Waste Management beyond the North-South Divide: Spatial Analyses of Geographical, Economic and Institutional Dimensions

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Abstract

Many advanced countries have been experiencing waste crises, namely a failure to properly collect and separate urban waste, difficulties regarding both the management landfill sites close to or beyond their full capacity, and the collocation of landfills and incinerators in the territory. These crises appear to be primarily driven by policy failures that include delays in introducing more economically-oriented instruments and a lack of new and diversified tools in waste management and disposal facilities. Italy has been and is a premier case study, with major crises appearing in its less-developed South. Though the North-South divide is a core part of other Italian 'convergence failures', we believe nevertheless that other forces and dynamics play an important role. The main research question is to assess whether it is truly just a North-South divide that largely explains the heterogeneous waste management and disposal performances inside Italy, or whether, a different type of geo-clustering becomes apparent, which depends more on the quality of waste policy and idiosyncratic socio-economic factors. On the basis of a 2000-2008 dataset that covers 103 provinces over a wide range of information on waste management, socio-economic, structural and policy features, we aim at identifying 'economic and institutional waste models' by grouping the performances of provinces over time and space. The dynamic evolution of clusters allows for an analysis of how the system performance has evolved, as well as what weaknesses and strengths in terms of 'waste management/policy models' may exist.

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KEYWORDS: municipal solid waste, waste management, waste policy, cluster analysis.

1. The Economics of waste in spatial and decentralised policy settings

Many advanced countries have been experiencing crises in their waste systems, characterised by hot spots for lack of disposal capacities and deficiencies within separated waste collection and recovery, resulting in detrimental effects on human health, environmental quality, and the general quality of public life in urban settings. As has been clarified by theoretical and empirical investigations within the 'economics of waste' (Kinnaman, 2006, among others, addresses key issues in waste management and urban waste recycling that are thematically relevant in our analysis[3]), these crises appear to be mainly driven by policy failure, a lack of new and diversified investments in waste management and inadequate disposal facilities. The European Environment Agency has analysed the extent to which EU countries have complied with EU policies (EEA, 2009). Bad waste management and disposal performances are often related to a high use of landfilling and a low amount of separated recycling collection. The latter is a key driver for improving both recovery (composting, material recovery) and disposal (incineration, landfilling), and is potentially linked to energy recovery. Waste management policies are behind the success of waste systems, which are otherwise almost totally driven by 'social capital' and market forces. These may or may not be sufficient and effective in determining successful waste management, namely compliance with targets determined by sanitary issues and/or cost benefit economic considerations which include externalities accounting.

Italy is a major case study with some 'crises' regarding municipal solid waste (MSW) that have occurred in Naples, Sicily and, more recently, even touched on Rome and the region of Lazio[4]. In addition, Italy has been increasingly decentralised over the years, mainly through a constitutional reform in 2001 that delegated key responsibilities to regions regarding environmental policies (Mazzanti and Zoboli, 2013).

One feature of such waste-related crises –economic and social in their nature - is that they are often regional in nature. This creates complications when evaluating a given country's waste performance. Waste management crises present a strong degree of embeddedness with environmental performances in both geographical, economic, institutional and policy dimensions. Local factors dominate over national policies in many countries. The occurrence of crises is strictly linked to the convergence (or divergence) of sub-national units in terms of economic and environmental performances. Within this evolution, it is also likely that different waste management 'models' emerge, surrounded by different socio-economic and policy features. In a decentralised spatial setting, many models can come to light and evolve, either attracting new 'units' or dividing themselves towards the formation of new models. In the end, a nation's performance is driven by the hidden evolution of sub-national clusters, whose units spatially interact. Here we thus aim to shed some light on aspects lying under the national surface.

The waste crisis that has primarily affected some southern regions of Italy in the last decade (D'Alisa, 2010), together with strikingly different environmental and economic performances

[3] The same do key works such as Fullerton and Kinnaman, 1995; Shinkuma and Managi, 2011, Pearce and Brisson, 1995; Mazzanti and Montini, 2008, among others.

[4] By 'crises' we intend the occurrence of critical local hot spots whose effects have found space within international broadcasting and media. Though the overall performance of the country witnesses increasing shares of separated collection and incineration and strong landfill diversion even in the South, the accumulation of institutional failures and the lack of waste reduction have "locked in" with respect to waste management and disposal performances in some areas. This lock-in becomes a 'crisis' to the extent that waste collection cannot keep the pace of waste generation and landfill site capabilities are exhausted. The reasons behind such crises are manifold. Among others, we mention the lack of necessary diversification in disposal options (e.g. only landfiling, and the monopolistic power of landfill owners as in the case of Rome), insufficient separated collection, insufficient reduction or mitigation of waste generation and a 'NIMBY' attitude towards incinerators and new (emergency) landfills. Crisis occurs when the waste system is not able to allow garbage to flow from collection to final disposal and waste streams are stuck at some step. Often a share of the garbage is exported to other regions or countries – at high costs - to mitigate its local effects in the short run. Illegal activity, attracted to the profits/rents that derive from managing waste in a social crisis must be added to these factors. Thus, institutional, policy and technological failures support the action of the criminal world.

between areas within the country, has created problems both regarding the management of local 'hot spots' (Pasotti 2010 and 2009 for an institutional analysis of Naples) and for the positioning of waste disposal infrastructure (Jenkins et al., 2004). State and market failures were both present as pre-conditions of such ongoing crises. This partially unresolved situation calls for a deep investigation of the drivers of waste performances and management choices vectored through a new spatial view.

In fact, if on the one hand the nation can survive local crises and still present good average figures, the presence of hot spots generates both unequal and inefficient outcomes. Through this dynamic, it is likely that such crises tend to assume irreversible features at the local level. Issues of environmental federalism are greatly at stake here. As Oates (1999) states: 'the issue is not a simple one of centralization versus decentralization of environmental management. Our governmental systems consist of several levels, and it is clear that there are important roles for nearly all levels of government in environmental protection. The issue is one of aligning specific responsibilities and regulatory instruments with the different levels of governments so as best to achieve our environmental objectives. Thus, it is true that circumstances differ and we should take advantage of the opportunities provided by decentralization. We point out nevertheless that taking into account the costs of hot spots is crucial. In this contribution we aim at highlighting expected and unexpected hot spots in Italy. In this way, policy makers will have the opportunity to target these areas with this acquired knowledge of the underlying socio-economic and policy factors.

Though the 'North-South Italian divide'[5] is surely a core part of the issue of waste and other economic-environmental 'convergence failures' (see Mazzanti et al., 2012 for analyses on spatial and convergence issues around waste performances in Italy), we believe that other forces and dynamics cannot be overlooked. For instance, the process of policy decentralisation that has characterised many good public provisions, which delegates competencies to regions and provinces (e.g. mainly for waste tariff and landfill tax implementation), is a key factor behind waste performances. Within larger autonomous spaces, different provinces can achieve different performances, by either imitating or differentiating themselves from neighbouring agents. This development is relevant for waste and can well explain different performances, reaching beyond the simplistic north south divide.

Several recent works concentrate on waste generation and disposal drivers, focusing in particular on the analysis of regional frameworks (Ham, 2009, Hage and Soderholm, 2008; De Jaeger and Eyckmans, 2008, Dijkgraaf and Gradus, 2009), and enrich the more usual analyses of waste performance determinants (Mazzanti and Zoboli, 2009; Johnstone and Labonne, 2004: Mazzanti et al., 2008). Within regional analyses, spatial issues flourish (see the collection of works in D'Amato, Mazzanti and Montini, 2013), both related to international/trade (Kellenberg, 2009, Baggs, 2010, D'Amato et al., 2012) and local (Yamamoto et al., 2011; Mazzanti et al., 2012) issues.

We here investigate the local aspect of the spatial arena, given both the more limited evidence available and its relevance for understanding ongoing regional waste crises.

Our main research questions are twofold: (i) to assess whether it is really just a North-South divide that mainly explains the heterogeneous municipal waste management (MSW) and disposal performances inside Italy, or whether a different type of geo-clustering may be illustrated, which depends more on the quality of waste policy, as well as factors related to crime intensity, to tourist pressure and social capital among other things; (ii) to examine the role of spatial issues and the

[5] The divide is historically defined in terms of GDP per capita and indicators of development, including social capital. The GDP per capita in 2009 was 30,409€ in the northwest (where Milan and Turin are located), 29,966€ in the northeast (where Venice and Bologna are), 27,924€ in the centre (Rome) and 17,366€ in the south. The poorest Italian Region is Calabria (16,534€), the richest Valle d'Aosta (34,099€). Though many countries present significant regional divides, we note that the economic divide is not being reduced by economic and industrial policies and it correlates to the environmental performance divide. This demonstrates that economic and environmental performances do not belong to isolated realms but are part of the same dynamic (Costantini et al., 2013). Due to the commented decentralisation policy, waste is a primary area where institutional and environmental divides are prominent.

spatial decentralisation of waste management 'policy' as a fundamental element in waste performances, namely in the separated collection of waste - the aspect that presents the most striking north south divide (see Figure 1).
An ever-increasing generation of waste (see Figure 2) is the key problem: in association with its reduction, waste separation is crucial to enhancing its management and disposal.

On the basis of our past analyses and on the results of other works in the economics of waste literature, we expect to find various clusters, namely 'models' of waste management, that go far beyond the north south divide. Secondly, we expect spatial phenomena to represent a central feature for recycling performances of Italian provinces. It is difficult to formulate an ex ante hypothesis regarding spatial correlation: if, on the one hand, a clear cut north-south divide is to some extent coherent with positive correlations at local level, the presence of different clustering may also lead to negative types of correlations (e.g. lower than average performances of some provinces in the North, as well as above average performances in the South. One such anecdotal case study is represented by the Salerno province next to Naples).

Thus, we intend to provide original insight into the above-mentioned literature through spatial waste analyses. We concentrate on clustering waste, policy and socio-economic factors at a highly decentralized level (e.g. the province). Clustering techniques are able to dig out non-evident patterns, which we believe could show interesting evidence beyond the north-south divide 'at first sight'. We compare the provincial clustering across different years from 1999 to 2008 to assess the evolution and dynamics of socio-economic and institutional-policy settings over a period of increased decentralisation. For clarity and brevity we only comment on 3 years: 2000, 2004, 2008. However, other analyses are available. This facilitates the understanding of possible cluster changes depending upon variations in the economic, policy and waste indicators of provinces.

We aim at clustering Italian provinces, despite their geographical proximity, on different 'models' of waste management and related performances. Thanks to the rich panel datasets, we can observe the variation of clusters over time as well.
The attention given to the 'evolution' of economic and waste management models in a space framework touches on the relatively new but very relevant issue of 'spatial sustainability'. Coenen et al. (2012) have very recently stressed that the diversity in transition processes follows from a natural variety in institutional conditions, networks, strategies and resources across space. They claim that explicit sustainability transition geographies are to be analysed by taking into account two interrelated problems: the institutional embeddedness of socio-technical development processes within specific territorial spaces, and an explicit multi-scalar conception of socio-technical trajectories. Economic geography thus meets the economics of waste. An interesting analogy is between 'national innovation systems' and 'national waste systems'. Even though 'national systems' provide specific insight into how different performances are generated in different contexts due to idiosyncratic factors (beyond the space/institutionally free neoclassic economics), in both cases there is a need to deepen the spatial flavour of the analysis (Coenen et al., 2012).
The achievement of a reduction in waste generation, as well as a high level of material recovery and essentially landfill-free environments is to be a considered a radical type of sustainability transition path over the next 30 years, similar to – and included in - the decarbonisation of the economy.
To our knowledge, this is the first spatial analyses regarding separated collection of waste (recycling) that exploits continuous data covering an *entire relevant* OECD country (Yamamoto et al., 2011 use dummy variables and focus on a region of Japan). We additionally and originally exploit the material composition of separated collection: glass, plastic, organic, paper and metal.
This analysis thus extends the investigation of waste performance drivers to a proper analysis of 'spillover-related drivers' that have been studied for years in areas such regional economics, geography of innovation. These spillovers are related to waste management, waste disposal,

institutional quality, economic performances, structural conditions of contiguous or close provinces. The administrative unit is thus not 'alone', but analysed as encapsulated in the spatial environmental-economic setting. We thus aim at providing points for reflection at policy and methodological levels.
This contribution is structured as follows: Section 2 describes the sources of data and the main variables we may use in the analysis, Section 3 comments on the clustering investigation and Section 4 concludes.

2. Data sources

This analysis builds on the yearly editions of ISPRA environmental agency waste reports as data sources (formerly known as the APAT, National Agency of the Environment - APAT, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009). These reports provide a very rich set of waste management and disposal data, including data on MSW that has been recycled and landfilled, data on the implementation of waste management policies, such as the introduction of the new waste tariff which follows a 1999 Bill. All Italian Provinces (103) are covered over the 1999–2009 period. We concentrate on 2000-2008 given possible idiosyncratic statistical facts occurring after the economic downturn in 2009. We merged this waste data with official data on provincial level socio-economic drivers, such as value added, as a proxy of provincial income, population density and tourist attendance, which become a crucial factor considering that these add opportunity costs to the effects of density. Waste performances differ widely among Italian provinces, making a provincial level of analysis desirable. Though northern Italy is rapidly evolving towards a high level of recycling, which peaks at around 75% in some provinces, the average figure for the country is still dominated by landfilling. Nevertheless, even some northern regions suffer from landfill criticalities given the increasing land scarcity in physical and economic terms (opportunity costs) and the non decreasing stabilized trend for waste generation. It is clear in this setting how an 'average' national picture is insignificant in providing clear evidence.

It is worth briefly reflecting on the nature and contents of the main variables, referring to table 1 for a summary. Waste indicators (namely MSW, generation of municipal waste, RECPERC, separated collection of MSW, in total and by material; Incinerated and landfilled waste) are introduced in *per capita* terms. Other socio-economic factors are population density (DENS) and tourist attendance (TOURPOP). Population density may control for different land values (we assume here that in more populated areas the opportunity cost of land is higher, which would explain the closure of the Milan landfill jointly with sanitary problems), and it may control for the presence of agglomeration and scale effect. Tourist flows, on the other hand, control for different choices made by tourism-oriented municipalities, in which the amenity value of landscapes and the amount of waste totally generated may play an important role in waste management. Waste management/policy-oriented proxies are captured by the share of provincial municipalities and the provincial population covered by the new 'waste tariff' regime, which substitutes the old 'waste tax' regime (COPCOMTAR in table 1). The new household waste management tariff (known as TIA) was introduced by Italian Law No. 22/1997, and in theory substitutes the former waste management tax. The tax, however, is still in force in many Italian municipalities because the Dlgs. 22/1997 (Decreto Ronchi) provides for a transition phase that has shown to be quite gradual and slow (Mazzanti et al., 2012). The former tax was calculated on the size of household living spaces, while the tariff is based on principles of full-cost pricing for waste management services and introduces some market-based incentives to the system[6]. Effective implementation of the tariff system remains highly dependent on local policy

[6] Part of the tariff covers fixed costs and part refers to variable management costs. The former correlates to the size of household living space and, as a new element, to the number of people in the family. The latter, the variable component,

decisions and practices, which is partly based on the choices made by the municipalities located within the provinces that coordinate waste regulations at the local level. Early implementations of the new tariff-based system, therefore, may be a sign of stronger policy commitment. We note that the current implementation status of the 'new tariff'[7] is heterogeneous, in terms of population covered and/or number of municipalities that have decided to promptly shift to TIA according to the law, even across areas with similar incomes and similar socio-economic variables. Other determinants have influenced the timing of this shift and transition phase. At a macro scale, the observed shift from the old 'non environmental' tax to a new tariff system[8], the TIA, with some intrinsic incentives to support waste reduction and recycling behavior, should allow for capturing the higher 'incentive effect' of the latter.

3. Clustering waste performances. Beyond the north-south divide towards a deeper understanding of waste management and disposal dynamics

This section investigates the agglomeration of Italian provinces through various clustering analyses. We aim to draw out 'models' of behaviour and performance regarding waste management and correlated factors that might, in our opinion, reach well beyond the simple north-south divide. We take a dynamic view, seldom used in clustering analysis, in order to depict the evolution of the socio-economic system. We analyse the evolution of clusters (their numbers and inherent contents) over time, taking the years 2000, 2004, 2008 as reference for reasons of conciseness[9]. Table 2 offers an intuitive insight on the content and evolution of such provincial clusters.

Evolutionary analysis is able to capture possible changes in the aforementioned 'models' due to policy and economic transitions which take place. It is of interest to policy makers to better understand where the system has 'failed', what the best 'models' are, and why and how they aggregate.

The aggregation of provinces into homogeneous units that results from the use of Cluster Analysis is investigated on the basis of the following factors: economic factors (value added), waste management and disposal factors (waste generation, separated collection/recycling, defined in total and by material – organic, plastic, paper, glass, metal – incinerated waste, landfilled waste), policy factors (waste tariff diffusion), socio-economic factors (volume of tourism, social capital – proxy by electoral turnout). See table 1 for descriptive statistics (referring to the year 2008).

Clustering procedures can be viewed as "pre-classificatory" methodologies, in the sense that the researcher has not exerted any judgment prior to partitioning the rows of the data matrix that represent the units. These methodologies allow for the identification of groups of individuals (or other statistical units) that are similar to each other but different from other individuals in other

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is associated with the (expected) amount of waste produced, which is calculated on the basis of past trends and location-related features. The variable component is abated by around 10–20% if households adopt domestic composting and/or join garden-waste door-to-door collection schemes. The tariff constitutes a structural break with respect to the old tax insofar as it presents incentives for landfill diversion and it should cover higher recycling costs. Most provinces that have introduced the new tariff system also increased the price level year by year.

[7] We observe that 2013 witnesses the introduction of a tariff that will turn over the TIA, the TARES (*Tassa Rifiuti e Servizi* or *Tributo comunale sui rifiuti e sui servizi*). It is to be effectively implemented in mid 2013. As it thoroughly defines the concept of full cost recovery of waste services, it will further increase waste tariffs, though at the moment it does not embody strong elements which pertain to 'economic instruments' (e.g. tariff correlated to waste produced); these may be introduced by municipalities through their delegated policy competences. One currently debated point is whether the tariff should cover 'indivisible' public goods such as road maintenance.

[8] We define it as a non environmental tax, given that it was merely and mainly calculated on the basis of the square metres of the house, thus resembling a property tax. Even though the TIA and the TARES present property tax features, the related bills contain normative elements for shaping them partially into an 'environmental economic instrument', as some incentive mechanisms are introducible.

[9] Analyses for all years are available upon request.

groups. Thus, initially it is assumed that some of the considered units are heterogeneous; that is, that "clusters" exist. Cluster Analysis has emerged in the literature as one of the most important tools in creating target groups, both in marketing and socio-economic fields. Similarities among statistical units in the same cluster could be used in ex-post analyses, or to target offers or policy interventions to the subgroups that are most likely to be receptive to them.

In this study we define clusters of Italian provinces in two ways. First, we exclude economic and social capital factors to focus on core waste performances. We then add the remaining two factors as proxies of socio-economic factors. As illustrated below, we will witness interesting similarities within the results.

From the methodological point of view, Italian provincial data has been elaborated through a two-step process. The first step consists of a principal components analysis to permit the identification of non-correlated components; while the second step comprises a cluster analysis on the first step principal components which allowed for cluster identification[10].

Four principal components represent almost ¾ (from 74% to 79%) of the overall variability in the entire set of elaborations for the years 2000, 2004 and 2008. The choice of the optimal cluster number occurring in the second step was based on a preliminary hierarchical procedure carried out on the 103 provinces in which the values of three statistics (pseudo F, CCC and pseudo T2) were considered. In this way, the optimal cluster number defined by the hierarchical procedure was introduced as exogenous data in the final clustering analysis with non-hierarchical aggregation (k-means procedure).

An easy and explicative lecture of the cluster profiles was based on the clusters' means of waste and socio-economic related variables.

3.1 Clustering waste performances: Dynamics, 2000-2008

We here follow the transition of the national context from the point of view of waste management and disposal, in which many regional institutional and economic models have been embedded over the past decade. It is worth recalling that 1999 marked the beginning of the reform that introduced a more economically minded new waste tariff with the potential inclusion of economic incentives (e.g. tariff reductions in the case of households which opt for composting activities[11] or in the case of households which bring some of their separated waste to specific drop-off points of collection named as 'ecological islands' (*isole ecologiche*[12])). Municipalities and provinces are also free to decide on infrastructural investment, disposal sites, and many other waste-related issues such as the waste collection systems. The national context is thus framed from the bottom up, under general national (and regional) legal guidelines[13]. We also note that provinces were already responsible for

[10] It is crucial to perform the cluster analysis on non-correlated variables/indicators. If highly correlated variables are used for cluster analysis, specific aspects covered by these variables will be overrepresented in clustering identification.

[11] There is also the EU Directive on landfill diversion dated 1999 and the incineration Directive in 2001, which set targets for future periods up to 2015 (Mazzanti and Zoboli, 2009; Mazzanti et al., 2012).

[12] "Ecological havens" are separated waste collection sites where separated collected waste brought by households is weighed, and, depending on this weight, households obtain a corresponding tariff reduction.

[13] In principle, the nation ratifies EU Directives, then delegates to regions the implementation of most environmental management and policy. Regions are free either to introduce general bills and further delegate actual implementation to lower government levels or to keep substantial implementation power.

managing many environmental issues at the time. Thus, waste management very likely represents one of the most decentralised aspects in the Italian 'federal' system.

Starting from the entire set of 103 Italian provinces, 4 clusters emerge in year 2000. We consider their performances relative to the national average of each variable. We therefore analyse the distance of each cluster from the average values considering a performance positive if the cluster has, for example, low levels for both the per capita MSW and per capita landfilled waste, and high values for incinerated waste and their share of separately collected waste.

In 2000, first, we observe a cluster composed of 54 units (C1 in table 2), which mainly contains southern provinces. It also includes 5 out of the 10 largest Italian cities (Rome, Turin, Naples, Palermo, and Genova) and all of the four autonomous provinces of Sardinia. Overall, it is a low level cluster in terms of performance; it leads only in landfilled waste.

The second cluster we comment on is composed of 42 provinces (C3), where northern and central provinces represent the cluster. Its features are more evident regarding comparative performances: high levels of municipal solid waste (MSW) generation, high volumes of tourism, high levels of waste incineration waste and higher than average tariff diffusion in the very first period of its introduction. In all probability, the last point and the exclusive geo-location of this cluster in the centre-north of Italy are the key issues to underline.

A third small 6-unit cluster (C4) includes some northern provinces which aggregate together and contains two of the autonomous provinces of Friuli Venezia Giulia (Trieste and Gorizia), which have special fiscal autonomy and an even greater number of delegated competences. Its performance is very good indeed: separated collection is above average, as is incineration. This is thus a pioneristic "incineration oriented" cluster that emerges in northern Italy where in some cases pionieristic investments in incinerators have been forced by high tourist flows (as a driver of low landfilling, Mazzanti et al., 2011).

Finally, the fourth cluster (C2) is represented by a single autonomous province (Bozen) that leads Italy with the best waste management and disposal model, according to the analysis of the distances of each considered variable to the national average since 2000.

As expected, we initially began to notice various trends and aggregations that offer insights beyond the north - south divide. This, then, represents the 'origin' of the systemic evolution we scrutinise.

Moving ahead four years to 2004, 4 clusters still appear.
A "good" cluster (CC2, the second-best cluster in 2004) is represented by 10 provinces (including Trieste, Bologna and Brescia) reveals some distinctive features: low landfilling, high tourist flows and high incineration as an alternative to landfilling. It is a medium 'recycling' oriented cluster but shows good properties and a specific 'management model'. It illustrates a positive link between tariff diffusion and separated collection, which is a key feature of well-performing waste management systems.

The third-ranked aggregation of provinces regarding overall MSW performances is that composed of 36 units (CC4), whose width can signal an average improvement of the national system. Here we observe 4 provinces in Emilia-Romagna, 9 provinces in Tuscany, 7 provinces in Lombardy and 6 provinces in Veneto. Turin, Florence and Milan are present in this cluster, though most provinces are related to medium-sized cities. We note a strict link between tariff and separated collection performances signalling that a certain province environmental stringency gives positive results. Landfilling is favoured over incineration as a disposal option.

Third, a 54-unit cluster (CC1) shows lower than average overall performances: high landfilling, further enriched by low tariff diffusion and low separated collection. It appears that the situation had not changed since 2000, apart from the absence of three Piedmont provinces (Asti, Biella and Cuneo), that shifted positively into the northern CC4 cluster.

We witness a final 3 province cluster with the best performance (CC3), apart from high MSW levels (forced in part by high tourist flows), where we find the virtuous province of Bozen together with Rimini and Venice.

The final 'equilibrium' the system reaches in 2008, almost a decade after the key policies were introduced is worth comment.

Five clusters define the 2008 situation (figure 3 represents the clustering maps for each considered year). The worst one is clearly represented by 42 (mainly southern) provinces (CCC1), with a notable reduction in number from the original 54 in 2000 and 2004.
The provinces comprising this cluster (including a few central/northern provinces such as Ancona, Ascoli Piceno, Macerata, Genova and La Spezia, as well as some big cities like Rome, Bari, Napoli and Palermo whose gap from the Italian average has widened instead of reduced since 2004) still show a very low rate of separated collection and a very high instance of landfilling. These provinces also have not invested much in incineration and in the slow transition towards the tariff.

The remaining centre-north provinces are distribuited into 4 clusters.
Cluster CCC5 represents the "Recycling North", 26 northern provinces together with three of the four autonomous Sardinian provinces and only one central/southern province (Teramo) with lower than average per capita MSW and a very high separated collected waste share. Quite interestingly, in this final year, both the northern provinces and a few southern (or islander) ones stay in the same, quite virtuous cluster. These have converged over time and now aggregate. Thus, an initial mixed north and south cluster with big cities (Milano and Turin) as well as medium-sized realities is emerging, showing a general national performance that has improved over time.

The small distinctive cluster CCC3 is comprised of 7 municipalities including medium-sized northern municipalities such as Trieste, Ferrara, Pavia and Brescia. It is an incineration-oriented cluster. We cannot distinguish a clear geographical bonding, but rather a similar 'institutional' model in dealing with waste issues in a proactive and innovative way. Waste generation is high as a result of high value added (income). This is addressed by high levels of incineration, as well as high levels of separated collection, which is correlated to strong tariff diffusion. The reaction to higher than average waste generation has not been landfilling. The diffusion of the new tariff system is at its peak in this cluster. Policy seems to matter.
The top recyclying and tariff-oriented North is led by two autonomous provinces (Bozen and Trento) and Venice, with make up the smallest cluster (CCC4).

Finally, the 21 provinces in cluster CCC2 constitute wealthy and high per-capita waste generators that are not pushing towards feasible and higher than current separated collected and incineration levels. Noteworthy is the inclusion of most of the region of Emilia-Romagna, where 6 out of 9 provinces appear in this cluster.

Italy is, then, to some extent divided into two when considering waste performances. Nevertheless, the dividing line does not resemble a crystal clear north-south socio-economic 'divide'. Other policy and institutional factors matter. The decentralised implementation of environmental policies, which is certainly characterised by processes of geographical 'imitation', has generated clusters of a

more diversified nature. This is a positive result if we focus on southern areas, where excellence can arise through appropriate waste management actions. It is also a warning for some more developed northern areas that present waste performances well below the 'standard' one should expect given their level of income and overall social performances.

The 2000 – 2008 evolution thus shows a substantially clear pattern. The original situation was characterised by a more restricted level of heterogeneity in performances than the final one, which, from the beginning, was mainly characterised by a north-south divide but with some exceptions. Since then, the evolution in performances has been reflected in some 'cluster adjustments'. Within a general improvement, testified by a notable reduction in the worst waste management and disposal performance cluster down to 42 units in 2008 (from an original 54), an increased divergence also seems to be part of this reality. Bad and good institutional economic models come up over the Italian geography. Spatial closeness is usually a relevant issue (for both autonomous smaller regions and larger regions) however it is not the significant factor.

3.2 Adding income and social capital into the picture: still a partial and mixed picture or a definite north-south divide?

We now include provincial value added and a proxy of social capital[14] into the set of factors, which have been cited often as a key issue in Italian economic and institutional development (Putnam, 1995). The aim is twofold. We first present a robustness check to the analyses we present in §3.1, while we observe whether the inclusion of such radical factors in regional development may recombine a clearer north-south type of divide. We refer to table 3 for a summary of results.

In 2000, 4 clusters appear (figure 4). One cluster is composed of only one province (Bozen). Bozen is a German-speaking province with some unique features (e.g. very touristic, very autonomous in policy and fiscal terms).

The other 3 clusters are as follows: The largest is a 51-unit cluster which is strongly based on southern provinces (S1). We do not see any northern units here. We thus observe that the introduction of the two aforementioned factors moves the picture back toward an image indeed more intuitively framed on north-south divides. This is in fact the largest southern oriented cluster, which also shows the worst overall waste performances at the beginning of the new century. It is of interest to observe whether or not this cluster may then react to national regulations and eventually split into various clusters or partly join others.

The best-performing cluster is, on the other hand, a niche-like 15-unit cluster (S2) which is highly consistent with what previous works on EKC in Italy found (Mazzanti et al., 2008). Wealthier provinces are those that perform better and might eventually achieve a turning point in waste

[14] Following the literature on social capital and regulations (Ng and Wang, 1993; Hettige et al. 1996), and social capital and development, with an historical emphasis on Italy as a case study (Guiso et al., 2006; Tabellini, 2010), we believe that social capital-cultural indicators may be a valid additional factor to explore.
We fruitfully exploit a 'social capital' indicator that is often used in regional studies: the share of electoral turnover. This is correlated to actions of local commitment to the provision of public goods (e.g.; policy actions), but not directly linked to waste performances. Provincial heterogeneity is striking in Italy. Even in the June 2011 national referendum, where citizens voted for/against environmental issues concerning the public good (water utility privatization, nuclear power), the voter turnout averaged 54%, with peaks of 65% in some northern regions and lower shares in some southern regions of around 50%. Even lower shares could be seen in rural areas with respect to some urban areas where the voters peaked at 70%. The February 2013 national elections presented significant variability as well: turnout ranged between 78 and 82% in principal northern regions, while in the south the voter numbers ranged between 62 and 75%.

generation. Venice is within this cluster with other northern provinces, 4 out of 9 of which are in the Emilia-Romagna region.

Another large cluster related to Lombardy-Veneto and the remaining part of Emilia-Romagna emerges (S4, 36 units). Very interestingly, this is a centre-north type of cluster which shows below average performances and detaches itself from the above-mentioned one. That is, provinces in the same affluent Regions may perform quite differently due to decentralised policy implementation. There is essentially an historical heterogeneity at a decentralised level, which the 'decentralised waste management policy' (the new tariff) of 1999 had insisted on and reinforced.

The year 2000 represents the beginning of a recent transition. We note that even though the inclusion of income drives a clearer north-south divide, differences remain. Firstly, it is of interest that within the same (wealthy) regions, even contiguous provinces tend to aggregate into different clusters, a signal that decentralisation matters at any rate. Secondly, very "good" niche clusters and "bad" southern-oriented and mixed clusters emerge out of the average poor performances. This is an expected starting point: overall WM&D performance is pretty gloomy, with some wealthier areas leading the way. The origin of the system resembles a typical EKC environment when we add income into the picture.

Let us observe what happened in the transition between 2000 and 2004, when most management and institutional changes should have taken place. Aggregation forces tend to play a role, given that the clusters now shrink to 4 with even more marked differences.
Two aggregations share the lead position in terms of units (41) and thus comprise about 80% of Italy.
The first (SS1) is the extension of the 51 unit southern-oriented cluster we observed before. Apart from Genoa, this is a southern-biased aggregation of provinces that share the worst waste and economic performances. A clear beginning of an EKC-type picture in terms of cluster analysis.
Then, the "rest of Italy" is a mixed average performance cluster that is especially characterised by high landfilled waste per capita and limited implementation of the tariff policy (SS2).
Two clusters with good performance are northern-biased clusters which show similar situations to those in 2000. We thus probably only observe further aggregation. Bozen, Rimini and Venice (SS3), for example, together represent a group of distictive areas where tourism and incineration levels are high, landfilling low and, importantly, tariff diffusion reaches the highest peak.
The best performances are nevertheless shown by the 18-unit (SS4) cluster of Lombardy and Veneto provinces that still are characterised by a joint high level of separated waste collection and high tariff diffusion, a key link in the development of performances we here comment on. It is worth noting that this cluster appears to expand on the small 5-unit "best" cluster we commented on above. Further aggregation around best practice cases appears to take place in northern Italy between 2000 and 2004.

Finally, using data from 2008 four clusters emerge (and again with the inclusion of the two socio-economic variables). A negative type of development that explains many of the critical aspects in Italian waste management is reflected in the extension of the southern-biased cluster to 45 units (SSS1). Practically half of Italy, then, is represented by similar, below-average performances. The odd additional drawback is that the cluster, which was entirely south-based in 2000, is now more mixed in nature: Rome and other Lazio provinces become part of it, as well as Trieste (north, near Slovenia) and Genoa-La Spezia in Liguria, (also northern). Laggard provinces extend in the general picture, and spread over the south, centre and north of Italy. It is alarming that the tariff in this cluster is only diffused at a rate of 6% of the municipalities in the province. Basically no improvement has been made compared to 2000; this means that the new policy has not been implementated. Its correlation to separate collection might explain in large part this lack of

development in waste performances. The north-south divide is perhaps more clear cut in this second exercise that adds income and social capital. Nevertheless, throughout the years we witness a contagion or a convergence of some northern areas to initially separated southern areas, which testifies to the more complex reality of waste policy effectiveness in Italy and in decentralised settings in general.

The provinces of an autonomous region that did not group in 2000 and now present amalgamation, are those of Trentino-Alto Adige (SSS4), a region neighbouring Austria. Both highly autonomous and wealthy provinces are within a cluster that shows very high tariff diffusion (90% vs. the 6% commented on above) and high collection rates for separated materials. This arises as an excellent 'model', which is probably not extendable given its strong peculiarity.

Two other models finally emerge in 2008 and are relevant to compare. The first is a set of 31 provinces in the north-centre that focus around Piedmont, Veneto, Lombardy and Friuli regions, including the cities of Milan and Turint. One could thus crefer to this as the 'north' model (SSS3).

The second in contrast revolves around the Tuscany and Emilia-Romagna regions (SSS2). For the first time in 2008, the provinces of the latter are not scattered around different clusters but amalgamate. In terms of the two large models that represent northern and central-northern Italy, the picture is not very clear cut. GDP per capita is very similar. The northern-biased cluster SSS3 excels in separated collection and landfilling performances, the central-nortern SSS2 in tariff diffusion (still only at 24% on average) and incineration.

Essentially(i) adding income and social capital has brought about a more evident north-south division, though (ii) throughout the development we can observe that some provinces in the north have joined the southern group, which shows worse average performances. The overall picture becomes more mixed by the end of this transition, with some convergence occurring in the wrong direction, while (iii) some excellent performance niches aggregate around the rich and more autonomous provinces, a well-expected result. (iv) Two good performing models appear in relation to centre-north and northern areas. They reflect a different evolution of waste management and disposal, which can represent local preferences for incineration and landfilling. It is strikingly clear nevertheless how both models might well improve tariff policy performance. This is a sign that in those relatively "better" regions, among whose 'models' one cannot currently pinpoint the best overall, a more intense diffusion of the tariff (and other economic policy instruments) might help move the system forward, closing the gap with the niche of excellence. Which of the two big models (clusters) will prevail, and which laggards it could attract, is the key factor influencing the future. The weight of national policies and regional/provincial waste management and waste policy coordination might well prove substantial in defining these trends.

4. Conclusions

We have presented spatial analyses of waste management and disposal (WM&D) performances of Italian provinces which originally investigate how provinces aggregate depending upon WM&D, socio-economic and institutional features. We further analyse the aggregation of clusters following the transition from the introduction of a new, more 'economic minded' waste tariff which substituted the older lump sum tax in 1999. We conceptually embed applied analyses within the theoretical analyses of the pros and cons of decentralised management and the provision of environmental goods of public and mixed natures. The overall success of a decentralised system such as the Italian one, wherein the State delegates competences in environmental policy to regions

and provinces, could be potentially higher. But even in this case, we should be aware of the possible (irreversible) creation of hot spots, namely laggard provinces locked into bad performances. All in all, a decentralised system performance should be evaluated by weighing the performances of "leaders" and "laggards".
We analyse how the highly decentralised waste management Italian system has evolved over the last decade. This analysis complements previous EKC studies on waste dynamics. We aim at shedding light on the WM&D economic-institutional 'models'[15] that have appeared through decentralisation. Further and possibly more importantly, we scrutinise if and how such 'models' – namely the aggregation of similarly-behaving provinces – changed and evolved from 2000 to 2008. This can be useful for policy making as well, to possibly tailor efforts to laggard areas or try to diffuse best practices and 'models'. It is worth noting that the good models are potentially many and different, in relation to the diverse possibilities in tackling the management and disposal of waste flows in socially efficient ways. Then, linking to one of our main aims, we analyse the extent to which aggregations have taken place along the north-south divide or through more complex socio-economic and geographical dimensions.

The various analyses on spatial agglomeration have shown that many 'models' have arisen since 2000. Some models– of good and bad WM&D performances - have affirmed themselves by integrating more units over time, while some have vanished. A decentralised provision of environmental goods emerges as a dynamic and changeable framework, driven by spillovers and imitation among provinces.
First, we show that the simpler north south divide is present, but it is not the only lens we should use when evaluating the waste or the waste-socio-economic system. This divide is more evident when we include income and social capital in the analysis. In this case, the worst cluster of provinces is indeed southern oriented, and decreases from 51 to 45, nevertheless almost 50% of Italian provinces, along time. While at the beginning of the analysed transition in 2000, the best performing cluster is a 15-units aggregation of very wealthy areas together with one autonomous northern province (Bozen), the conclusion of the transition, in 2008, seems to present various 'models' that perform well and are characterised by different features: first, the two affluent and autonomous provinces of Trentino Alto Adige separate out along with Venice; second, a northern-oriented aggregation of 24 provinces present high levels of separated collection and low landfilling; third a Centre North cluster of 31 units shows a high use of incineration and good tariff diffusion. It is impossible, in our opinion, to assess whether a best 'model' exists among the three. What is evident is that all provinces, even the ones that aggregate to clusters SSS3 and SSS4, would benefit from intensifying the diffusion of the TIA tariff, which is a proxy of 'management and policy commitment', and peaks in cluster SSS2 at 90%.

Leaving aside income, the north south divide is similarily evident. Nevertheless, waste-related features emerge more neatly in the aggregation of different performances and a mixed pattern emerges. In the beginning, in 2000, the situation is varied: There is one southern cluster which presents low separated collection levels, one northern cluster with high landfilling but initial levels of incineration, and two small "good" clusters which show high incineration levels 'pionieristic disposal oriented' clusters, which intuitively aggregate a few northern provinces. The system clearly starts with a north south divide also with the exclusion of income from the empirical analysis.
The situation changes moving to 2004: while the southern cluster (including larger population centres such as Rome, Naples and Palermo) maintains the same size, and shows a clear link between high landfilling and low separated collection, a small idiosyncratic cluster of northern touristic provinces presents low landfilling and high incineration.

[15] We define as 'model' an aggregation of spatial units which is characterised by similar features regarding waste, institutional and socio economic dimensions.

One above-average performing cluster can be set aside: it is located in the north and includes cities such as Milan, Turin and Florence (CC2).

The final situation, in 2008, confirms the inclusion of three autonomous Sardinian provinces in the cluster that perform above average (CCC5). These cities are now not exclusively in the north.
The transition seems to have widened the performances between models. Without considering income, there is no neat north-south divide in the end. Some southern provinces aggregate with well-performing aggregations of northern provinces. All in all, 61 out of 103 provinces are within good WM&D aggregations. One big 30-unit mixed cluster and one 21-unit geographically bound cluster that show how 'models' may be replicated. The other two small aggregations (7 + 3 provinces) seem to excel in incineration, which is still underdeveloped (and opposed by local communities) in many areas, and is unrelated to mere spatial proximity.
The year 2008 then witnesses a clear gap in waste performances between areas of Italy that is motivated partially by structural north-south divides when income is omitted. This means that good WM&D systems can be replicated. The role of the tariff and the link to separated collection are at the core of the observed gap. Investing more in incineration than recycling is an option that can further differentiate 'good models'.

A more profound investigation based on further clustering and spatial dynamic econometric analyses can provide further insight, and thus consistutes the next step in this research endeavor.

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Figure 1 – Separately collected waste by province (%)

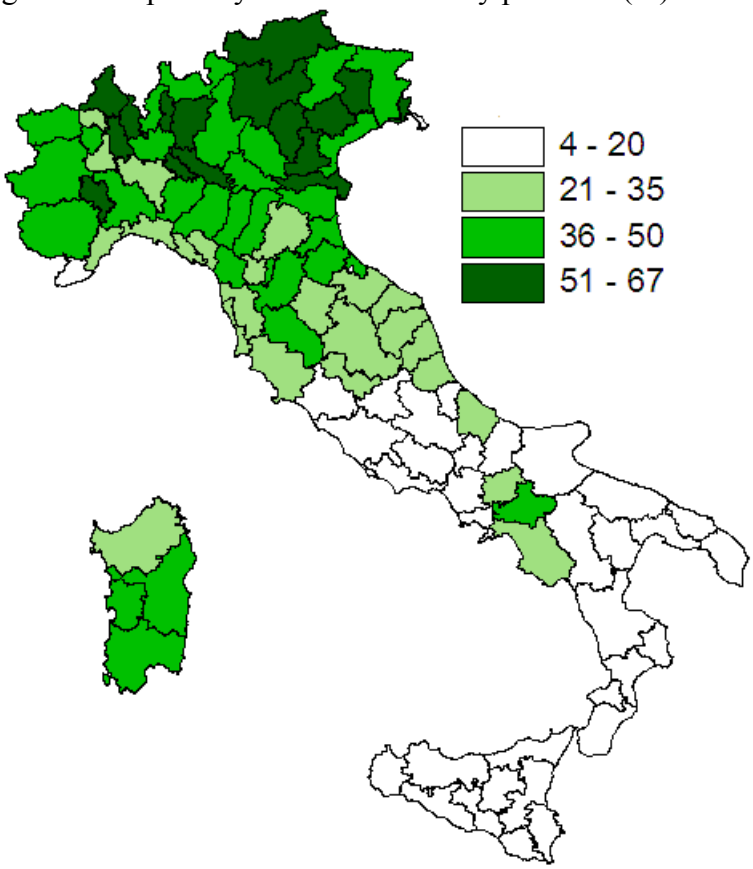

Figure 2 – Waste generation and disposal trends in Italy

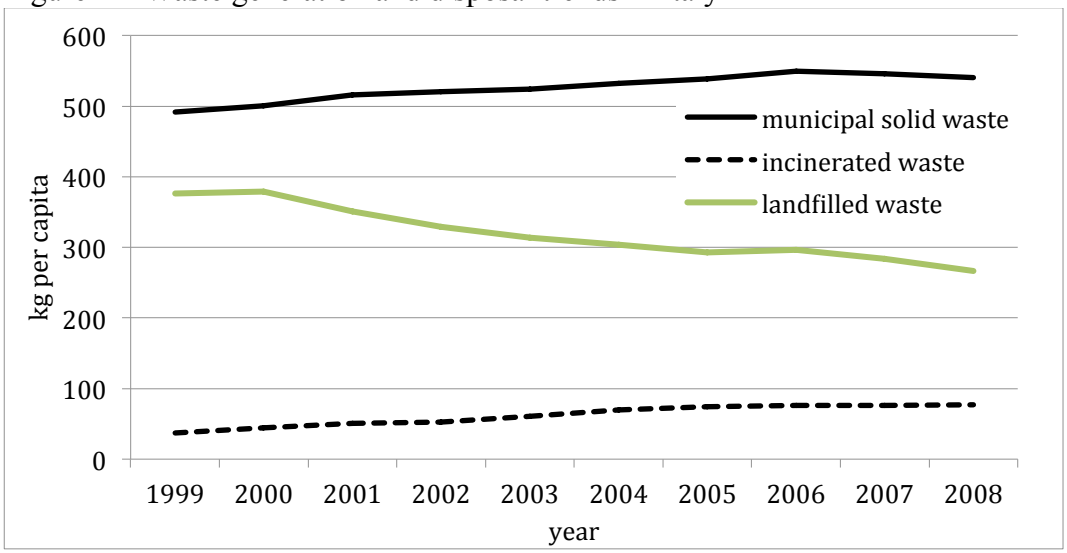

Table 1 – Descriptive statistics (year 2008)

Variable	Mean	Std Dev	Minimum	Maximum
Municipal solid waste (MSW), per capita kg	541.03	104.2	356.27	848.62
Separated collected waste, %	30.81	17.6	4.05	66.92
Organic waste, per capita kg	37.36	38.4	0	233.97
Glass waste, per capita kg	24.94	14.7	2.35	59.62
Plastic waste, per capita kg	10.19	7.5	0.39	35.14
Paper waste, per capita kg	48.19	28.1	3.76	156.40
Metal waste, per capita kg	6.77	6.2	0.16	37.88
Incinerated MSW, per capita kg	76.96	147.0	0	766.77
Landfilled MSW, per capita kg	278.36	227.9	0	928.43
Municipalities with tariff (instead of tax), %	15.21	24.5	0	100.00
Value added, € per capita	18704.62	4690.1	10211.80	28702.1
Electoral tournover, %	80.54	4.8	64.90	87.57
Tourist overnights stays, per 1000 inhabitants	7.36	9.5	0.48	55.53

Table 2 – The evolution of clusters

YEAR 2000	YEAR 2004	YEAR 2008
C1 (54) – Mainly Southern provinces including all autonomous areas (4) in Sardinia, big cities and a few Northern provinces. Low-average MSW levels but landfilling oriented cluster.	CC1 (54) – Mainly Southern provinces including all autonomous areas (4) in Sardinia, big cities and a few Northern provinces. Low-average MSW levels but landfilling oriented cluster.	CC1 (42) – South; high landfilling; almost no tariff diffusion and no recycling.
C2(1) – The autonomous province of Bolzano. High separetd collection, high incineration and high tariff diffusion.	**CC2 (10)** – A few pioneristic Northern provinces, "incineration oriented cluster"; high MSW levels but good WM&D performances (e.g. separated collection); increased tariff diffusion.	**CCC2 (21)** – Northern medium provinces High MSW and high landiflling; average/high tariff diffusion.
C3 (42) – Norther and Centre provinces. High separated collection, initial incineration but with high landfilling levels.	CC3 (3) – The recycling and tariff oriented virtuous North (two autonomous provinces and Venice).	CCC3 (7) – Incineration oriented cluster High MSW but high separated collection, high incineration, average/high tariff diffusion. Policy seems to matter.
C4 (6) – A few pioneristic Northern provinces, "incineration oriented cluster"; high MSW levels but with good WM&D performances (e.g. separated collection).	CC4 (36) – Norther and Centre provinces. High separated collection, initial incineration but with still high landfilling levels.	CCC4 (3) – The recycling and tariff oriented virtuous North (two autonomous provinces and Venice).
		CCC5 (30) – The recycling North and three of the four Sardinia autonomous areas.

*In brackets the number of units in a given cluster. WM&D is Waste management and disposal
*Clusters that present good WM&D performances higher than the average are highlighted in bold. Arrows indicate plausible transitions.

Table 3 – the evolution of clusters by adding income and social capital as factors

YEAR 2000	YEAR 2004	YEAR 2008
S1 (51) – Southern Italy oriented cluster Overall worst WM&D performances.	SS1 (41) – Southern Italy oriented. Bad overall performances in WM&D, low tariff diffusion.	SSS1 (45) – Worst and enlarging cluster. Now aggregating Rome, Genua and even North east areas such as Trieste. Very low tariff diffusion after 9 years from the setting bill.
S2 (15) – Some wealthy Emilia Romagna and other Centre-North provinces presenting good WM&D performances.	SS2 (41) – Mixed 'rest of Italy' cluster. High landfilling, good tariff diffusion.	**SSS2 (3)** – Trentino Alto Adige autonomous region 'model' and Venice. Very high tariff diffusion (90% of municipalities, vs 6% in C23).
S3 (1) – Bozen.	**SS3 (3)** - Bozen, Rimini and Venice (C21), for example, are together representing a group of idiosyncratic areas where tourism is high, incineration high, landfilling low and importantly tariff diffusion reaches the highest peak.	**SSS3 (31)** – Clustered around Piedmont, Veneto, Lombardy and Friuli regions. Milan and Turin are in it. Very Good separated collection and landfilling performances.
S4 (36) - mixed north centre that includes Turin and Milan), characterised by average good performances (for this year): high landfill, medium incineration, high recycling, initial tariff diffusion.	**SS4 (18) –** Lombardy and Veneto provinces. joint high separated waste collection and high tariff diffusion.	**SSS4 (24)** – Clustered around Tuscany and Emilia Romagna regions. Good tariff diffusion (24%) and incineration.

*In brackets the number of units in a given cluster. WM&D is Waste management and disposal.
*Clusters that present good WM&D performances higher than the average are highlighted in bold. Arrows indicate plausible transitions.

Table 4 – Cluster profiles (variables' means, year 2008, without economic and social variables)

Variable	Cluster CCC1 (42[§])	Cluster CCC2 (21[§])	Cluster CCC3 (7[§])	Cluster CCC4 (3[§])	Cluster CCC5 (30[§])	Mean (Italy)
Municipal solid waste (MSW), per capita kg	498.04	694.34	560.39	548.19	488.66	541.03
Separated collected waste, %	14.31	34.23	29.20	51.63	49.82	30.81
Organic waste, per capita kg	12.18	32.35	28.52	65.37	75.40	37.36
Glass waste, per capita kg	13.38	26.90	23.05	44.29	38.27	24.94
Plastic waste, per capita kg	4.15	14.45	9.40	9.51	15.92	10.19
Paper waste, per capita kg	23.76	75.69	51.73	74.89	59.64	48.19
Metal waste, per capita kg	2.37	12.66	6.54	16.29	7.90	6.77
Incinerated MSW, per capita kg	18.42	68.41	535.92	65.54	55.51	76.96
Landfilled MSW, per capita kg	380.95	369.82	145.48	174.54	112.10	278.36
Municipalities with tariff (instead of tax), %	6.86	21.41	22.64	89.39	13.39	15.21
Tourist overnights stays, per 1000 inhabitants	4.00	13.40	3.33	41.14	5.40	7.36

[§] The number in brackets indicates the number of provinces in each cluster

Table 5 – Variables' means by cluster (year 2008, with economic and social variables)

Variable	Cluster SSS1 (45)	Cluster SSS2 (3)	Cluster SSS3 (31)	Cluster SSS4 (24)	Mean (Italy)
Municipal solid waste (MSW), per capita kg	490.23	548.19	499.59	688.90	541.03
Separated collected waste, %	15.19	51.63	48.09	35.19	30.81
Organic waste, per capita kg	15.12	65.37	69.34	34.26	37.36
Glass waste, per capita kg	13.52	44.29	37.90	27.21	24.94
Plastic waste, per capita kg	4.30	9.51	15.57	14.36	10.19
Paper waste, per capita kg	23.47	74.89	59.90	76.07	48.19
Metal waste, per capita kg	2.47	16.29	7.86	12.23	6.77
Incinerated MSW, per capita kg	54.50	65.54	74.42	119.49	76.96
Landfilled MSW, per capita kg	362.69	174.54	121.70	335.57	278.36
Municipalities with tariff (instead of tax), %	6.66	89.39	13.25	24.47	15.21
Value added, € per capita	14398.79	23756.34	22029.82	21851.52	18704.62
Electoral tournover, %	76.71	83.81	83.06	84.05	80.54
Tourist overnights stays, per 1000 inhabitants	3.91	41.14	5.21	12.38	7.36

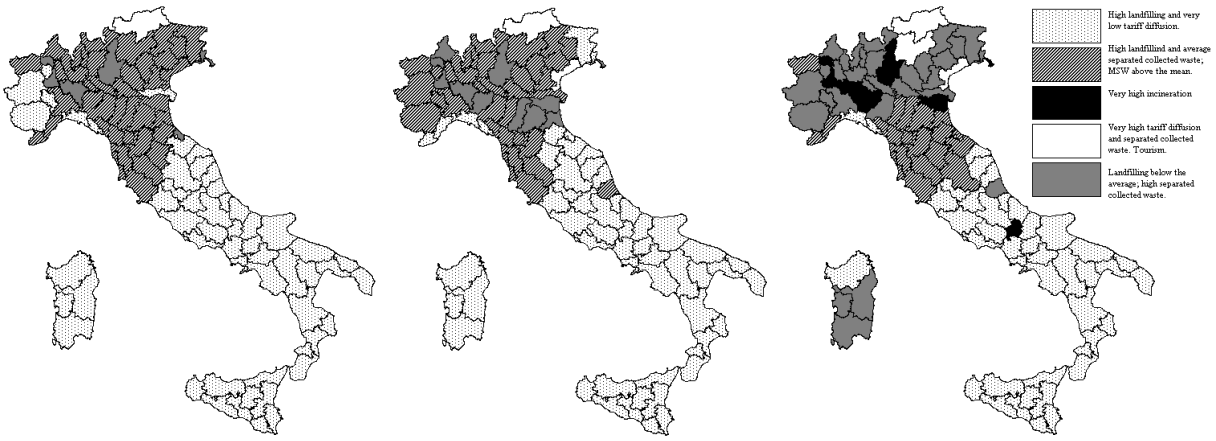

Figure 3 – Clusters in 2000, 2004 and 2008 (without socio-economic variables)

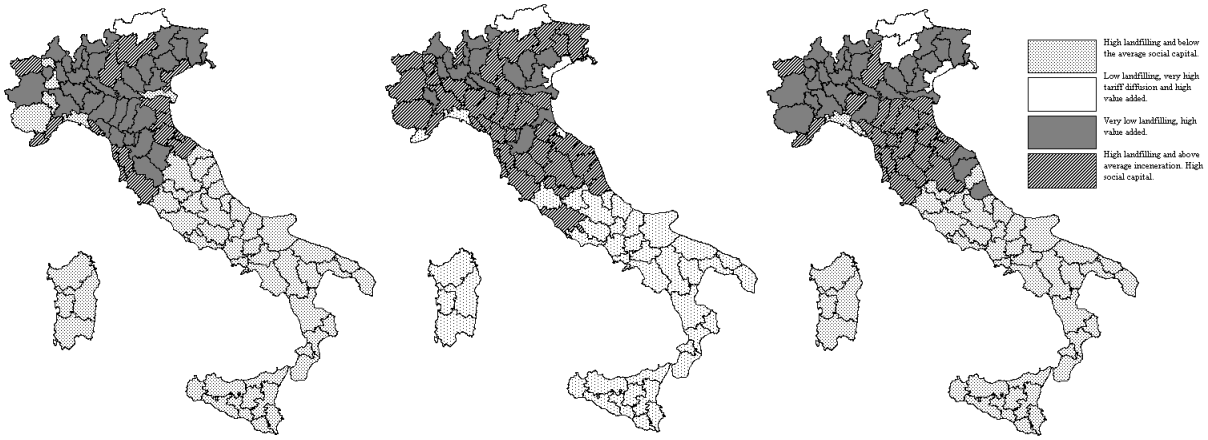

Figure 4 – Clusters in 2000, 2004 and 2008 (with socio-economic variables)