentives for only one activity assigned to the agent can entail a reallocation of the total effort and attention s/he devotes to all activities. In fact, the model will conclude that when it is difficult to effectively measure performance in every activity, it could be convenient and desirable not to fix incentives. In fact, providing incentives will encourage reaching high levels of performance only in the most well-compensated task. This is relevant when we address the key current management policy issue in European (and beyond) contexts: the achievement not only of increasing recycling and landfill diversion targets, but of waste generation reduction per se. The latter is in fact at the top of the waste hierarchy, though most policy interventions have triggered performances at other layers of the system, namely management and disposal. Real (absolute) decoupling, namely higher resource efficiency and productivity (the latter intended as same/more value obtained with less material inputs) can in the end be obtained through waste generation reduction.

This is a new pillar of the EU policy, which has introduced since the new Waste framework Directive was implemented. It entails the formulation of new policy schemes, coherent with the definition of the EU as a 'Recycling society'.

Our evidence further supports the idea that current policy efforts, though have often been effective to increase recycling and reduce landfilling, are uncorrelated to the main target of waste reduction at source. They have not provided incentives even through indirect mechanisms. This is also scope for further research. Not only landfills and incinerators, but also recycling options can generate sub optimal lock in waste management systems, in the sense they prevent the economic-policy system from moving towards less production of waste. This can happen by radical transformations of production and behavioural attitudes, that include technological and organizational innovations.

In addition, Italy is to any extent a much decentralized country, which shows peculiar differences and divides from economic, social and economic perspectives. We thus analyzed the achievement of multiple policy targets by exploiting the rich regional dataset. When observing results by geographic macro-area, we can conclude that the policy variables present the same results as the aggregated estimates. Therefore, the multi-tasking problem also emerges if we consider the local specificities of different Italian areas.

In a nutshell, neither the 'new' waste tariff introduced in 1999 nor the landfill tax introduced in 1996 are statistically significant drivers of waste generation, which should be the first objective for a waste management and policy. The tariff, though it presents some Pigouvian contents related to bio-food management, is not a "punctual tariff" related to waste generated by a family. It cannot constitute an economic incentive to reduce waste. This is an important message meanwhile the Parliament is designing through a fiscal bill the new waste tariff, which should present more pigouvian contents.

5 Acknowledgement

We gratefully thank our friend and colleague Susanna Mancinelli for her brilliant theoretical ideas and comments, which always aims at bringing together theory and empirics in a meaningful way

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