Measure the difference in efficiency in waste disposal and collection services from the EU targets in the Campania municipalities.

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Abstract

The study analyses the economic and environmental performance of the 353 municipalities in the region of Campania in the waste disposal and collection services. This study consists of three steps, firstly municipal performance in the management of waste services from a linear economy point view is assessed. Secondly, a circular economy paradigm is considered and jointly the economic (minimization of management costs) and environmental (waste minimization) performance of municipalities management is measured; two different DEA models are employed using information provided by the Institute for Environmental Protection and Research for the year 2016. Third, in order to rank the most virtuous municipalities in the environmental dimension (toward a circular economy paradigm), the study defines a measure of the efficiency deviation from environmental sustainability. The results show a cluster of municipalities in the metropolitan area of Naples and Caserta with a worse performance in the environmental dimension but with a good performance in the economic dimension. The succession of national and regional regulations has accentuated the uncertainty in the executive process and in the management of the waste cycle, creating a regulatory vacuum. Local governments should act on citizen motivations, promoting awareness on environmental issues, and should implement time-saving collection methods.

JEL: D61; H3; H76; I38; Q24; Q53; Q56; R14;

Key words: *environmental performance, economic performance, environmental sustainability, Environmental economics, waste services, DEA, Campania municipalities, separate waste collection (SWC), Legislative Decree 152/2006.*

Highlights*:*

1. *Collecting recyclable materials is the basis for the processes of circular economy's recovery, reuse, and recycling*

2. *We analyze the economic and environmental performance of the 353 municipalities of the Campania region in waste disposal and collection services.*
3. *Two different input-oriented models are used using the input and output information provided by the Institute for Environmental Protection and Research for the year 2016.*
4. *The analysis highlighted the importance of jointly assessing the economic and environmental dimensions of the production process relating to the municipal solid waste management service*

1. Introduction

Significant concerns over the environmental impact of waste, primarily involving human health and the environment, have emerged in European countries. There is a need for a more efficient use of resources throughout their entire life cycle. In this context, a development strategy achieving zero waste is highly relevant in the path towards a circular economy, since it allows to keep products at their highest value for as long as possible through recycling (European Commission Report 2014; Malinauskaite, et al., 2017). Collecting recyclable materials is the basis for the processes of circular economy's recovery, reuse, and recycling. Over the last decades, waste management has become a pivotal element in European environmental protection policies. The growing focus on municipal solid waste reduction, re-use and recycling by national and local governments has prompted important reforms of municipal waste policies.

Regulatory frameworks, both at European and national level, pose great emphasis on the prevention and minimization of unsorted urban waste production and on the maximize the recovery of materials through the separation collection. The recent European framework directives (UE 2018/850, 2018/851 and 2018/852) impose on the one hand the necessary misalignment between economic growth and the increase in consumption and production waste, and on the other hand the optimization of waste management systems for the purpose of maximizing the recovery of waste (recycling objective) and of minimizing the production of unsorted waste (reduction landfills use objective). In particular, the circular economy package sets targets for the recycling of municipal waste (reaching at least 55% by 2025, 60% by 2030 and 65% by 2035), the reuse of different materials and the reduction of use of landfills (by 2035 a maximum of 10% of the total urban waste). However, it is not possible to achieve they, without taking into account the effectiveness issue of waste management system at municipal level. These, among other things, allow the achievement of both direct and indirect economic benefits, as the creation of new firms and the increase in jobs (Agovino et al., 2019a).

In deep, the Directive 2008/98/EC established specific targets, in order to limit the production of waste, using it as a resource, so as to create a "recycling society with a high level of efficiency". The Directive has been transposed in Italy by the Legislative Decree 205/2010, which set the targets for separate waste collection, recovery and recycling, defining the responsibilities among the actors of the national waste management system. However, it is not possible to achieve these targets, without taking into account the effectiveness issue of waste management policies as well as the efficiency of disposal and collection waste services. In Italy, the regulation of the waste management system passed through three milestones: 1) in 1982, Decree of the President of the Republic (D.P.R.) n. 915/1982; 2) in 1997, L.D. n. 22/1997; 3) in 2006, L.D. n. 152/2006. After the introduction of L.D. 152/2006, the level of separate waste collection increased at a national level, but high regional differences persisted. Northern regions seem to be more dynamic and reactive to the regulatory novelties, while Southern regions achieved poorer and more heterogeneous results in terms of separate waste collection (Agovino et al., 2021). Crociata et al. (2016) studied the separate collection rate across Italian provinces between 1999 and 2012. They highlighted the presence of two clusters of provinces: i) Northern Italian provinces with values above the national average (good cluster); ii) Southern Italian provinces, including Campania, featuring values below the average (bad cluster). These studies showed that improving separate waste collection (SWC) achievements plays a pivotal role in narrowing the territorial gaps between Campania and top regions in terms of environmental performance. However, achieving a high level of SWC requires significant efforts, that can only be obtained through the joint action of citizens and institutions (Agovino et al., 2018). There are regions where the planting framework is completely lacking or totally inadequate; this is the case of Sicily, where municipal waste disposed of in landfills still accounts for 69% of the total waste produced, but also of Lazio and Campania, which cannot close the cycle within the regional territory.

A significant part of current literature has focused on waste management issues (collection and disposal process) in order to evaluate the efficiency of the process and the effectiveness of the implemented policies and/or study the relationships between policy makers guidelines and citizen action (Barr et al., 2001; Barr et al., 2005; McDonald and Oates, 2003; Tonglet et al., 2004; Timlett and Williams, 2009; Lombrano 2009; Marques and Simões, 2009; Koushki et al., 2004; Agovino et al., 2018). The negative impact of poor management of the waste process can have both environmental and economic effects (Distaso, 2012). Most of the current literature has focused on the issue of waste management in Campania addressing the complexity of the underlying causes of a waste emergency in the region (D'Alisa and Kallis 2016, Garofalo et al., 2019).

In the light of all the above, Campania is an interesting case study since, despite the declaration of emergency status from year 1994 to 2009 year (‘waste crisis’). Numerous papers have been written on the topic of waste in Campania (Armiero and D'Alisa, 2012; Triassi et al., 2015; De Biase, 2009; Membretti, 2015; D’Alisa and Kallis, 2016; Agovino et al., 2019b), addressing the complexity of the factors underlying the waste emergency that recently affected the region. A mix of technical-administrative errors and political, industrial and only partially identified criminal interests may be held responsible for the poor environmental performance of the area (see Distaso, 2012; Armiero and D'Alisa, 2012; D’Alisa and Kallis, 2016). In 2009, during the waste emergency, the rate of separated waste in Campania was 29.3 %, far below the 48 % achieved in Northern regions and about one half of the 57.8 % recorded in Trentino-South Tyrol, the best performing region (Ispra, 2014). In the space of 22 years, in the territories belonging to two provinces (i.e. Naples and Caserta), about 10 million tons of waste of any type and degree of danger have been buried (Legambiente, 2013). These constitute only a part of the waste buried in the Campania territories. This is confirmed by the discovery of the largest illegal landfill in Europe. The landfill has an area of 25 hectares, and it is estimated that about one million cubic meters of waste are buried in it; over 50% of the waste was found to be “special hazardous waste”.

This region has gone from one of the worst Italian regions in terms of separate waste collection to one of the most virtuous in southern Italy, as shown by Agovino et al., 2020. However, it is often at the local level (especially at the municipal level) that the national laws are operationalized, and further waste management policies and schemes are adopted. It is for this latter reason that the study investigates the performance of the waste services process in Italian municipalities after about ten years on from the ‘waste crisis’. These facts certainly constitute strong arguments for the need for careful monitoring of the performance of local waste management systems on the various EU targets mentioned above.

This study consists of three steps. Firstly, the performance of Italian municipalities in the collection and disposal process of solid urban waste considering only an economic dimension is assessed. In this case, the more efficient local government units will employ, on equal output levels, a lower amount of expenditure to dispose waste. Secondly, following the suggestions made by Sarra et al. 2017, the joint economic and environmental performance of the municipalities in the waste services process is evaluated. In this case, the municipalities with the best performance will use, on equal levels of ‘good’ output, both a lower amount of expenditure to dispose waste and a lower amount of bad output which increases the risk of landfill use (economic and environmental dimension of efficiency). The landfill is in fact the last stage of the waste cycle. It contains all the materials that are no longer usable (undifferentiated) and that must be permanently eliminated. To this end, two different input-oriented models, the Banker, Charnes and Cooper Data Envelopment Analysis models are employed using input and output information provided by ISPRA (The Institute for Environmental Protection and Research) for the year 2016. Third, in order to rank the most virtuous municipalities in the environmental dimension, the study defines a measure of the efficiency deviation (gap) from environmental sustainability (a measure of the efficiency deviation from EU targets). This gap may occur when the environmental dimension is neglected in the production process to a greater economic efficiency: expenditure minimization, while environmental damage occurs.

The remainder of this study is as follows. Section 2 presents the empirical strategy, the case study and the dataset. Section 3 reports the results and discusses them. Section 5 presents some conclusions.

2. Material and methods

This section presents the methods and the dataset used to investigate the waste service process performance of the Campania municipalities.

2.1 Methods

The study employs Data Envelopment Analysis (DEA) to evaluate municipal's efficiency of waste services.

In the municipal solid waste sector especially, DEA analysis has been performed to evaluate particular services provided by municipalities, like waste collection (Worthington et al., 2001; Benito-López et al., 2011, Simões et al., 2013), to estimate the performance of different regions in recycling (Lozano et al., 2004, Chang et al., 2013, Yeh et al., 2016, Crociata and Mattoscio, 2016), to optimally select sites for locating SW facilities (Khadivi and Ghomi, 2012). Most of those studies aim to evaluate the cost efficiency (Huang et al., 2011, Rogge and De Jaeger, 2013, Spallini et al., 2016, Amaral et al., 2022) or the operational efficiency (Ichinose et al., 2013, García-Sánchez, 2008) of municipal solid waste services. Recent studies have focused on the importance of inter-municipal cooperation the efficiency of waste management (Guerrini et al., 2017, Máñez et al., 2016, Pére z-López et al., 2018, Sarra et al., 2017, Amaral al., 2022).

Unlike parametric techniques, DEA does not require a detailed description of the production process and allows to assess the relative efficiency of homogeneous operating units (DMUs). The efficiency scores are obtained assuming the *input-orientation* in the (collection and disposal) solid urban waste services production process manage by the municipalities (our DMUs). The orientation to input assumes that DMUs have more control over the inputs (i.e. costs) than over the outputs (i.e. waste). Municipalities performance is assessed for two different models i.e., Model I and Model II respectively. In particular, Model I computes municipalities performance considering only the economic dimension of production process. In this case, DMUs with a better *performance* (more efficient) will employ, on equal output levels (total disposed waste), a lower amount of expenditure to collect and dispose waste**.**

Model II, following Sarra et al. 2017, jointly assesses the economic and environmental performance of municipalities in the urban waste services process. In this case, the municipalities with the best performance will use, on equal levels of *good output* (environmental benefit), both a lower amount of expenditure to dispose waste and a lower amount of *bad output* which damages the environment (*economic and environmental dimension of efficiency*). The waste from Sorted Waste (SW, good output) and Unsorted Waste (UW, bad output) are treated differently when municipal performances are evaluated from an *environmental dimension*. Collecting recyclable materials is the basis for the processes of recovery, reuse, and recycling, while the amount of unsorted waste cannot be reused and it must be disposed of in either landfills or incinerators, and this damaging the environment. Environmental performance of the production process increases when UW to be treated is reduced. There are different literature approaches that account for bad output (see Halkos and Petrou, 2019), Model II, in light of the analysis aims, treats UW as a classical input (indirect approaches): UW is an undesirable output which public agents have to minimize. Indeed, considering UW among the inputs allows to consider an *input-oriented model* where the maximum reduction refers not only to expenditure (costs) but also to undesirable waste as a deterrent factor for environmental sustainability.

Both Models (II and I) analyse the efficiency of DMUs by the *input-oriented* Banker, Charnes and Cooper (BCC-I) DEA model. The following linear programming (LP) problem under the BCC-I model is solved:

$$h_o = \min_{\theta_o, \gamma} \theta_o$$

s.t.

$$\theta_o x_{oki} - \sum_{i}^{n} \gamma_i x_{ki} \geq 0 \qquad k = 1, \dots, K$$

$$\sum_{i}^{n} \gamma_i y_{mi} \geq y_{omi} \qquad m = 1, \dots, M$$

$$\sum_{i}^{n} \gamma_i = 1 \qquad \text{convexity constraint}$$

$$\theta_{oi}, \gamma \geq 0$$

where $\boldsymbol{y_{mi}}$ is the amount of the *m*-th output to DMU i, $\boldsymbol{x_{ki}}$ is the amount of the *k*-th input to DMU i and $\boldsymbol{\gamma}$ are the weights of DMU *i*. The value of $\boldsymbol{\theta_o}$ obtained is the ES for the i-th municipalities and is bounded between 0 and 1. According to the Farrell (1957) definition, when $\boldsymbol{\theta}$=1 the DMU is technically efficient (i.e. a point on the frontier), while inefficient DMUs will score less than one.

In summary, the empirical analysis is divided into three steps.

The first two steps evaluate the performance of the waste management service considering two different dimensions and employing two different BCC-I DEA models, which assumed Variable Returns to Scale, under *input-orientation* to calculate the ES (θ_o) of DMUs:

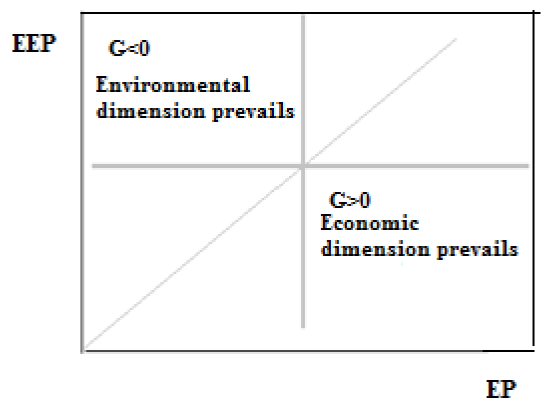
- Model I of the economic dimension: The production process involves as a factor of production one input – i.e., the total annual costs per capita of managing the urban hygiene service - to produce the final output (disposed waste).

- Model II of the environmental and economic dimension: The production process involves as a factor of production one input – i.e., the total annual costs per capita of managing the urban hygiene service – to produce two outputs: a good output (environmental benefit) and a bad output (environmental damage). Both input and undesirable outputs are the values that need to be minimized. The model incorporates environmental damage as an input, which needs to be decreased to improve the performance of a DMU. The following constrain is added to the BCC-I DEA models considered**:** $\theta_o d_{osi} - \sum_i^n \gamma_i d_{si} \geq 0 \;\; s = 1, \dots, S$; where d_{si} is the amount of the *s*-th bad output to DMU *i.*

In the third step of analysis, in order to operate a ranking of the most virtuous municipalities in the environmental dimension, we define a measure of the efficiency deviation from environmental sustainability, labelled G. G is given by the difference between the Model I and Model II efficiency scores. This gap occurs when the environmental dimension is neglected in favor of greater economic efficiency (expenditure reduction while environmental damage occurs).

Figure 2 shows the deviation box. The vertical axis measures the economic performance achieved without damage to the environment while the horizontal axis measures the performance of the municipalities in the waste management and disposal process in the absence of environmental compliance assessments. There are four possible outcomes. In the first quadrant, there will be the most virtuous municipalities: the environmental performance exceeds the economic one (G <0); The municipalities in the second quadrant will have a high environmental performance and a high economic performance. The municipalities above the bisector, however, will have an environmental performance higher than the economic one (G <0); while for the municipalities below, the bisector economic dimension will prevail (G> 0). The municipalities of the third quadrant will be characterized by a low environmental and economic performance. The prevalence of one or the other dimension depends on the position with respect to the bisector. In the fourth quadrant G, it is greater than zero and the municipalities reach high levels of economic performance but with a positive gap of environmental inefficiency.

Figure 2. Deviation from environmental efficiency Box



Note: environmental inefficiency gap (G) = Scores mod. I - Scores mod. II

2.2 The case study

Campania is a predominantly hilly and mountainous region and the plain part is mainly on the coast. The population is concentrated in the plains and hills. The main characteristics of this area are: the very high population density (427 inhabitants/sq. Km) first among the Italian regions, the very high concentration of population in the metropolitan city of Naples (about 53% of the regional population). The degree of urbanization is very low in over half of the municipalities, while almost 60% of the population lives in those with a high degree of urbanization (about 15.5%). With regard to the administrative structure in the Region, there are mainly medium-small municipalities (84.5% below

15,000 inhabitants) where 31% of the population lives; in addition, there are few municipalities with over 50,000 inhabitants where 38% of the population lives.

The Region produces about 2.6 million tons of waste per year (above the national average), with a per capita level of 450 kg/inhabitant/year. The organization and management of waste collection, disposal and recovery services and the collection of related taxes are functions entrusted to the municipalities.

However, in order to avoid fragmentation in service performance and achieve an optimal operational scale, art. 199 of 'Consolidated Environmental Law' provides that the Municipalities have to exercise their urban waste management competences in a collective form, on the basis of Optimal Territorial Areas (ATO). Regional law n.14 of 2016 defined a structure divided into seven ATOs, four of which correspond to the provincial (NUTS-3) territories (Avellino, Benevento, Caserta and Salerno) and three within the territory of the Metropolitan City of Naples. Each ATO can be divided into homogeneous areas called Sub-District Areas (SAD) within which the municipalities can regulate their relations through agreements. With regard to the size and characteristics of the ATOs, it should be noted that those of a provincial dimension, despite having a territorial extension and a number of municipalities greater than the sub-provincial ones (in the metropolitan cities of Naples), nevertheless have a lower population. Until the full operation of the local authorities, the municipalities can manage and decides how to contract their services. For this reason, the analysis considers municipalities as DMUs.

The urban waste management system can be divided into various heterogeneous phases with their own characteristics: collection and transport, treatment, energy recovery/recycling of materials/disposal. The phase of waste collection and transport is characterized by the prevalence of the labor over capital input and, therefore, by a limited incidence of *sunk costs*. The treatment phase is characterized by the prevalence of the capital on labor input, by the high initial investment costs (sunk cost) and the long amortization periods. The disposal phase is the last phase of the waste cycle. This is since the waste management hierarchy set by the European Commission establishes that the use of the landfill should only affect materials that cannot otherwise be exploited. The waste remaining after the treatment phase is sent to the landfill.

Table 1 shows the descriptive statistics of the variables used in the analysis. The data are provided by ISPRA (The Institute for Environmental Protection and Research) and refers to 353 municipalities (NUTS-4) in the Campania region for the year 2016.

The total cost (TC) of the municipal solid waste management service is on average 161.395 euros per inhabitants and includes the following cost items, as set by the provisions of Presidential Decree 158/99

"*Regulation containing rules for the development of the standardized method for defining the tariff for the urban waste management service urban*":

- *Operating costs of services regarding unsorted municipal waste* (UWC) is on average 60.580euros per inhabitants and includes four components: street sweeping and washing costs; collection and transport costs; treatment and disposal costs; other costs, inherent to the management of unsorted municipal waste, not included in the previous items.

- *Costs of managing separated waste collection cycle* (SWC) is on average 58.361 euros per inhabitants and includes: costs of separated collection of individual materials; treatment and recycling costs, net of proceeds from the sale of materials and recovered energy and CONAI contributions.

- *Common costs and capital costs* (KC) that include the following expenditures: administrative costs of the assessment, collection and litigation; general management costs; depreciation of machinery for collection, sweeping, collection containers, financial depreciation; return on capital (R).

The average per capita cost for the management of unsorted waste (on average 60.580 euros per inhabitant) is higher than the average per capita cost of services linked exclusively to separate waste collection (on average 58.361 euros per inhabitant).

SC (on average 225.546 kg per inhabitant) and WS (on average 143.663 kg per inhabitants) denote, respectively, urban waste separately collected and unsorted urban waste collected variables. Art. 183 of Legislative degree 152/06 (paragraph f) provides a definition of separate collection. It is defined as: "*collection which aims to: i) group urban waste into homogeneous categories; ii) group packaging waste materials separately from other waste. Finally, separate collection must be performed according to cheapness, efficiency, transparency and efficiency criteria*".

Table 1. Summary statistics

Variables	**Minimum**	**Mean**	**Maximum**	**Standard Deviation**	**Median**
Inputs					
UWC	1.73	60.580	277.07	36.547	54
SWC	0.95	58.361	207.76	35.155	56.74
KC	0.01	42.45	277.39	43.073	30.72
TC	34.66	161.395	522.23	64.71314	150.12
Outputs					
SW	6.508	225.546	609.248	83.11064	213.9122
UW	4.798	143.663	505.99	78.25892	123.1645

TW	137.581	369.429	1008.18	117.3605	354.9546

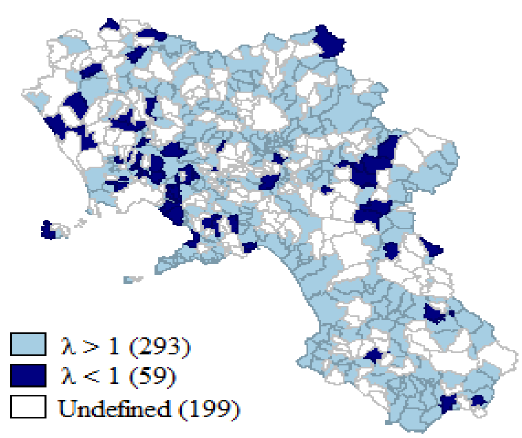
Source: Elaboration of ISPRA 2016 data

Notes: all costs are expressed in euros per inhabitant; UW and SW are expressed in kg per inhabitant.

In order to have additional information on the levels of UW and SW in each municipality, we define a measure of environmental tightness in the management's urban waste services as the ratio of SW to UW, λ labelled. This tightness may affect the performance of the production process and, therefore, the results of efficiency deviation from the environmental sustainability i.e., to have or not to have a gap in terms of environmental efficiency. This is because separate collection is a precondition for recycling (as set by the European and Italian normative frameworks). On the contrary, the quantity of unsorted waste (which cannot be recycled) ends up in landfills. If $\lambda < 1$ the amount of separate collection per capita is less than the amount of unsorted waste per capita and it means that the process is characterized by a high environmental tightness (high risk of environmental unsustainability). For municipalities with a value of λ less than one, the probability of being placed in the third or fourth quadrant of *deviation from environmental efficiency Box* (**Figure 2**) is high. Lower levels of λ make it more difficult to achieve environmental sustainability by local government and implies negative externalities. Conversely, if λ is above the unit, the municipal waste management should be performer better in terms of environmental sustainability.

Figure 3 shows that only 56 municipalities have values of λ less than one i.e., the amount of per capita separate collection is less than the amount of unsorted waste per capita. These municipalities are mostly concentrated in the Neapolitan and Caserta area and only a few municipalities are in the Avellino, Salerno, Benevento area.

Figure 3. Box map of environmental tightness

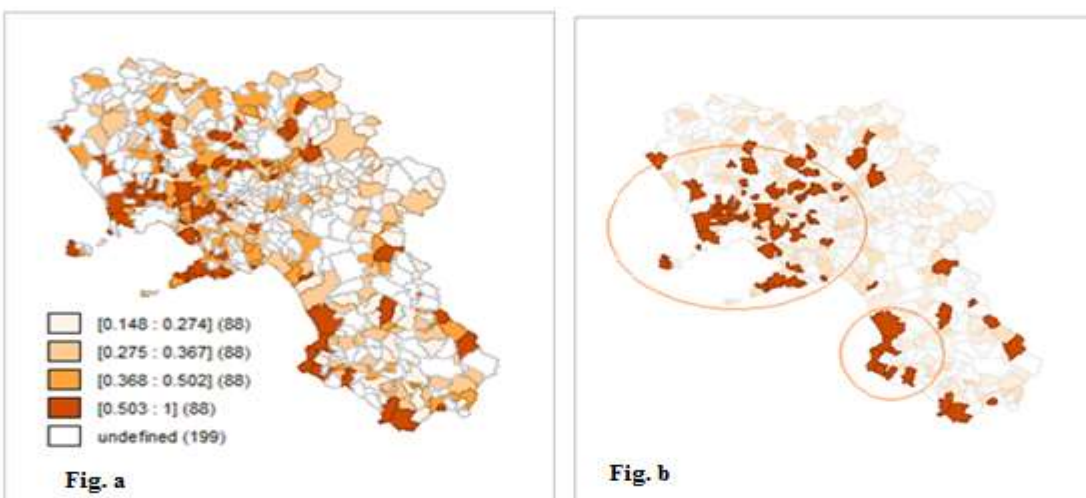


Source: Elaboration of ISPRA 2016 data

3. Results and discussions

Figure 4 shows the efficiency scores of municipalities in the production process of the waste collection and disposal services from Model I. The box map (**Figure 4a**) shows the distribution of the performance considering only the economic dimension. The map features heterogeneity among the municipalities. However, a small cluster of more efficient municipalities emerges in the area between the Neapolitan and Caserta areas and a small cluster of municipalities on the Salerno coast (with the scores from 0.5 to 1, **Figure 4b**). The municipalities of these latter areas, on equal output levels (disposed waste), use a smaller amount of expenditure to dispose of it. However, this performance analysis does not consider any damage caused to the environment due to environmental unsustainability of the waste services production process. The results of the performance analysis that includes not only the economic dimension but also the environmental one are presented **in Figure 5**.

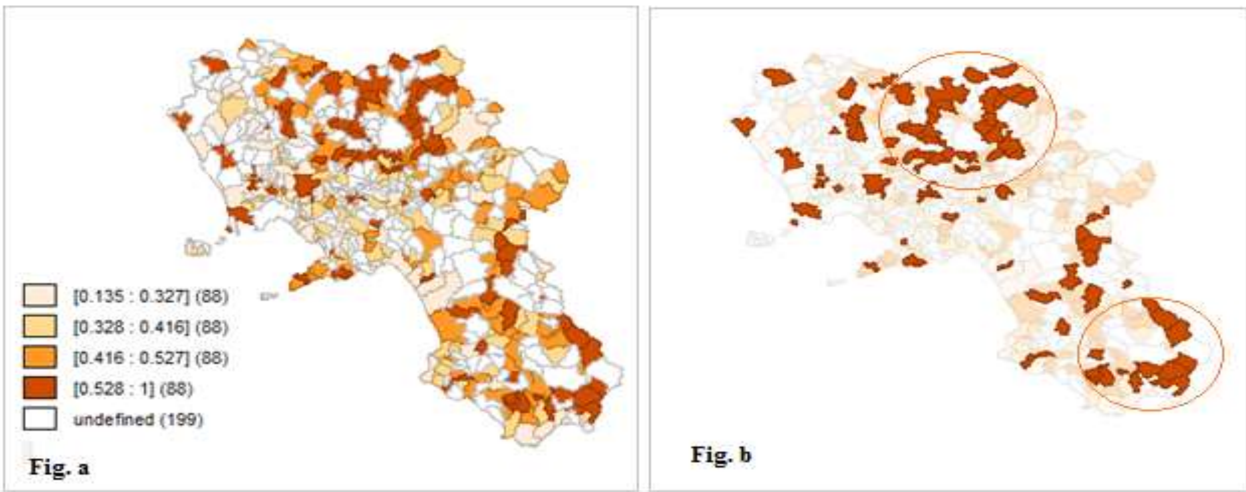
Figure 4. Box map of Economic efficiency scores



Source: Elaboration of ISPRA 2016 data

The box map (**Figure 5a**) shows the distribution of the efficiency scores taking into account environmental sustainability i.e., when local governments are efficient from economic perspective but without damaging the environment. The municipalities with a high score are those that in the production process of waste collection and disposal services use fewer resources and minimize the quantity of unsorted disposed waste: minimization of the spending, while reducing environment damage. **Figure 5b** shows two small clusters of municipalities with a better performance located in the Benevento area and in the Salerno area (with the scores in the rage 0.5-1).

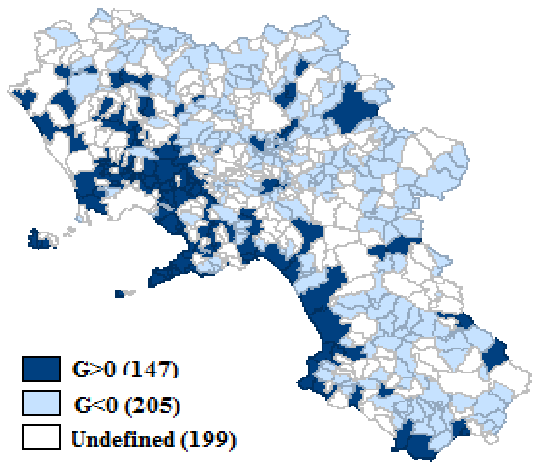
Figure 5. Box map of Economic and environmental efficiency scores



Source: Elaboration of ISPRA 2016 data

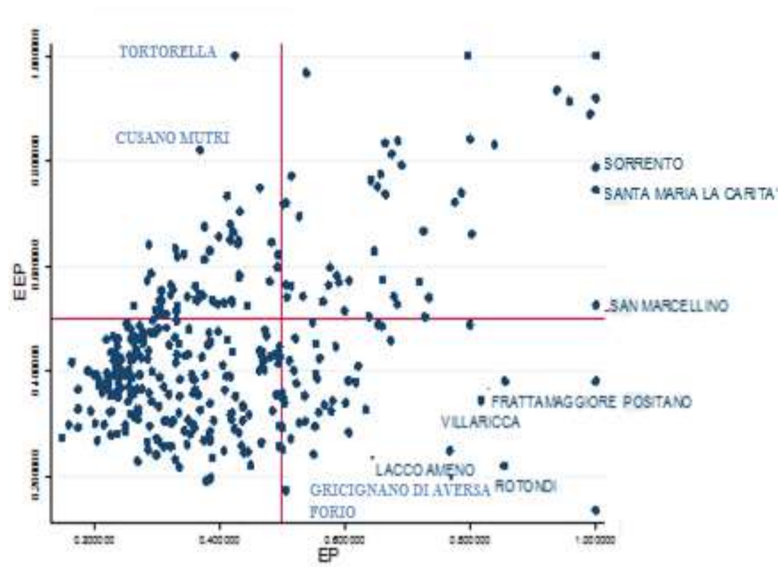
As introduced in Section 2.1, in order to operate a ranking of the most virtuous municipalities in the environmental dimension, we define a measure of the deviation (or gap) of efficiency from environmental sustainability, G. It is given by the difference between the Model I and Model II efficiency scores. This gap occurs when the environmental dimension is neglected in favor of greater economic efficiency: cost savings but with damaging the environment while producing and disposing of a high quantity of unsorted waste. If the deviation from environmental sustainability, G, is negative, the municipality has a good economic and environmental performance (205 municipalities in light blue, fig. 5); if G is positive (147 municipalities in blue, fig. 5) the municipality is efficient from an economic point of view but to the detriment of environmental sustainability which would require a reduction of undesirable output. Figure 5 shows the distribution of G in Italian municipalities. **Figure 6** shows two clusters of municipalities that have G values greater than zero: one in the Neapolitan area (that also includes some municipalities in the Caserta area) and another along the Salerno coast. **Figure 7** presents the deviation box in order to have more information on the placement of the municipalities in the box. The municipalities in the first quadrant are the 'most virtuous', while the municipalities classified as the 'worst' from an environmental point of view are located in the fourth quadrant. The latter, although they have a high economic performance, present a high environmental unsustainability from the production process (such as Frattamaggiore; Villaricca; Gricignano di Aversa Lacco Ameno; etc..,).

Figure 6. Box map of deviation from environmental sustainability



Source: Elaboration of ISPRA 2016 data

Figure 7. Deviation box



Source: Elaboration of ISPRA 2016 data

The environmental efficiency gap in these areas (especially in the cluster of the Caserta and Naples area), other factors being equal, depend on the levels of unsorted waste that should be reduced to improve environmental performance. As shown in **Figure 3**, these municipalities and especially those in blue in the Neapolitan area have a waste services production process characterized by environmental tightness (λ). On the other hand, these areas were also those most affected by the waste emergency in Campania. The huge amounts of waste on the streets of Naples have gone around the world (see for example The Economist, 2009; New York Times, 2007). There is a mix of public (technical and administrative) errors combined with private interests (political, industrial and criminal) that can be partially identified: delays in the design and preparation of suitable landfills; delays in the design and construction of incinerators and composting plants for the organic fraction of waste; low levels of separate waste collection (Armiero and D'Alisa, 2012; D'Alisa and Kallis, 2016). In addition, the poor waste management is linked to a low institutional quality and to the Kapp theory of social cost (see also Berger, 2008; Cecere et al. 2014; Garofalo et al., 2019; Agovino et. al., 2019c).

Achieving a high level of SWC requires significant efforts, which can only be achieved through the joint action of citizens and institutions (Agovino et al., 2018). Missed objective in Campania during the period of the waste crisis, due to the declaration of a state of emergency between 1994 and 2009 (Armiero and Fava, 2016). During this period, the state was the only active agent in the waste management process, excluding the active participation of citizens. Citizens organized themselves into associations and protested, risking imprisonment to be heard by central or local administrations, which continued to exclude them from decision-making processes (D'Alisa et al., 2010; Caggiano and De Rosa, 2015; Armiero, 2014; Martinez-Alier et al., 2016; Lucchini and Membretti, 2016; Armiero and D'Alisa, 2012). As a consequence of this state of emergency, a collaboration between citizens and local authorities has been established in Campania, resulting in better waste management and an increase in the regional level of SWC (Agovino et al., 2018). However, differences remain between the municipalities in the region, with many areas ranking at the bottom of the distribution (Garofalo et al., 2019).

Among the factors that could explain the deviation highlighted in these areas, there is the cost to dispose of waste in landfills, that continues to be very low (110 euros per ton of waste disposed) when compared to the damage caused to the environment. A too low cost does not discourage the dumping of waste, on the contrary, this makes it more convenient from an economic point of view (a lower disposal cost). In Italy, 383 landfills are currently active where almost 20 million tons of urban and special waste have been disposed (Ispra, 2017). The best (most virtuous) situations in terms of environmental sustainability in waste management (Veneto, Piedmont and Sardinia region) are often present where the cost of landfill disposal is higher. In the case of the Campania region, the low costs associated with the disposal of municipal waste in landfills have on the one hand, discouraged the creation of sustainable methods (of collection and disposal) from an environmental point of view, thus favoring the excessive use of landfills. This is also due to the failure to start a waste cycle, which has implied that landfills have become a central node in the disposal of waste in Campania rather than an accessory element.

The sequence of national and regional regulations, that have shifted tasks between the authorities (region, provinces and municipalities), has further accentuated the uncertainty of both the executive and management of the waste cycle process. This has generated both confusion in the preparation of local administrative interventions as well as a loss of citizens trust in the public institutions. This uncertainty of competence has led to a regulatory gap on the central issues relating to the starting of an integrated cycle, creating the conditions, on the one hand, for the exploitation of public functions for clientelist purposes and, on the other, for the infiltration of organized crime. D'Alisa et al. (2010) argued that Campania's waste problem cannot be analyzed as one of simple waste mismanagement. The latter spoke of a "crisis of democracy" in the waste management process that generated conflict between citizens and government. Integrated waste management is only achieved through the joint action of citizens and institutions (central and local) (Agovino et al., 2018).

In the light of Directive 2008/98/EC and Italian L.D. 152/2006, evaluating public service provision performance is a crucial element to improving any service's efficiency (Nogueira and Jorge, 2016). Efficient management entails identifying and measuring the performance of the various parts operating in a particular sector (Pires et al., 2018). The control and monitoring of these elements are vital for the intelligent use of resources. In recent decades, numerous studies have attempted to analyze efficiency in waste service provision (Romano et al., 2020). The type of management may vary with the region's characteristics, so that to improve efficiency, the kind of management should be appropriate to the area (Yang et al., 2018). Bosch et al., 2000, Dijkgraaf and Gradus, 2007, the competitive environment in which the service is provided may be more critical than the dichotomy between public–private management.

An important role to improve environmental performance and to achieve behavioral models consistent with the objectives set by legislation is also played by well-designed incentive system. This should guarantee various principle as the full cost recovery and the polluter pays' principle. For instance, a quantity-based price system (related to volume, weight, or frequency as Pay-As-You-Throw schemes, PAYT) acting as a Pigouvian tax could be establish a negative incentive approach (discouraging citizens from producing waste) (Thøgersen 2003; Acuf and Kaffi, 2013; Bucciol et al., 2015). However, despite the continuous normative changes, the financing of urban waste services, in Campania, are not directly related to the services provided to each citizen (user-payer). If not well-designed, a system could not only rise late payment phenomenon while endangering the fully costs recover (as in the flat-rate system, see Bilitewski, 2008), but it could also not favorite the achievement of environmental sustainability goal (waste reduction) undermining environmental performance. In particular, at national level, there are 24.43% of uncollected percentages, and there is an average rate of 43% in the South, 15% in the Center and 19% in the North (CRIF Ratings, 2020). The late payment phenomenon also affects the timing of payments from local authorities to companies to which the waste services are outsourced. The outsourcing of services is mostly entrusted to in-house companies (71% of municipalities). They mainly concern larger municipalities (such as Naples) and municipalities in the province of Avellino, where integrated waste management is carried out by an in-house company (*Irpiniambiente SpA*).

Moreover, the level of citizen efforts required to sort their waste can depend on the type of program operated by local institutions. If the local administration does not provide an easy separate collection system (e.g. door-to-door collection), the level of effort required to recycle is high and only individuals with intrinsic motivation and strong pro-environmental attitudes will be likely to recycle (e.g. taking up valuable storage space) (Agovino et al., 2018). In addition to the benefits for the environment, high levels of recycling can give tax benefits to local governments which are responsible for the waste services production process. For example, in Veneto art. 39 of Regional Law 3 of 21 January 2000 introduced tax benefits for municipalities that were able to achieve certain separate collection objectives. This benefit resulted in a reduction in a tax for disposing of waste in landfills. Nationwide, law of 28 December 2015, n. 221 (Related Environmental art.32 and 34 - entered into force on February 2, 2016), has made some changes to Legislative Decree 152/2006 (art.205), providing for the application of a 20% increase of Eco-Tax to municipalities that have not reached the legal minimum of sorted waste. Conversely, a reduction in the tax is envisaged for the cases where the minimum level of separate waste collection exceeds the target. Specifically, while on one hand, L.D. 152/2006 has favored the growth of SWC, on the other hand it has increased the disparities among Italian regions. The main problem is related to the fact that L.D. 152/2006 defined higher thresholds, without indicating the path to achieve them, leaving this problem to the regions; moreover, L.D. 152/2006 does not take into account the economic, infrastructural, institutional, social, and demographic disparities that characterize Italian regions. Only recently L.D. 152/2006 was amended, with the definition of penalties (paragraph 3 of article 152) and incentives (paragraph 3 bis of article 152). In particular, in the case of penalties, an additional 20% is defined on the tribute for the delivery of waste to landfills for administrations that have not reached the percentages set by L.D. 152/2006. These penalties have the objective of pushing up SWC rates in Southern regions, characterised by a high use of landfills. Furthermore, L.D. 152/2006 does not consider the historical dif- ferences existing between Italian regions and the possible causes that generate delays in these regions. In this regard, the Green Book (AA.VV, 2018) shows that in Northern Italy 69% of the waste generated is burned to produce energy, while in the South 62% ends up in landfills, due the low cost of land; the latter result has the effect of reducing the percentage of SWC in the regions of Southern Italy. In general, the legislation ends up penalising the regions of Southern Italy, which on average continue to record low SWC percentages (38% against 64% of Northern Italy) and to favour the regions of Northern Italy. In this way, the gap between Northern and Southern Italy will continue to widen. National legislation must consider territorial differences and above all the socio- economic characteristics of the regions (Agovino et al., 2021).

4. Conclusion

The study analyzed the economic and environmental performance of the 353 municipalities in Campania (NUTS-4) in the waste disposal and collection services. The analysis highlighted the importance of jointly assessing the economic and environmental dimensions of the production process relating to the municipal solid waste management service. A production process that ensures the expenditure minimization does not necessarily translate into a system that protects the environment. The analysis shows how the municipalities with good economic performance are the less virtuous with a high efficiency deviation from environmental sustainability. Numerous factors contribute to explaining these results recorded in these areas: waste emergency; delay in starting an integrated waste cycle; a low Ecological Tax; the need for a negative economic incentive system such as PAYT. The latter, in addition to being able to achieve economic sustainability of the waste services process (cost recovery), can favor, as a Pigouvian tax, an allocative efficiency in the waste production. It is also important to underline how good environmental performance achieved through the separate collection of recyclable materials and the reduction of unsorted waste (for the intermediate ‘recycling’ target and the ultimate goal of ‘zero waste’) can also guarantee a good economic performance. Recycling allows to obtain a double efficiency: *Economic efficiency*: waste recycling is the process of transforming waste into reusable materials; an intelligent waste disposal system is a way to reduce energy consumption and industrial costs; *Environmental efficiency*: recycling is the most advantageous alternative to conventional waste disposal systems, which in addition to being no longer sufficient to dispose of the ever increasing load of waste produced, have a non-negligible environmental impact.

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