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

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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

JEL: Q53; R11; K42

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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at all levels of waste management, thanks to which traditional waste disposal technologies, such as landfilling, have been replaced by recycling and, to some extent, incineration.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[3] 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. 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 8 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

[3] 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).

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 et. Al (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.

[FIGURES 1 - 5 ABOUT HERE]

2. Multi-tasking Model

We analyse Italian waste management using the multi-tasking model (Holmstrom, Milgrom, 1991). It represents an extension of the traditional principal-agent model, and it treats the case in which the principal assigns two tasks to the agent (therefore, we overcome the classic dissertation where the agent has to execute only one task). We also assume that the costs for the agent only depend on the total attention and effort that he has to devote to the different tasks at hand.
We will 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.
We consider a principal-agent relationship where the agent chooses a vector of effort t = (t_1, ……, t_n), which entails a cost, C(t). There is a direct relation between the principal's wealth and the effort devoted by the agent to his tasks, in fact t leads to a benefit for the principal that is B(t)[4].
We also assume that r measures the agent's risk aversion, while the principal is risk neutral.
We are in a situation where there is asymmetric information, for which the principal is not able to perfectly observe all aspects of performance carried out by the agent. For this reason, we introduce an economic concept that permits us to overcome this problem in part. We refer to signaling, and

[4] We also assume that the cost function is convex, whereas B(t) is concave.

we assume that the agent's effort generates information for the principal, which is expressed by the following signal:

$x = \mu(t) + \varepsilon$

The contract between the principal and the agent sets a wage that is a function of the information signal, because the principal bases the amount of compensation to assign to the agent on observable performance. The wage is $w(x) = w(\mu(t) + \varepsilon)$

In particular, the contract signed between the principal and the agent in this model contains a payment that is linked to the measured performance. We have assumed symmetric information between the two parts, therefore we consider the case in which the different activities assigned to the agent are measured with different degrees of precision. In fact, we assume that the levels of performance obtained in one of the two activities are not effectively observable by the principal.

At this point, we can introduce the agent's utility:

$U(CE) = E\{U[w(\mu(t) + \varepsilon) - c(t)]\}$ where:

- $w(\mu(t) + \varepsilon)$ is the wage;
- $c(t)$ is the agent's cost linked to the effort.

Under this hypothesis, the expected net benefit for the principal is $B(t) - E\{w[\mu(t) + \varepsilon]\}$, that is the difference between the gross benefit and the wage that the principal will have to assign to the agent.

If we introduce the linear compensation rule, namely $w(x) = \alpha^T + \beta$, we can write the agent's certainty equivalent as:

$CE = \alpha^T \mu(t) + \beta - c(t) - \frac{1}{2} r \alpha^T \Sigma \alpha$, where:

- $\alpha^T \mu(t) + \beta$ is the expected wage;
- $c(t)$ is the cost;
- $\frac{1}{2} r \alpha^T \Sigma \alpha$ is the risk premium, namely it is the variance of the agent's income.

At this point, under this linear scheme, the expected net benefit for the principal is:

$B(t) - \alpha^T \mu(t) - \beta$

and the total surplus derives from the sum between the surplus of the principal and the agent:

$B(t) - c(t) - \frac{1}{2} r \alpha^T \Sigma \alpha$.

Now we can see that the intercept β is only important in allocating the certainty equivalent between the principal and the agent, in fact it does not appear in the total surplus.

At this point, we may note that the optimum contract has to maximize the certainty equivalent between the constraints regarding the effort t, and the incentive α, and, in fact, we have to solve this problem:

$$\underset{t,\,\alpha}{\text{MAX}} \quad B(t) - c(t) - \tfrac{1}{2} r \alpha^{T} \Sigma \alpha \qquad (1)$$

$$\text{subject to} \quad t \text{ maximizes } \alpha^{T} \mu(t') - C(t') \qquad (2)$$

At this point we can see that according to this scheme, the intercept β that will allocate the total CE between the two parts is:

$$\beta = CE - \alpha^{T} \mu(t) + C(t) + \tfrac{1}{2} r \alpha^{T} \Sigma \alpha$$

At this point we can introduce another important hypothesis that renders the multi-tasking model different from the traditional principal-agent model: in this model economic incentives fixed by the principal also are important in allocating the agent's effort and attention between the two tasks. In fact, now we assume that the agent's attention and effort are a homogeneous input that s/he can allocate to different tasks, and we study what logic and reasoning the agent follows in making this decision. The fact that the amounts of effort dedicated to these activities are perfectly substitutable in the agent's cost function is another pillar of the model.

We assume that the agent is not adverse to the effort, and in fact $\bar{t} > 0$ exists so that $C'(t) \leq 0$ for $t \leq \bar{t}$ and $C(\bar{t}) = 0$. It means that contracts with fixed wages could entail an effort as well. We suppose that the principal assigns two activities (1, 2) to the agent, who has to devote to them two different degrees of attention and commitment, t_1 and t_2, but we also assume that the total measured quality is mono-dimensional, namely $\mu(t_1, t_2) = \mu(t_2)$ and $x = \mu + \varepsilon$.

The total quality is composed of the levels of performance reached in all the activities: therefore there are different aspects that compose the quality observed by the principal. In particular we suppose that some of these aspects are measurable and are increased by the effort (t_1) on the first activity, and other aspects are not measurable but are increased by the attention (t_2) devoted to the second one. Therefore, we can see that a direct relation always exists between effort and final performance level reached by the agent.

The wage under the linear compensation scheme is:

$S = \alpha x + \beta$

and the profit is a function both of t_1 and t_2, namely $B(t_1, t_2)$. Also, $B(0, t_2) = 0 \ \forall \ t_2 \geq 0$.
The model states that in this case the optimal compensation scheme entails no incentives and a fixed wage only.

We demonstrate this by analysing three cases:

- $\alpha = 0$, in this case the agent chooses $\bar{t}$ so that $C'(\bar{t}) = 0$ and s/he chooses $\bar{t}_1 \in [0, \bar{t}]$ with the purpose of maximizing $B(\bar{t}_1, \bar{t} - \bar{t}_1)$[5]. Since there are no incentives, the contract does not have variable payments so that the agent's risk assumption is zero and the total profit is $B(\bar{t}_1, \bar{t} - \bar{t}_1) - C(\bar{t})$. In fact, we can see that there is no risk premium due to the absence of income variance.

  In particular, with a fixed wage only, profit is a function of $\bar{t}_1$ and the residual attention that the agent devotes to the second activity. As a consequence, this contract induces the agent to devote a certain amount of effort to both tasks.
- $\alpha > 0$, in this case $t_1 = 0$, and the total profit is $0 - C(\bar{t}) - r\,\alpha^2\,\sigma_\varepsilon^2 / 2$, where σ_ε^2 is the error variance, namely the possibility that the measurement process can be subject to some distortions. We can see that profit is less than $C(\bar{t})$ and therefore this profit is also less than the profit found in the previous point. In this case, the agent is not encouraged to work hard at the first activity because it is not measurable, and s/he will thus focus on the second one, which is observable and well-compensated[6].
- if a < 0 then $t_2 = 0$ and $t_1 < \bar{t}$ since $C'(t_1) < 0 = C'(\bar{t})$. At this point, the third profit is $B(t_1, 0) - C(t_1) - r\,\alpha^2\,\sigma_\varepsilon^2$, which is less than the profit found at the first point. If negative incentives are set, the agent will focus on the non-measurable activity t_1, in order to avoid them.

Therefore we can see that the highest profit is to be found at the first point where incentives were not set.
From this analysis we may conclude that when one of the two tasks assigned to agents by the principal is not observable with an elevated degree of precision, it could be advisable not to fix incentives. 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. In this way, the total quality observed

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[5] This expression is positive because we have assumed that $\bar{t} > 0$.
[6] In fact, we have assumed that the amount of profit reached with only attention t_2 will be equal to zero.

by the principal will decrease. Also, 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 only on well-compensated activities.

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[7].

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. 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 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.

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.

[7] Hereafter referred to as ‘separate collection’.

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[8]. 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

[8] 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.

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.

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:

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

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 ABOUT HERE]

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 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).

[TABLES 2-4 ABOUT HERE]

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.

[TABLES 5-7 ABOUT HERE]

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 nut shell, 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.

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

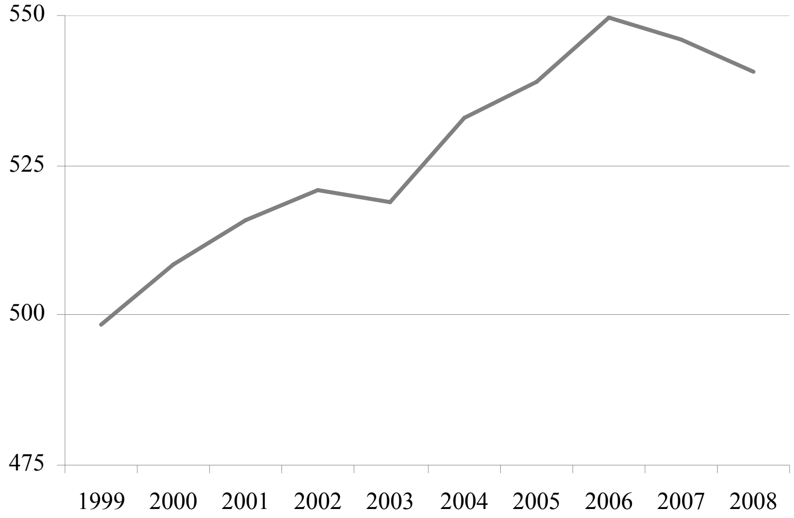


Figure 2: Italian waste disposal options trend, year 1999=100.

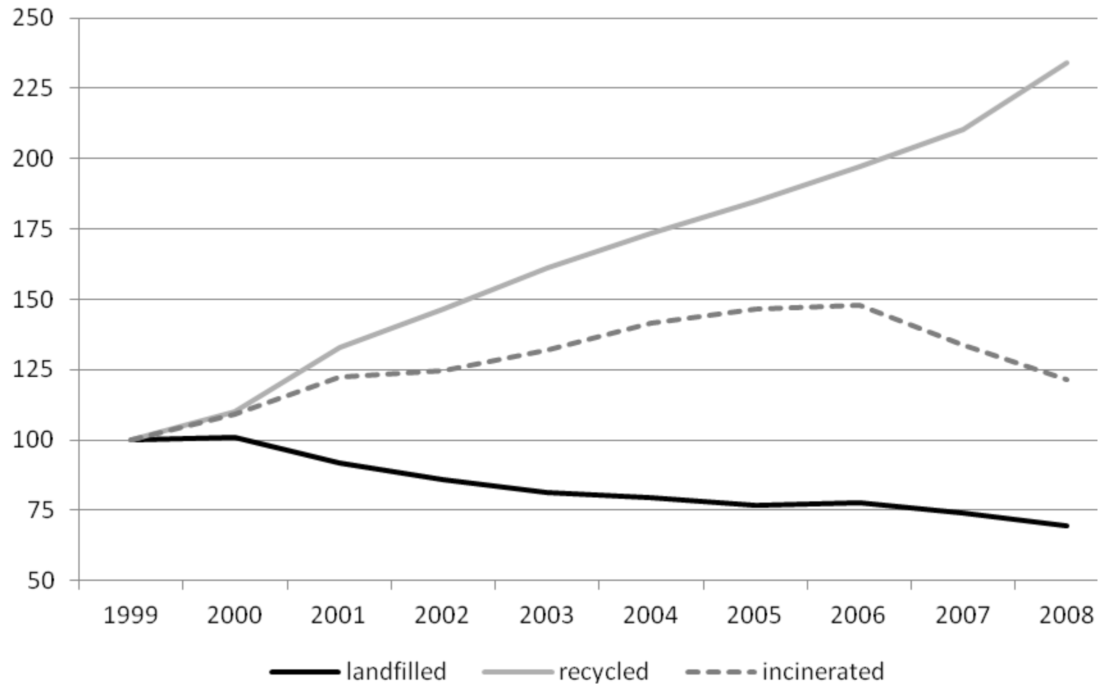


Figure 3: Landfilled waste – regional comparison (Kg) in 2008.

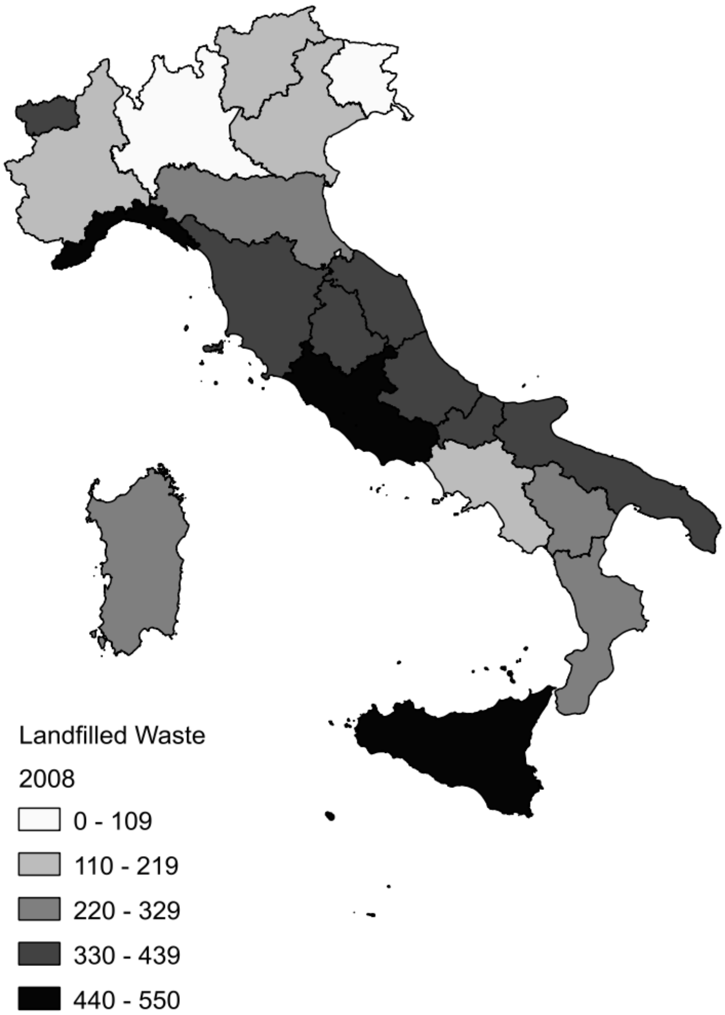


Figure 4: Recycled waste – regional comparison (Kg) in 2008.

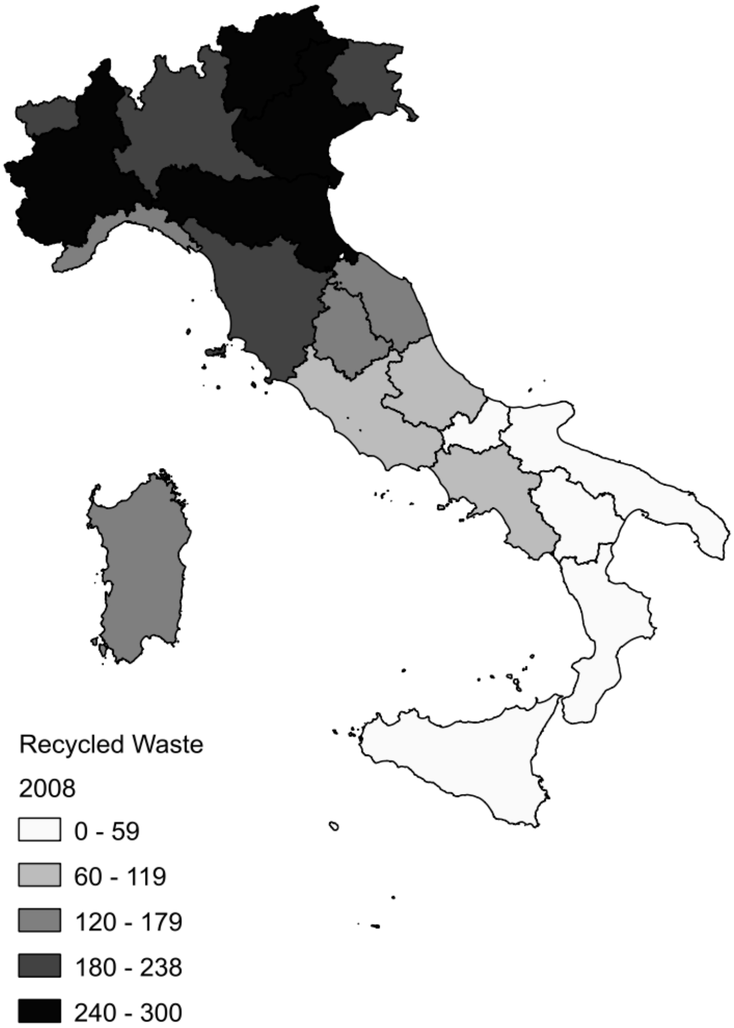
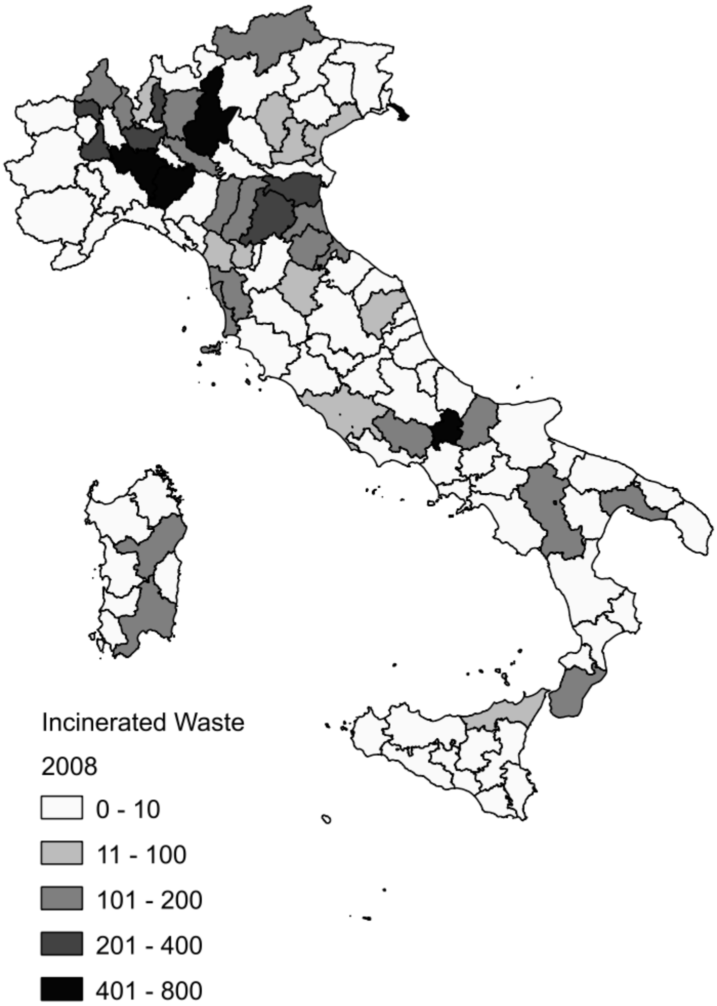


Figure 5: Incinerated Waste – provincial comparison (Kg) in 2008.



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
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

Table 1: Descriptive analysis and research hypothesis

Table 2: Estimation results using waste generated 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							-0.0259***	-0.025***	-0.0260***	-0.0254***	-0.0260***
llandfilled								-0.003			
copcomtar									-0.0000		-0.0000
copoptar										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**
copcomtar	-0.0001		-0.0001	0.0002		0.0002
copoptar		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.

	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
copcomtar	-0.0004		-0.0004
copoptar		-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.

Table 5: Estimation results using waste generated 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			
copcomtar					0.006***		0.007***
copoptar						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***
copoptar	0.007***		0.007***	0.006		0.006
copocomtar		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

	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.