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How Far is Campania from the Best-Performing Region in Italy? A Territorial-Divide Analysis of Separate Waste Collection

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Abstract The aim of this paper is to investigate the divides in separate waste collection (SWC) between Campania and Veneto from a twofold perspective that considers both intensity (the size of the gap) and inequality (the differences among the SWC distributions across municipalities). In the framework of Kapp's social cost theory, the Recentered Influence Function regression allows an evaluation of the amount of territorial divides that are accounted for by the: (i) regional component, which captures the extent to which regional authorities transpose national legislation into programs of waste management; (ii) municipal component, which explains the effect of the operational strategies adopted by each local authority to guarantee an adequate performance. As the best-performing region in Italy, Veneto reached an average SWC level far superior to that of Campania in 2012, and more importantly, most of its municipalities exceeded the 65% target set by Legislative Decree 152/2006 with a smaller variability within the region. However, a more detailed analysis shows that the policies and strategies for waste management set by the regional authority in Campania should be more effective at the initial stage, but are partly held back by the successive implementation steps controlled by each municipality. One of the primary

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deterrents of reaching a better performance in waste management in Campania lies in the weakness of its institutions, which makes the region more vulnerable with a large amount of heterogeneity in waste management performance across municipalities.

Keywords Waste management · Separate waste collection · Government policy · Regional Government analysis · Inequality · RIF regression

JEL Classification C21 · Q5 · Q53 · Q58 · R11 · R5

1 Introduction

In recent years, Campania (a region of southern Italy) has often been associated with the term "waste". Images of the streets of the City of Naples submerged in rubbish have been discrediting the history and culture of Parthenopean citizens around the globe (The Economist, February 26, 2009; New York Times, May 31, 2007). Among other things, the negative publicity has also significantly affected the regional economy and particularly the tourism sector.

Numerous papers have been written on the topic of waste in Campania (De Biase 2009; Armiero and D'Alisa 2012; D'Alisa and Armiero 2013; Triassi et al. 2015; Membretti 2016; D'Alisa and Kallis 2016), which address the complexity of the underlying causes of a waste emergency in the region. Among the many studies, only Distaso (2012) used economic theory to investigate the waste emergency in Campania. By means of Kapp's theory, Distaso (2012) showed that sustainable and integrated waste management could be achieved only if waste is regarded as a social cost rather than a negative externality.[1] According to Kapp (1950, 1969, 1970, 1974, 1977), social costs derive from the use of resources that have a market (monetary elements) and resources that do not have a market (qualitative elements) (Distaso 2012). Since social costs are not easy to measure because they are not completely monetisable, they cannot be considered externalities, which in contrast are totally monetisable.[2] If environmental damage caused by poor waste management is understood in terms of social costs, it will be possible to distinguish environmental damage whose costs are monetisable from that whose costs are not. In the specific case of waste, the environmental disruption caused by poor waste management falls into the second category. Distaso (2012) believes that the problem of bad waste management is not solvable solely through the monetisation of the costs associated with it. In summary, the social cost theory applied to waste management finds its realization in the two following operating principles: (1) Rigid control of the waste collection and disposal phases through

[1] A negative externality occurs when the production or consumption activities of a subject negatively affect the well-being of another person without the latter receiving compensation (in the case of negative impact) equal to the cost borne. For a review of the literature on environmental externalities, refer to the van den Bergh's paper (2010).

[2] The way to reduce waste production is not taxation because taxation only responds to the market logic and does not solve the problem (Distaso 2012). The cost of waste disposal in northern Italy is much higher than that sustained in the southern regions, resulting in a shift of waste from north to south, which, in part, is generating the waste emergency in Campania. In contrast, the "polluter pays principle", which is associated with the concept of extended producer responsibility, allows treating waste as a social cost. For a definition of extended producer responsibility see http://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm.

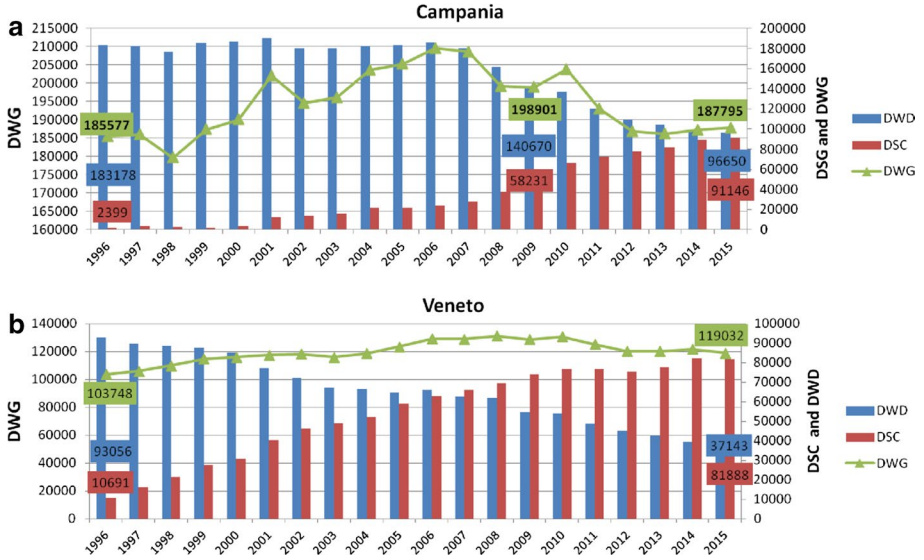

Fig. 1 DWG, DWD and DSC in Campania and Veneto, 1996–2015. *Source*: our calculations based on ISPRA data

a deterrent action (taxation) by the local authorities (region, provinces, municipalities); (2) Favouring separate waste collection.

The waste crisis that has affected Campania is partially justified by Kapp's social cost theory and specifically by the non-monetisable component of social costs (i.e., poor waste management). Integrated waste management is only achieved through joint action of citizens and institutions (central and local). This result was missed in Campania during the period of the waste crisis due to the declaration of emergency status between 1994 and 2009 (Armiero and Fava 2016). During this period, the State was the only active agent in the waste management process, leaving out active citizen participation. Citizens were organised into associations and protested, risking arrest to be heard by the central or local governments, which continued to exclude them from decision-making processes (D'Alisa et al. 2010; Armiero and D'Alisa 2012; D'Alisa and Armiero 2013; Armiero 2014; Caggiano And De Rosa 2015; Martinez-Alier et al. 2016; Lucchini and Membretti 2016).[3]

The signal of government failure in waste management is represented by the increase in waste produced during the emergency period (1994–2009). Figure 1a shows an increasing trend of waste produced per square km, at least until 2007;[4] from 2007 onwards, a decreasing trend is observed. The cause of waste reduction is probably the issuance of the

[3] D'Alisa et al. (2010) argued that Campania's waste problem cannot be analysed as one of simple waste mismanagement. They spoke of a "crisis of democracy" in the waste management process that has generated conflicts between citizens and government.

[4] D'Alisa et al. (2012) suggested using as complementary indicators the density of waste generated (DWG), the density of separate collection (DSC) and the density of waste disposed or the amount of waste not separately collected (DWD). The relationship among these variables is as follows: $\frac{WG}{KM^2} = \frac{SC}{KM^2} + \frac{WD}{KM^2}$, where WG, SC, WD, and KM^2 are the waste generated, separate collection, waste disposed and square kilometres, respectively. These variables offer a measure of the demographic pressure that the observed phenomenon exerts on the territory.

Legislative Decree (L.D.) 152/2006 ("Norms Concerning the Environment", commonly called the "Single Environmental Text"). The L.D. 152/2006 integrated the previous law (L.D. 22/97 or the Ronchi decree) and marked an important turning point in the waste management process by defining time targets in terms of recycling (see Agovino et al. 2016c, 2017). Article 205 of the L.D. 152/2006 ("Measures to Improve Separate Collection and Recycling") governs the achievement of the separate collection targets for urban waste in each optimal management area (ATO, which are generally represented by provinces). It imposes on municipalities that do not reach the target of separate collection an additional charge of 20% for waste that ends up in landfills (the so-called eco-tax) (**first point of operating principles of social cost theory**). The tax is a deterrent to producing waste that ends up in landfills and favours separate collection (**second point of operating principles of social cost theory**).

Separate collection is fully included in Kapp's social cost theory applied to the environment to promote sustainable waste management (Distaso 2012). In the framework of the social cost theory, in this work, we compare Campania with Veneto (a region of northern Italy) in that the latter is considered the most virtuous and dynamic region, in terms of both economic and waste management, and is very similar to Campania regarding population density. In reality, what makes Veneto a benchmark in waste management is its successful urban waste model that dates back the 1980s following an emergency in waste collection. With a series of waste management plans (Regional Council Decrees 785/1988, 59/2004, 264/2004), the regional authority of Veneto introduced a minimum level of separate collection and homogeneous waste management areas in the framework of regional self-sufficiency for urban waste. Moreover, the introduction of taxation on untreated and unsorted waste pushed the municipalities to adopt separate waste streams, whose levels are certified annually by the Regional Waste Observatory, and to reduce landfill.

Interesting evidence emerges by comparing the data related to Campania with those related to Veneto. In particular, although in Campania the density of waste generated (DWG) remains higher (Fig. 1a) than in Veneto (Fig. 1b), a decreasing trend exists that tends to strengthen after the emergency of 2009. This result is associated with a continuous reduction in the density of non-separated waste (DWD) and an increase in the density of separate collection waste (DSC). Campania shows higher values of DWG and DWD and lower values of DSC than the corresponding values of Veneto (Fig. 1b).

More precisely, in addition to offering more robust results in terms of separate waste collection (SWC hereafter) compared to Distaso's descriptive analysis, we aim to explain the differentials in performance between Campania and Veneto, taking into account the role played by the driving forces of separate collection of municipal waste. The analysis is performed from a twofold perspective to consider both the *intensity* (the size of the gap) and *inequality* (the differences in the SWC distribution across municipalities of the two regions). The inspiration comes from the awareness that regulations are adopted at the regional (the region plans the waste management, art. 196, L.D. 152/2006) and municipal levels (the municipality implements the methods of conducting SWC and transporting municipal waste, art. 198, L.D. 152/2006). For this purpose, we use the Recentered Influence Function (RIF hereafter) regression (Firpo et al. 2007; Fortin et al. 2011), which allows us to evaluate how much of the SWC divide between the two regions is accounted for by the proposed planning (regional component) rather than by the operational methods (municipal component) of waste management.

Some authors studied the municipal solid waste management at both regional and municipal levels with different methodological approaches and outcomes that allow our findings to be better contextualised. Rogge and De Jaeger (2012) used an adjusted

"shared-input" version of Data Envelopment Analysis (DEA) with the double benefit of estimating the municipalities' overall cost efficiency and the municipalities' cost efficiency in the treatment of the different fractions of solid waste in the northern region of Belgium (Flanders). Similarly, Expósito and Velasco (2018) used the DEA to analyse the efficiency of Spanish regions in the development of the recycling market. Chang et al. (2013) investigated the efficiency of the organisational learning effect of municipal solid waste recycling systems through a two-stage approach in which the effect of a latent learning effect is used as an input in the DEA Slacks-Based Measure (SBM) model. Guerrini et al. (2017) tested a non-parametric method based on conditional order-m efficiency to identify the performance drivers of the waste collection services in 40 municipalities in Verona province (Italy). Finally, other studies looked at the role played by spatial effects in explaining the different performances in SWC across local areas (Mazzanti et al. 2012; Agovino et al. 2016a; Crociata et al. 2016).

The paper is structured as follows. Section 2 presents the context analysis. Section 3 describes the econometric model used. Section 4 presents data and variables. Section 5 discusses the main empirical results from the threefold perspective of overall gaps and of the role played by the regional and municipal components. Section 6 contains a synopsis of the main results. Section 7 concludes with some ideas for future studies.

2 Context Analysis: Campania Versus Veneto

The choice of Campania and Veneto as regions of interest reflects the idea of comparing two realities that, in the collective imagination, are regarded as diametrically opposed in terms of virtuosity of SWC management. Campania is a region in the south of Italy with an area of 13,670.95 km^2 and a population of 5,850,850 (Istat[5]). The territory of Campania is divided into five administrative provinces (Naples, Avellino, Benevento, Caserta, and Salerno) with 551 communes in 2012. Its capital and main municipality is Naples, whose metropolitan area is the second most populous in Italy, after Milan. The provinces of Napoli and Caserta have been dubbed by the media the "Land of Fires" for the relationship between illegal waste disposal and health effects (see Comba et al. 2006; Fazzo et al. 2008; Martuzzi et al. 2009; Triassi et al. 2015; Armiero and Fava 2016; Cantoni 2016).

In contrast, Veneto is a region that performs very well. Veneto is in the north-east of Italy with an area of 18,407.42 km^2 and a population of 4,915,123 (Istat[6]). Its territory is divided into seven provinces (Belluno, Padua, Rovigo, Treviso, Venice, Verona, and Vicenza) with 581 communes in 2012; its capital and main municipality is Venice, which is also part of the homonymous metropolitan area. Veneto is the first Italian region to reach SWC values close to the 65% target, and it has confirmed its primacy as the most virtuous region in recent years. Its virtuosity has since followed a positive trend in line with the objectives of the Regional Waste Management Plan, which aims to reach SWC of 76% by 2020, a threshold that was already exceeded in 2012 by 171 municipalities. Due to its socio-demographic similarities with Campania and its efficient waste management, Veneto is an excellent benchmark for Campania.

[5] http://demo.istat.it/ (accessed June 2017).

[6] http://demo.istat.it/ (accessed June 2017).

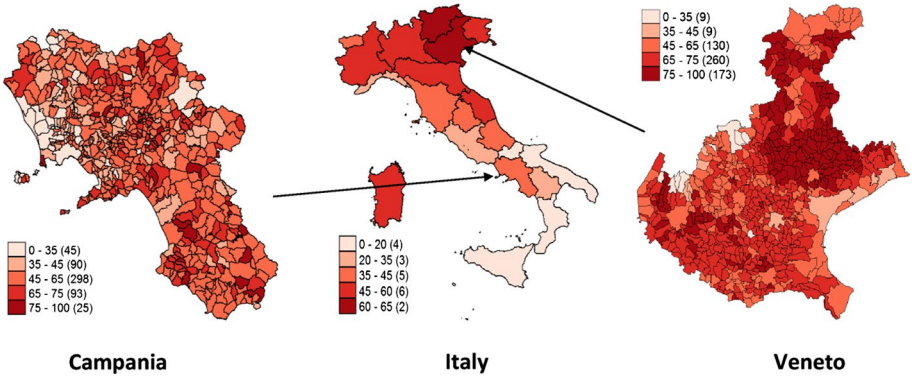

Fig. 2 Separate waste collection (SWC) in Italy, Campania and Veneto, 2012. *Source*: our calculations based on ISPRA data

The L.D. 152/2006 defines the tasks of the administrative units responsible for waste management and the operations of separate collection. The Decree establishes an administrative hierarchy that attributes to: (i) the regions the task of planning the waste management process (art. 196), (ii) the provinces the monitoring of the waste collection process (art. 197), and (iii) the municipalities the definition and implementation of the operational strategies through which waste is handled (art. 198). In light of the competences set by the Decree, the comparison between Campania and Veneto takes account of the double levels, regional (in which the plans are developed) and municipal (in which the plans are implemented) excluding the intermediate level of provinces because their role just looks at a supervising action of municipalities. Moreover, the high number of units ensures the convergence of the statistical models and the validity of hypothesis tests. Finally, our analysis will focus on the year 2012 due to the greater availability of variables needed to conduct it.

Figure 2 shows the distribution of SWC rates[7] across Italian regions by quintile with a focus on Campania and Veneto, for which the SWC rates are detailed at the municipal level. First, it is worth noting the dichotomy between the northern and southern regions with better SWC management in the north of the country, especially in the north-eastern macro-area. Excluding Liguria, the SWC rates of the northern regions are sufficiently above the national average of 40% with the peaks of Veneto (62.6%) and Trentino-South Tyrol (62.3%). An opposite trend describes the southern regions, which are all characterised by SWC rates dramatically below the national average with Sicily (13.2%) and Calabria (14.9%) the least effective. However, within the southern regions, Sardinia (48.5) and Campania (41.5%) exceed the national average, resulting in the most virtuous regions of the macro-area. In more detail, Fig. 2 highlights the presence in Campania of two main areas of virtuous municipalities that correspond approximately to the provinces of Benevento (37.17% of virtuous municipalities) and Salerno (30.37%), in contrast to the provinces of Caserta (5.76%) and Naples (6.52%). In Veneto, however, where most municipalities are virtuous, there are some noteworthy cases, such as the areas of Treviso (93 of the

[7] Following the literature on the factors that drive separate waste collection, we analyse the SWC rate as the ratio of tons of separate waste collection to total tons of urban waste collected (see Agovino et al. 2016, 2017; Mazzanti et al. 2008, 2009, 2012; Mazzanti and Zoboli 2013).

Table 1 Distribution of municipalities by SWC rates, Campania versus Veneto (2012). *Source*: our calculations based on ISPRA data

SWC rates	Campania		Veneto		Italy	
	N°	%	N°	%	N°	%
0 –| 15	9	1.63	3	0.52	1258	15.63
15 –| 25	14	2.54	2	0.34	720	8.95
25 –| 35	22	3.99	4	0.69	689	8.56
35 –| 45	90	16.33	9	1.55	939	11.67
45 –| 55	127	23.05	28	4.82	1100	13.67
55 –| 65	171	31.03	102	17.56	1535	19.08
65 –| 75	93	16.88	260	44.75	1355	16.84
75 –| 85	21	3.81	164	28.23	421	5.23
> 85	4	0.73	9	1.55	30	0.37
Total	551		581		8047	

95 municipalities in the province) and Belluno (48 of the 67 municipalities in the province), where the 2012 target has been widely exceeded.

Table 1 shows a more detailed distribution of municipalities by SWC rates in Campania and Veneto. In both regions, most municipalities show SWC rates above 35%, which is the first goal, set by L.D. 152/2006, to be achieved by the end of 2006. The same L.D. (152/2006) states that by the end of 2012 all municipalities must exceed 65% in SWC rate. However, in Campania, most of the municipalities (70.41%) have SWC rates between the intermediate threshold values of 35% and 65%, whereas in Veneto only 24.62% of the municipalities are still in this range. Regarding virtuous municipalities (rates above 65%), three of four municipalities in Veneto exceed 65% SWC, whereas in Campania only one municipality of five exceeds that threshold. Among the virtuous municipalities, it is worth noting that almost 30% exceed 75% SWC in Veneto (with some excellent communes that even exceed 85%), whereas fewer than 5% succeed in achieving this primacy in Campania. The six outstanding municipalities in Veneto located in the last percentile show SWC rates between 85.7 and 88%, whereas in Campania the municipalities of the same percentile have SWC rates between 84.4% and 91.8; consequently, Campania boasts some municipalities with degrees of virtuosity even higher than those in Veneto.

3 Methodology

After eight years from the end of the waste state of emergency, an important question is the following: Is Campania still today the icon of waste mismanagement and socio-ecological disaster in Europe (D'Alisa et al. 2012)? The "waste crisis" that afflicted Campania in past years prompted intrusive measures by the European Commission due to a lack of adequate policies in the region. However, without undermining the complexity of waste management in Campania, in recent years, SWC figures are not so discouraging despite the bad media image and the weaker socio-economic scenario. For this purpose, we use an effective methodology that allows us to test whether Campania has managed to overcome the serious problems in waste management through a better process of separate waste collection.

With the aim of understanding the leading determinants of SWC management, the Recentered Influence Function (RIF) regression (Firpo et al. 2007, 2009; Fortin et al. 2011) is performed. This multistage technique, which comes from the Oaxaca-Blinder decomposition (Blinder 1973; Oaxaca 1973), is well suited to the objective of the work since it allows linking the decomposition of spatial gaps in SWC—both at the average levels and in the territorial distribution across municipalities—to the contribution of each covariate that drives these gaps.

For each group, RIF regression replaces the dependent variable Y—in this work, the SWC rate—with the Recentered Influence Function of the statistic of interest v:

$$RIF_g(Y;v) = IF(Y;v) + v \quad for \quad g = A, B \tag{1}$$

The groups (g) are composed of municipalities located in Campania ($g = A$) and those in Veneto ($g = B$). IF is the influence function of the distributional statistic, which measures the relative effect of a small change in the underlying outcome distribution on the statistic of interest (Hampel 1974), and ν is, alternatively, the mean or the Gini index. The overall territorial divide between Campania and Veneto can be measured as follows:

$$\Delta_O^v = v_B - v_A = \left(v_B - v_C\right) + \left(v_C - v_A\right) = \Delta_R^v + \Delta_M^v \tag{2}$$

v_c is the counterfactual distribution required for the calculation of the territorial divide. It represents the distributional statistic that would have prevailed if municipalities observed in the region A had the same structure as those in the region B. Intuitively, Δ_R^v and Δ_M^v are the regional and municipal components, respectively. Identifying the parameters of the counterfactual distributions requires first the estimation of weights function (Firpo et al. 2007):

$$\omega_{\mathrm{B}}(\mathrm{G}) \equiv \frac{G}{\mathrm{p}}; \quad \omega_{\mathrm{A}}(G) \equiv \frac{1-\mathrm{G}}{1-\mathrm{p}}; \quad \omega_{\mathrm{c}}(G,\mathrm{X}) \equiv \frac{\mathrm{p(X)}}{1-\mathrm{p(X)}} \cdot \frac{1-\mathrm{G}}{\mathrm{p}} \tag{3}$$

where $p = N^{-1} \sum_{i=1}^{G} G_i$ and $p(\cdot)$ is an estimator of the true probability of being in group B given X. Once the weighting functions have been estimated, the coefficients of the RIF regression for each group, γ_g (γ_A if $g = A$, γ_B if $g = B$), and for the counterfactual distribution, γ_C, can be estimated as follows:

$$\gamma_g = \left(\sum_{i\, f\, G} \omega_g\left(G_i\right) X_i \cdot X_i^T \right)^{-1} \sum_{i\, f\, G} \omega_g\left(G_i\right) X_i RIF\left(Y_i; v_g\right), \quad g = A, B \tag{4}$$

$$\gamma_C = \left(\sum_{i\, f\, G} \omega_C\left(G_i, X_i\right) X_i \cdot X_i^T \right)^{-1} \sum_{i\, f\, G} \omega_C\left(G_i, X_i\right) X_i RIF\left(Y_i; v_C\right) \tag{5}$$

3.1 The Case of Mean

In the case of mean ($v = \mu$), the RIF decomposition is identical to the Oaxaca-Blinder procedure. The Influence Function is:

$$IF(Y;\mu) = \lim_{\varepsilon \to 0} \frac{\left[(1-\in) \cdot \mu + \in \cdot y - \mu\right]}{\in} = y - \mu \tag{6}$$

with $0 < \in < 1$ (Hampel 1974). The recentered influence function of the mean is simply the outcome variable *Y*. In this case, the regression of $RIF(Y;\mu)$ on *X* is the same as that of an OLS regression of *Y* on *X*:

$$RIF(Y;\mu) = IF(Y;\mu) + \mu = y \tag{7}$$

The question is how much of the difference is accounted for by group differences in the vector of covariates *X*. The overall mean gap can be written as:

$$\Delta_o^{\mu} = \mu_B - \mu_A = \left(\mu_B - \mu_C\right) + \left(\mu_C - \mu_A\right) = \Delta_R^{\mu} + \Delta_M^{\mu} \tag{8}$$

μ_c, Δ_R^{μ} and Δ_M^{μ} are the counterfactual mean, the regional and municipal components, respectively. In the last stage, both the regional and municipal effects can be disaggregated as the sum of explanatory variables to study the contribution of each covariate. Further methodological details can be found in Firpo et al. (2007, 2009) and Fortin et al. (2011).

3.2 The Case of Gini

Focusing on the SWC distribution among municipalities, the distributional statistic *v* and the *IF* of the Gini index are defined as follows:

$$v^{GC}\left(F_Y\right) = 1 - 2\mu^{-1}R\left(F_Y\right) \tag{9}$$

$$IF\left(y;v^{GC}\right) = 2\mu^{-1}R\left(F_y\right) + 2\mu^{-2}R\left(F_y\right) - 2\mu^{-1}\left[y\left[1 - p(y)\right] + GL\left(p(y);F_y\right)\right] \tag{9}$$

where $R\left(F_y\right) = \int_0^1 GL\left(p(y);F_y\right)dp$ with $p(y) = F_Y(y)$ and the Generalised Lorenz ordinate of F_Y is given by $GL\left(p(y);F_Y\right) = \int_{-\infty}^{F^{-1}(p)} z dF_Y(z)$. As demonstrated by Firpo et al. (2007), the recentered influence function of Gini can be rewritten as:

$$RIF\left(y;v^{GC}\right) = 1 + 2\mu^{-2}R\left(F_y\right) - 2\mu^{-1}\left[y\left[1 - p(y)\right] + GL\left(p(y);F_y\right)\right] \tag{10}$$

The gaps in the Gini index between regions, as well as the contribution of the single covariates, can be detailed as shown for mean.

4 Data and Variables

The data used to perform this analysis are taken from several sources and are related to three hierarchical levels of territorial disaggregation for the year 2012: (i) 20 regions, (ii) 110 provinces, and (iii) 8047 municipalities.[8] The outcome variable, the *separate waste collection* (*SWC*) *rate*, comes from ISPRA (Italian Institute for Environmental Protection and Research) and from the National Land Registry (Catasto Nazionale dei Rifiuti). SWC, regulated by Art. 183 of L.D. 452/2006 (paragraph f), is obtained as the ratio of tons of urban waste diverted from trash—organic, packaging (paper and cardboard, plastic, glass, metal, and wood) and multi-material—to total tons of urban waste collected. Additionally, Art. 183 states that the SWC rate meets the criteria of cheapness, efficiency and transparency (Agovino et al. 2016c, 2017). In this work, we consider the urban waste generated by

[8] The municipalities for which official data were unavailable are not considered in the current analysis.

households excluding the waste produced by other activities (i.e., industry, construction or demolition).

The explanatory variables are from the National Institute of Statistics (ISTAT) and particularly from the 2011 census. After a careful review of the specialised literature, they have been grouped into three macro-areas of geomorphologic, socio-economic and institutional quality factors.

Geomorphologic variables are among the most commonly discussed covariates in the waste literature. Among these factors, we consider *overall surface area* and *elevation above sea level* at the municipal level. The former, which refers to the square kilometres of the entire town, may affect SWC because if the surface area increases the costs of SWC, then the collection costs are reduced (Domberger et al. 1986; Simões et al. 2012). Elevation above sea level may influence the operational complexity of the service and consequently its costs (Sarra et al. 2017).

The socio-economic factors considered in our analysis are: (i) *Population density* as the ratio of the number of people per square kilometre, which may control for different land values and for economies of scale in waste management (D'Amato et al. 2015; Mazzanti et al. 2008). (ii) *Metropolitan area* as a dummy with 1 if the municipality belongs to a metropolitan area and 0 otherwise, based on the classification proposed by Legambiente (2012). In Campania and Veneto, there are the metropolitan areas of Naples and Venice, respectively; controlling for them is important because larger areas may make the separate waste collection process more difficult (Fiorillo 2013). Waste management will be successful if people are "participative" and show a pro-environmental attitude, which, in turn, may be characterised by the following socio-economic variables: (iii) *Education rate* can have a strong link with efforts in SWC (Schultz et al. 1995; Callan and Thomas 1997; Hage and Söderholm 2008). In our work, education is expressed as the ratio of young people (aged 19–34) who have completed upper-secondary education to the total population of the same age-group. (iv) *Unemployment rate* is the ratio of people, aged 16–64, who are unemployed (and seeking a job) to the overall labour force. Unemployment status may encourage pro-environmental behaviour in which the opportunity cost of the time spent to differentiate the garbage is likely to be lower for unemployed people (Hage and Söderholm 2008). (v) *Couples with children* is the share of couples with children of the total number of couples. It is a good proxy of citizens' willingness to be involved in the separate collection process due to parents' wish to maintain the environment in the best possible condition for their children. Many studies show that pro-environmental behaviours are more common in people with altruistic values (Stern et al. 1995; Corraliza and Berenguer 2000). *vi) Value added per capita* at the provincial level is the best proxy of the economic prosperity (Mazzanti et al. 2008) and one of the main driving forces of the waste management process (Mazzanti et al. 2009; D'Amato et al. 2015; Agovino et al. 2016).

The *Institutional Quality Index* (IQI), which is inspired by the World Governance Indicator (WGI) proposed by Kaufmann et al. (2011), represents a measure of the Italian institutional quality. Following Nifo and Vecchione (2014), IQI is a composite indicator, varying in the range [0,1], obtained by the combination of five dimensions of institutional quality (Voice and Accountability, Government Effectiveness, Regulatory Quality, Rule of Law, and Corruption). In particular, Voice and Accountability measures the degree of freedom of the press and association. Government Effectiveness evaluates the quality of public service and the policies formulated and implemented by the local government. Regulatory Quality measures the ability of government to promote and formulate effective regulatory interventions. Rule of Law quantifies the crime levels, shadow economy, police force, and magistrate productivity. Control and Corruption measures the degree of corruption of those

Table 2 Descriptive statistics for the explanatory variables. *Source*: our calculations based on ISTAT data

	Campania				Veneto				Italy			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
GeomorPHological												
Overall surface	0.12	186.74	24.82	23.83	2.97	415.89	31.61	33.14	0.12	1287.35	37.43	50.19
Elevation ab. sea	2	1090	322.49	244.33	0	1475	175.78	296.87	0	2035	357.13	298.13
Socio-economic												
Population density	7.65	12,224.41	806.10	1581.03	5.53	2216.5	291.35	273.72	0.92	12,224.41	297.80	634.31
Metropolitan area	0	1	0.16	0.37	0	1	0.07	0.26	0	1	0.15	0.36
Education rate	44.59	91.67	70.15	8.23	42.39	80.49	62.27	6.16	16.67	100	64.02	9.21
Unemployment rate	3.78	41.27	18.22	6.20	1.67	13.12	6.15	1.48	0.64	42.18	10.20	6.31
Couples with children	0.46	0.81	0.68	0.06	0.41	0.74	0.63	0.04	0.09	0.87	0.61	0.07
Value added per cap	13,774.65	16,216.1	14,921.81	826.52	21,817.23	28,354.7	26,708.08	1701.9	12,493.58	44,959.9	22,032.82	5968.25
Institutional quality												
IQI	0.25	0.53	0.44	0.09	0.65	0.79	0.73	0.03	0	1	0.61	0.20

Table 3 RIF decomposition of Mean and Gini on log-SWC rate

	Campania–Veneto	
	Mean	Gini index
Total gap	−0.2857***	0.0225***
	(0.0192)	(0.0035)
Regional effect	0.6366***	−0.0118
	(0.108)	(0.0192)
Municipality effect	−0.9223***	0.0343*
	(0.107)	(0.0189)

Standard errors in brackets

*Significant at 10%

**Significant at 5%

***Significant at 1%

performing public functions and crimes against the public administration. The importance of introducing IQI comes from the relevant role that local institutions (e.g., regions, provinces, and municipalities) play in the success or failure of the waste management process (Agovino et al. 2016). According to Mazzanti and Zoboli (2008), policy failure, in terms of waste management, was a leading determinant of the waste crises that have afflicted some Italian regions, among which Campania was the most affected. In other words, differences in the quality of local institutions might be able to explain an important part of the SWC divide between Campania and Veneto. Table 2 shows the summary statistics of the explanatory variables regarding Campania, Veneto and Italy as a whole. More details on variables can be found in "Appendix" (Table 6).

5 Empirical Results

The purpose of this section is threefold. We analyse the SWC divide between Campania and Veneto in both the average levels of SWC and their distribution across municipalities within each region (Sect. 5.1). Then, to explore the role played by local authorities in achieving good performance in SWC management, we devote our efforts to evaluating (i) the extent to which the regional authorities transpose European and national legislation (Sect. 5.2) and (ii) how municipal governments concretise regional plans in operational strategies of separate collection (Sect. 5.3).

5.1 The Overall Gaps: Mean and Gini Index

Decomposition methods are extensively used in labour economics with the aim of analysing the differences—e.g., income or socio-economic inequality divides or pay gaps—from time or space perspectives (see Castellano et al. 2017, 2018; Heckley et al. 2016; Garofalo et al. 2017). This work is the first attempt to perform decompositions of SWC rates through the RIF methodology, endeavouring to separately assess roles and responsibilities of regions and municipalities in a hierarchical framework. One of the main elements of this work's novelty is its linking the research of primary forces of separate collection levels and inequalities to the decomposition of the overall gaps between Campania and Veneto by any factor that drives these gaps.

RIF regressions are carried out using log–log models, which allow us to interpret coefficients as the elasticity of the outcome variable with respect to covariates. Therefore, each coefficient denotes the estimated percent change in SWC rate for a percent change of the given covariate (Table 5 in "Appendix").

Table 3 shows the decomposition results for the mean and Gini index. In the former case, the total gap gives evidence of the divide between the mean levels of SWC between Campania and Veneto and in the latter case of the divide between the inequality levels of SWC rates across municipalities within the same region. Both gaps are obtained as the sum of the regional and municipal effects. As the best-performing region in Italy, Veneto has average SWC rates greater than Campania, and most notably, their distribution across municipalities is consistently less unequal than in Campania. The negative sign of the first difference, which captures the gaps between the average SWC rates, denotes the advantage of Veneto, and the positive sign of the second difference denotes the greater equality in the performance of SWC management across the Veneto municipalities. In brief, this means that not only is Veneto much more virtuous than Campania in achieving the objectives of the L.D. 152/06 but also that the lower SWC inequality denotes that most of its municipalities have achieved high levels of performance in waste management with less variability within the region.

By analysing how each component (regional vs. municipal effects) contributes to the overall differences, it is worth noting a guiding principle: while the municipal level plays a significant role in increasing the advantage of Veneto over Campania, the regional level contributes to reduce it. This could imply that the policies and strategies for waste management deliberated by the regional authority in Campania should be even more effective at the initial stage. In compliance with the Directive 2008/98/EC, the regional plan of Campania, entered into force in 2012, is based on the following objectives: (1) minimising the impact of the waste cycle, protecting human health and the environment; (2) conserving resources such as materials, energy, and space; (3) managing waste for future generations ("after care free"); (4) achieving regional self-sufficiency in urban waste management; (5) treating in a reasonable time all the waste that had been stored for years in regional territory; and (6) achieving economic sustainability of the waste cycle. In particular, the plan is based on the concepts of prevention, preparation for reuse, recycling, other recovery types, and disposal. However, the potential of the regional plan has not completely exploited in the successive implementation steps determined by each municipality. Veneto otherwise seems to overcome the geographical fragmentation in waste management across municipalities promoting managerial integration among the different activities involved in the waste cycle.

5.2 Regional Component

The regional component of decomposition allows evaluating the effectiveness of policies, strategies and plans for waste management that have been adopted in Campania and Veneto based on the criteria defined by the national legislation (Art. 196, L.D. 152/2006). As discussed in Sect. 5.1, Campania has a better position in SWC mean levels with respect to Veneto in the regional effect, while there is no statistical significance of this component as regards the Gini gap. This confirms the equivalence of the strategies at a regional level that seek to give each municipality the best conditions to manage urban waste. In this section, we investigate the main determinants of the advantages of Campania in waste management.

Table 4 shows the contribution of covariates to the regional and municipal components. It is noteworthy that the regional divide between the mean levels of SWC is explained by

Table 4 RIF decomposition of Mean and Gini on log-SWC rate by each variable. Gap Campania versus Veneto

	Mean		Gini index	
	Regional effect	Municipality effect	Regional effect	Municipality effect
GeomorPHOlogical				
Overall surface	0.443 (0.624)	0.246*** (0.053)	−0.023 (0.140)	−0.035** (0.014)
Elevation ab. sea	0.507*** (0.101)	−0.039*** (.009)	−0.061*** (0.014)	−0.017*** (0.005)
Socio-economic				
Population density	0.625 (1.261)	−0.121** (0.052)	0.025 (0.242)	0.019* (0.011)
Metropolitan area	0.102*** (0.02)	−0.005 (0.003)	−0.005*** (0.001)	−0.005** (0.002)
Education rate	2.234*** (0.718)	0.005 (0.011)	−0.502*** (0.140)	−0.014*** (0.003)
Unemployment rate	−0.177 (0.172)	0.007 (0.39)	0.012 (0.021)	0.005 (0.009)
Couples with children	−1.167 (1.396)	−0.106** (0.049)	0.056 (0.286)	0.015* (0.009)
Value added	1.795*** (0.352)	0.071*** (0.011)	−0.304*** (0.073)	0.002 (0.002)
Institutional quality				
IQI	−0.514** (0.205)	−0.979*** (0.092)	−0.089 (0.068)	0.064*** (0.018)
Constant	−3.213*** (0.930)	–	0.880*** (0.185)	–

Standard errors in brackets

*Significant at 10%

**Significant at 5%

***Significant at 1%

some *socio-economic* (e.g., metropolitan area, education rate, value added) and *institutional quality* determinants. Analysis of the socio-economic factors enables us to obtain interesting evidence in favour of Campania. The comparison between the *metropolitan cities* of Naples (Campania) and Venice (Veneto) shows that regional-level management of large areas is more difficult in Veneto. Venice makes it more difficult to improve the separate waste collection process through the implementation of regional planning policies, probably due to more complex management of the negative congestion effect (Hage and Söderholm 2008) that usually characterises the major cities. *Education* is linked to higher SWC rates in Campania. This means that the opportunity cost of time for educated young people in Campania is likely lower than that for their counterparts in Veneto. In other words, it seems that the citizens of Campania have greater appreciation for valuing future time periods (Bruvoll and Nyborg 2004) and better understand the social importance of pro-environmental behaviour. The interpretation of *value added*-based comparison is more ambiguous in that many empirical studies argue that separate collection and prosperity of a region are positively correlated (Callan and Thomas 1997; Di Vita 1997; Berglund and Söderholm 2003). Although Veneto is a richer region (Table 2), our results suggest

that value added plays a role in favour of Campania. This pattern may be explained by the relation among consumption, value added and opportunity cost of time (Mazzanti et al. 2008, 2009; D'Amato et al. 2015). This means that the growth of prosperity can lead to higher levels of consumption and thus more waste generation, and simultaneously, separate collection activities may become less attractive for citizens.

In contrast to socio-economic variables, *institutional quality* favours Veneto. IQI is a proxy for good waste management (and, in general, of virtuous management of public affairs), and the results confirm higher institutional quality in Veneto. The weakness of the institutions is a historical issue in Campania and was one of the major reasons for the waste emergency in 1994–2009 (D'Alisa et al. 2010). The failure of the political bodies has made the region vulnerable to illegal activities favouring the proliferation of speculative interests (D'Alisa et al. 2010), which, in turn, have made the waste management process in Campania more difficult than elsewhere. Poor waste management can be identified as a non-monetisable component of social costs that has created environmental disruption solvable though integrated waste management (D'Alisa et al. 2010; Distaso 2012). The aim of integrated management is environmental sustainability pursued through cooperation between citizens and institutions to create "environmental participation" in each step (design, implementation and evaluation) of regulation (de Miranda Ribeiro and Kruglianskas 2015; Agovino et al. 2017).

5.3 Municipality Component

The municipality component represents the lowest administrative level in the waste management process, and it makes the national and regional plans operative (Art. 198, L.D. 152/2006). As already illustrated (Sect. 5.1), the RIF decomposition highlights that the overall advantage of Veneto, in both mean and inequality analyses, is explained by the municipal effect, and the leading role of Veneto is mainly due to population density, elevation above sea level, couples with children, and quality of institutions. The results of the decompositions are shown in Table 4 (Sect. 5.2).

The region of Campania has a higher mean *population density* than Veneto (Table 2). Although the growth of population density can lead to reduction of separate collection costs (Bello and Szymanski 1996), due to the presence of economies of scale, high-density areas may have problems linked to congestion (Hage and Söderholm 2008). Campania could be penalised by the larger proportion of densely populated municipalities because these areas may have service inefficiency due to limited space for storing waste and more difficulty in implementing adequate strategies for separate collection (Simões et al. 2012). Unless convenient programs are underway in Campania's towns, trash may be the default, and SWC is utilised less intensely than in Veneto. Similar considerations can be made for *elevation above sea level*. In fact, in Campania, municipalities have, on average, higher elevation than those in Veneto (Table 2). This morphological characteristic makes both the operational management of separate collection and monitoring activities designed to control how citizens perform separate collection more complex (Sarra et al. 2017). Being a *couple with children* improves the mean level of SWC and inequality across municipalities of Veneto with respect to Campania. Because in our work this variable measures the pro-environmental sensibility of citizens, our results highlight the greater involvement and active participation of Veneto inhabitants in public problems. Pro-environmental behaviours, as well as socio-cultural factors in general, are critical to explain the SWC divide across areas. They represent an intrinsic incentive, which generates satisfaction from participating in programs that help the community preserve natural resources (Hornik et al.

1995). Furthermore, belonging to a virtuous community can lead to social influence (Vining and Ebreo 1990) according to which individuals are encouraged to recycle because it is considered socially qualifying conduct. In fact, in most municipalities of Veneto, many efforts have been oriented, through numerous campaigns, to making households aware of the need to implement radical transformations in the waste collection systems. This has led to exponential growth in SWC rates in most Veneto municipalities.

6 Discussions

The empirical results have confirmed Veneto as benchmark for Campania in the process of separate collection. We have shown that Veneto has a considerable advantage in terms of differentiated collection compared to Campania, in terms of both the average percentage and equidistribution of the separate collection rate at the municipal level.[9] In particular, Veneto's advantage is due to good management of separate collection by municipalities (Article 198, L.D. 152/2006). In contrast, at the regional level (Article 196, L.D. 152/2006), Campania shows an advantage over Veneto. The regional advantage of Campania is the effect of an improvement in planning activity that the region made in 2012.

2012 was the year in which Campania approved the new Regional Management Plan for Urban Waste. In a nutshell, the new regional plan has placed at the centre of the waste management process the enhancement of recycling as advocated by the theory of the social costs applied to waste management (the 2nd operating principle (see the Introduction)). Now, good planning does not always have a good result. In fact, our analysis shows that the municipalities of Campania (operational units in the separate collection process) have not yet caught up to the municipalities of Veneto, which are still a good reference benchmark. In particular, the municipalities of the city of Treviso (province of Veneto) demonstrate best practices for municipalities in Campania. The city of Treviso has a population of almost 83,731 (1507 inhabitants per square km) and the whole province consists of 95 municipalities. Treviso is a rich province with an average GDP per capita of € 30,274 (2008) against a national average of € 26,278 (Bucciol et al. 2011). In 1988, the province of Treviso was divided by the regional plan for urban waste management into three territorial units, TV1 (composed of 24 municipalities), TV2 (42 municipalities) and TV3 (25 municipalities). A consortium has been promoted within each of the new territorial units to ensure that decisions on waste management and disposal are no longer independently taken by each municipality as they had previously been. In this way, municipalities might benefit from economies of scale (Bucciol et al. 2011). TV1 was the most successful territorial unit in terms of differentiated collection through efficient and effective waste management plans. Their preparation and operational characteristics are important and can be a benchmark for the municipalities of Campania.

The Priula Consortium was founded in 1987 in the TV1 territorial unit. The first decisive turning point for this consortium took place in 2000 when the door-to-door waste collection system (DtD) and a consumer charging system PAYT (Pay-As-You-Throw) were introduced to the detriment of a drop-off system and of the standard flat rate system

[9] The municipalities of Veneto form homogeneous clusters with highly differentiated collection rates generating spatial clusters that can be explained by spatial diffusion processes (Agovino et al. 2016; Crociata et al. 2016). In contrast, the municipalities of Campania show a patchy distribution of SWC that does not generate spatial clusters.

calculated considering only the number of family members and the square metres of the house (Bucciol et al. 2011).

The new DtD waste collection system is innovative with respect to classic drop-off harvesting. In fact, with the old method, waste had to be differentiated in the home and then brought to the places where the bins had been placed, located along roads and sometimes not convenient to reach. Regarding the PAYT tariff system (Kinnaman 2006, 2010), the main innovation lies in saving on the urban waste bill. Thanks to this innovative system, the amount of tax is no longer calculated solely on the basis of the size of the dwelling and the number of family members but also on the amount of non-differentiated waste produced: To the fixed cost linked to these two characteristics was added a variable cost based on the number of times the bin containing the unsorted waste had to be emptied. This dual and concomitant innovation has had extraordinary and almost immediate effects on two fronts: (1) reducing the production of non-recyclable solid waste by increasing the SWC rates and (2) reducing the cost of waste disposal that weighs on the household budget.

Bucciol et al. (2015), decomposing the effect of PAYT and waste collection door to door, have shown that the former has generated an increase of 17% of separate collection in the municipalities of Treviso while the latter has increased recycling by 15.7%. This allows the conclusion that the combination of both schemes (PAYT and DtD) may be a solution to the high production of waste in Campania and a useful tool to increase the percentage of separate collection in its municipalities (Yeomans 2007).

7 Conclusions

In this paper, we compared two Italian regions, Campania and Veneto, to study their territorial SWC divides and understand the main forces underlying them. The analysis was carried out with the dual aims of analysing the gap between the mean levels of SWC (*intensity*) and the gap between their inequality levels across municipalities within the same region (*inequality*). In the framework of the L.D. 152/2006, which specifies the administrative competences of regions and municipalities in waste management, we decomposed these gaps into the share due to the regional component and the share due to the municipal component.

While a quantity of studies have been designed to assess—and decompose—the temporal SWC trends and differentials over time seeking to identify their origins, little evidence exists on the extent of regional gaps in SWC in light of national settings and local policies using municipal-level data. Our analysis highlights some interesting evidence. Veneto is more virtuous than Campania in achieving the objectives of the L.D. 152/2006, and the lower SWC inequality denotes that most of its municipalities have achieved high levels of performance in waste management. However, its best-performing position in Italy is exclusively due to the better capacity of local administrations in the implementation step of the waste management plans (municipality component). Conversely, the results show more effectiveness for Campania in terms of the regional component. This means that the policies set by the regional authority in Campania should be even more effective even though they are partly frustrated in the implementation stage controlled by each municipality. One of the primary determinants of poorer performance of most municipalities in waste management in Campania lies in the weakness of local institutions with inevitable environmental damage. The latter can be identified as a non-monetisable component of social costs, which can be at least partially reduced through ongoing cooperation among citizens, institutions, and other social partners.

Our analysis can be expanded in the future. Currently, it is only focused on 2012 and for this reason our goal will be to explore the evolution of territorial divides from a longitudinal perspective. This will enable us to capture the changes over time in the contribution of regional and municipal components to SWC gaps in light of the changes in local waste management plans. Since this analysis focuses on the urban waste generated by households, it could be useful to extend to the urban waste produced by other activities such as industry, construction or demolition. Finally, we could consider including in our analysis other Italian regions.

Appendix

See Tables 5 and 6.

Table 5 RIF-regression coefficients (Mean and Gini index) on log-SWC rate. Campania and Veneto, 2012

	Campania		Veneto	
	Mean	Gini index	Mean	Gini index
GEOMORphOLOGICAL				
Overall surface	−0.517***	0.097***	−0.674***	0.105***
	(.191)	(.037)	(.112)	(.023)
Elevation AB. SEA	0.068***	−0.012***	−0.027***	0.004***
	(.018)	(.003)	(.006)	(.001)
SOCIO-ECONOMIC				
Population density	−0.480**	0.095**	−0.595***	0.090***
	(.198)	(.038)	(.117)	(.025)
Metropolitan area	0.552***	−0.062***	−0.060*	0.008
	(.104)	(.020)	(.036)	(.007)
Education rate	0.569***	−0.012***	0.043	−0.005
	(.139)	(.027)	(.095)	(.020)
Unemployment rate	−0.055	0.005	0.006	−0.001
	(.047)	(.009)	(.037)	(.008)
Couples with children	0.448**	−0.091**	0.630***	−0.100***
	(.185)	(.035)	(.114)	(.024)
Value added	−0.009	−0.007	−0.199***	0.023***
	(.030)	(.005)	(.021)	(.004)
Institutional quality				
IQI	2.279***	−0.226***	3.432***	−0.103
	(.333)	(.064)	(.319)	(.068)
Constant	1.502*	0.600***	4.715***	−0.280***
	(.794)	(.154)	(.485)	(.103)

Standard errors in brackets

*Significant at 10%

**Significant at 5%

***Significant at 1%

Table 6 List of variables

Dimensions	Variables	Description	Source	References
Outcome	Separate waste collection rate	Ratio of tons of separate waste to total tons of urban waste produced	ISPRA	Legislative Decree 452/2006 Agovino et al. (2016, 2017)
Geographic	Overall surface	Square kilometres of the entire town	ISTAT	Domberg et al. (1986) Simões et al. (2012)
	Elevation above sea	Elevation (in metres) of a location in reference to sea level	ISTAT	Sarra et al. (2017)
Demographic	Population density	Ratio of the number of people per square kilometres	ISTAT	D'Amato et al. (2015) Mazzanti et al. (2008)
	Metropolitan area	Dummy variable: 1 if the municipality belongs to metropolitan area	ISTAT	Legambiente (2012) Fiorillo (2013)
Socio-economic	Education rate	Percentage of young people (aged 19–34) who have completed upper-secondary education	ISTAT	Schultz et al. (1995) Callan and Thomas (1997) Hage and Söderholm (2008)
	Unemployment rate	Percentage of workers (aged 16–64) who are unemployed to the overall labour force	ISTAT	Hage and Söderholm (2008)
	Couples with children	Percentage of couples with children	ISTAT	Stern et al. (1995) Corraliza and Berenguer (2000)
	Value added per cap	Value added per inhabitant	ISTAT	Mazzanti et al. (2008) Mazzanti et al. (2009) D'Amato et al. (2015) Agovino et al. (2016)
Institutional quality	IQI	Composite indicator obtained by five dimensions: Voice and Accountability, Government effectiveness, Regulatory Quality, Rule of Law, Corruption	SIEPI	Nifo and Vecchione (2014) Mazzanti and Zoboli (2008) Agovino et al. (2016)

ISPRA—Italian Institute for Environmental Protection and Research (http://www.isprambiente.gov.it/it)

ISTAT—National Institute of Statistics (http://dati.istat.it/)

SIEPI—Italian Society of Economics and Industrial Policy (https://siepi.org/)

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