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Pay-as-You-Throw (PAYT) for Municipal Solid Waste. The experience of the Benevento's municipality

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ABSTRACT
Growing public interest and awareness of environmental issues have contributed to the global spread of pay-as-you-throw (PAYT) schemes, highlighting their effectiveness in promoting cultural change toward more responsible and sustainable consumption practices. The objective of this paper, after a systematic review of the literature, is to analyze the system, methods, and calculation of point-based taxation, focusing on the benefits: from the point of view of environmental sustainability, the application of the point-based tariff leads to a reduction in waste, while increasing sorting and recycling; from the point of view of local finances, this could reduce the costs of waste management services, through more efficient use of public resources.After outlining trends in using the PAYT system in Italian municipalities over the past five years, we focus on implementation in Benevento, a medium-sized city in southern Italy. Introducing this system involves several significant investments, funds for which can be raised from Recovery and Resilience Plan funds and through a complex administrative process.

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1. Introduction

Success in the management of waste disposal services is a tangible indicator of the capacity and efficiency of local public institutions, directly reflecting on the quality of life of the communities involved and the surrounding environment. This success not only demonstrates the competence of local authorities in handling such a critical issue, but also underlines their commitment to educate and actively involve citizens on environmental issues.

Both developed and developing countries are actively exploring innovative policies and tools to promote waste reduction and improve segregated collection methods, thereby facilitating more effective recycling practices (Di Foggia and Beccarello, 2020).

Growing public interest and awareness of environmental issues have contributed to the global spread of pay-as-you-throw (PAYT) schemes, highlighting their effectiveness in promoting a cultural change towards more responsible and sustainable consumption practices.

Many municipalities have implemented PAYT, where households are charged based on the amount of waste they dispose of, rather than relying on factors such as property size or the number of household members, as observed in the general property tax-based 'pay-as-you-throw' system (Messina et al, 2023; Romano et Masserini, 2023, Andersson et Stage, 2018).

The aim of this paper, after a systematic literature review, is to analyse the system, the methods and the calculation of the punctual taxation, focusing on the advantages: from the point of view of environmental sustainability, the application of the punctual tariff leads to a reduction of waste, while at the same time increasing differentiation and recycling; from the point of view of local finances, this could reduce the costs of waste management services, through a more efficient use of public resources.

After outlining the trend of the use of the PAYT system in Italian municipalities over the last five years, we focus on the implementation in the municipality of Benevento, a medium city in Southern Italy.

2. Literature review

Experiences with the application of PAYT have been documented across numerous countries for decades due to their anticipated role in enhancing household responsibility, reducing unsorted waste, and promoting reuse, composting, and recycling within a circular economy framework. Circular economy constitutes a key element in the easy transition to a green and sustainable society and zero waste communities (Apolloni et al., 2022).

PAYT system offers a direct economic incentive to encourage waste separation at the source and increasing recycling (Alves et al., 2020), and policymakers should actively promote its adoption to address political, cultural, cultural, and technical hurdles with the economic goal of reducing costs of disposal to the municipality (Marques et al., 2018).

The programs have been implemented in many parts of the world, including in the United States, the EU, Japan and South Korea. (Gradus et al. 2019). Many studies show that solid waste charges lead to environmental benefits: the significant decrease in per capita production of municipal solid waste (Folz and Giles, 2002) and an increase in recycling (Sidique et al., 2010). For example, Dijkgraaf and Gradus (2017) found a PAYT system in the Netherlands raised recycling rates by five to ten percent, depending upon the method of pricing.

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Existing research has investigated various contexts regarding the impacts of implementing PAYTT systems. In the United States, throughout the 1990s, an escalating number of municipalities started implementing PAYT (Van Houtven and Morris, 1999).

In Europe, significant progress in applying PAYT began approximately 35 years ago (Reichenbach, 2008), but in the last years it has also grown due to the increased availability of transponder technology.

Dijkgraaf and Gradus (2004) focused on the Netherlands, the study unveiled that by the year 2000, over one-fifth of municipalities had implemented unit-based user fees for waste collection, varying according to the quantity of waste generated by individual households. Moreover, they found that the introduction of unit-based pricing resulted in a significant change in citizen behavior, with better results than weight- and bag-based pricing systems. Later, Dijkgraaf and Gradus (2008) demonstrated that unit-based pricing lowered the cost of municipal waste collection, even though this cost advantage decreased over time. Moreover, unit-based pricing was shown to be more effective in reducing costs than contracting urban waste collection.

In Italy, Messina and Tomasi (2020) documented changes in citizens' behavior following the introduction of PAYT, noting decreases in total waste and unsorted waste generation. Municipal costs for municipalities adopting PAYT also decreased, reducing expenses associated with managing undifferentiated waste. Additionally, Messina et al. (2023) estimated the impact of the general introduction of PAYT in Italy, revealing a significant reduction in both the quantity of waste produced and the associated costs.

A thought-provoking topic is how to design charging schemes that encourage efficient and effective use of spaces, reduce waste to landfills, and comply with the polluter pay principle (Di Foggia et Beccarello, 2023).

In relation to recycling, effective charging mechanisms can enhance recovery rates and influence decisions regarding technology investment, thereby supporting and enhancing the circular economy. This is particularly crucial for bolstering the capacity of the recycling and reuse industries (Bohm et al., 2010; Gullì et Zazzi, 2011; Pérez-Lopez et al., 2016; Sarra et al., 2017), which play a central role in the transition towards a circular economy.

The existing literature emphasizes the necessity for further studies to better clarify the effects of introducing PAYT concerning environmental targets, such as separate collection at the source, encompassing both quality and quantity.

3. Purpose and scope of the PAYT System

The Regulatory Authority for Energy, Networks and the Environment (ARERA) is an independent administrative authority that operates to ensure the promotion of competition and efficiency in public utility services and to protect the interests of users and consumers. It performs functions by harmonizing the economic and financial objectives of service providers with the general goals of social, environmental protection, and efficient use of resources (Del Corona, 2023).

The Law of December 27, 2017, No. 205, Article 1, Paragraph 527, assigned the Authority regulatory and control functions over the waste cycle, aimed at "*improving the regulation system of the waste cycle, including urban and assimilated differentiated waste, to ensure accessibility, usability, and homogeneous diffusion throughout the national territory, as well as adequate levels of quality under conditions of efficiency and economy of management, harmonizing economic and financial objectives with those of a general social, environmental, and appropriate use of resources nature, as well as to ensure infrastructural adaptation to the objectives imposed by European legislation, thus overcoming the infringement procedures already initiated with consequent economic benefits for the local authorities concerned by said procedures*."

With the resolution of January 4, 2018, 1/2018/A, the Authority initiated the necessary functional activities for the first operationalization of the regulatory and control tasks. With the subsequent resolutions of February 15, 2018, 82/2018/R/rif, and April 5, 2018, 225/2018/R/rif and 226/2018/R/rif, three procedures were initiated for the adoption of measures respectively on:

- the establishment of a system of safeguards for the management of user complaints and disputes;
- tariff regulation;
- Regulation on service quality.

This devices and also the subsequent ones (DCO 351/2019 – 352/2019) clearly aim to create a renewed regulation of the waste cycle. In particular, Directive 2018/851/EU, which amended Directive 2008/98/EC, has provided for the implementation of a circular economy model. In particular, the Member States use "economic instruments and other measures to incentivize the application of the waste hierarchy," such as pay-as-you-throw schemes, defined by Annex IV-bis as schemes that "charge waste producers based on the actual quantity of waste produced and provide incentives for the source separation of recyclable waste and the reduction of mixed waste" (Article 1, paragraphs 4 and 10).

Currently, Italian regulations establish that the Waste Tax (TARI) is the levy aimed at financing the costs related to the collection and disposal service of waste and is due from anyone who owns or holds, in any capacity, premises or open areas susceptible to producing such waste (Mirto, 2014).

The Waste Tax is composed of a fixed part, determined in relation to the essential components of the service cost, particularly referring to investments in infrastructure and related amortization, and a variable part, proportionate to the quantity of waste disposed of, the service provided, and the extent of management costs. It is structured into categories for domestic and non-domestic users.

Regarding the determination of tariffs, two possible alternatives are available:

1. general method (Article 1, paragraph 651 of Law No. 147/2013). In this case, for the determination of the tariff related to each type of user on which to calculate the amount to be paid, the Municipality will use the standardized method provided for in Presidential Decree No. 158/1999. In this decree, waste costs (investment and operating costs) are to be covered in full by tax revenues. In this case, the local authority will apply a "presumptive" tax (TARI). The Authority presumes the tax for certain categories of surfaces and users, citizens or companies, or corresponding types of waste, urban, special, or special waste assimilated to urban waste.
2. Specific method (Article 1, paragraph 667 of Law No. 147/2013). Municipalities use point measurement systems of the quantity of waste delivered to the public service to calculate the tariff. However, the obligation to fully cover the costs of waste remains. Therefore, municipalities that have implemented systems of punctual measurement of the quantity of waste delivered to the public service have the option of applying, instead of the Waste Tax (TARI), which

is a tax, a tariff in the nature of a fee (Art. 1 c. 668). In this case, the tax mechanism will be based, in terms of the costs generated by the service to determine the amount of the tax to be applied to each user, also on the quantity of waste produced. The prerequisite is the measurement (by weight or volume) of municipal and assimilated waste delivered to the public service, the application of which is, however, optional and not compulsory (IFEL, 2019).

4. Measurement methods

The PAYT has found concrete application in the Decree of 20 April 2017 issued by the Ministry of the Environment: "Criteria for the implementation by municipalities of punctual measurement systems of the quantity of waste delivered to the public service or management systems characterised by the use of correctives to the service cost allocation criteria, aimed at implementing an effective tariff model commensurate with the service rendered to fully cover the costs related to the management service of urban waste and assimilated waste".

Punctual waste metering systems must make it possible to:

a) identify the user who delivers by means of a code uniquely associated with that user or through the identification of the user who delivers;

b) record the number of deliveries by recording the display of containers or bags or direct delivery into controlled-opening containers with limited volume or accesses to municipal collection centres by each user. The devices and organisational methods adopted must guarantee the registration of each individual delivery, associated with the identification of the user or container, with an indication of the time of collection;

c) measure the quantity of waste delivered, through direct or indirect weighing methods.

The measurement of the quantity of waste conferred, according to Article 6 of Ministerial Decree 20/04/2017, is carried out by direct weighing, with weight detection, or indirectly by detecting the volume of waste conferred by each user and can be:

a) carried out on board the vehicle carrying out the collection, through identification of the container or bag;

b) carried out by a device in the collection vehicle through identification of the container or sack;

(c) integrated in the collection container;

(d) carried out at a collection point.

Whatever system is chosen, the guiding principle must be the correct determination of the amount of Residual Urban Waste (RUR), i.e. the fraction of undifferentiated waste delivered by each user to the public waste management service (Fosco et Limiti, 2020).

PAYT involves associating the individual user, corresponding for example to a household, with the undifferentiated waste it produces and measuring it by introducing a tariff partly calculated on the basis of the actual production of waste delivered by that user.

The tariff consists of two quotas:

- fixed rate, which covers the general costs of the service (such as the cleaning of streets and public spaces, emptying of bins, management of the collection centre, transport of waste, ...) and is based on the surface area of the property and the number of household members;

- variable fee, covering operating costs (such as separate collection of plastic, glass, paper and organic waste, ...) and other costs. It is determined based on the number of deliveries (in each case there will be a minimum number of deliveries): the less you deliver, the less you pay.

The measurement of waste will contribute to determining only the variable portion of the tariff, while the fixed portion, in both cases envisaged by the legislator - TARI or PAYT - will continue to meet the criteria set out in Presidential Decree 158 of 1999.

5. PAYT system in Italian municipalities over the last five years

Local authorities that are switching to a point-based pricing system in recent years are growing, as can be seen from the survey of the Higher Institute for Environmental Protection and Research (ISPRA, 2022).

The analysis of the economic and financial plans of the last five years (2018 to 2022) shows a growth in the number of municipalities choosing to apply the point tariff (PAYT) instead of the waste tax (TARI). The following table summarises the municipalities by macro-areas (North - Centre - South) and by regions.

Table 1. Distribution of point tariff municipalities by macro-area

Macro-area	Number of municipalities				
	2018	2019	2020	2021	2022
North	583	843	961	1.011	1.091
Centre	4	27	33	91	100
South	6	2	7	96	107
Total	593	872	1.001	1.198	1.298

Source: Our elaboration on ISPRA Environment data

Table 2. Distribution of point tariff municipalities by regions

Regions	Number of municipalities				
	2018	2019	2020	2021	2022
Piemonte	16	67	106	130	174
Valle d'Aosta	0	11	11	11	11
Lombardia	59	141	203	196	200
Trentino Alto Adige	202	242	249	249	252
Veneto	251	250	263	274	307
Friuli Venezia Giulia	14	38	33	35	41
Liguria	7	4	8	20	4
Emilia Romagna	34	90	88	96	102
Toscana	3	25	25	52	53
Umbria	0	0	2	20	24
Marche	0	1	2	5	5
Lazio	1	1	4	14	18
Abruzzo	3	0	5	12	18
Molise	0	0	0	5	0
Campania	1	0	0	0	0
Puglia	0	1	1	9	11
Basilicata	1	0	0	19	27
Calabria	0	0	0	31	24
Sicilia	1	1	1	16	15
Sardegna	0	0	0	4	12
Totale	593	872	1.001	1.198	1.298

Source: Our elaboration on ISPRA Environment data

From the above data, it can be seen that the number of municipalities adopting the punctual tariff system of the municipal waste management service is growing steadily, from 2018 to 2022 the number of municipalities grew by 118%.

The most peculiar element concerns its pronounced territorial connotation, which does not change over the years, as the regions of the North, especially those of the North-East, are always those with the largest number of municipalities and also with a constant growth over the years: almost 60% of the municipalities adopting the punctual tariff

is concentrated in the regions of Lombardia, Trentino Alto Adige and Veneto.

The southern regions are those where the percentage of application is the lowest, just 8% of the total Campania is the only region where there is no municipality adopting the punctual tariff.

Another interesting elaboration concerns the distribution by population class of the municipalities. The municipalities are divided into five classes as shown in the table below:

Table 3. Distribution of point tariff municipalities by population classes

Population classes	Number of municipalities				
Abitanti	2018	2019	2020	2021	2022
< 5.000	311	491	593	736	804
5.001 – 10.000	145	210	224	255	269
10.001-50.000	133	161	174	193	211
50.001-150.000	3	8	8	12	12
> 150.001	1	2	2	2	2
Totale	593	872	1.001	1.198	1.298

Source: Our elaboration on ISPRA Environment data

The result is therefore that the largest number of municipalities is concentrated in small municipalities, those with a population of less than 5,000. This leads to the observation that it is easier to implement a traced collection system to measure waste for smaller municipalities than for medium-sized municipalities.

To implement this charging system, the basic and necessary requirement is to carry out an automatic measurement of the residual municipal waste (RUR) delivered by each taxpayer.

The methodologies and systems that can be used can be based on the integration of electronic control devices in the containers (called 'smart bins') used by citizens to deliver their waste, or on the use of suitable equipment installed at specific delivery points, such as containers with controlled opening and weight/volume meters.

There are three types of selective collection, depending on the system that the municipality uses to collect municipal waste:

A) Container in case of door-to-door systems
1. Bar-coded tag system;
2. Reusable containers equipped with transponders;
3. Disposable bags equipped with UHF transponders;
4. Identification by weighing;
5. Prepaid sack;
6. Invoice prepaid sack.

B) Timely collection mode in street collection containers and at notable drop-off points;

C) Combined collection mode.

In all cases, these solutions involve a considerable economic commitment on the part of municipalities wishing to use this system, which is often not available from administrations. Depending on the type of collection carried out in a municipality, the most appropriate technical solution for the investment required must be found.

The funds of the National Recovery and Resilience Plan (PNRR) envisage investments aimed at improving waste management through the mechanisation of separate waste collection and the creation of additional waste treatment facilities, also with a view to reducing the number of European infringements opened against Italy and the significant regional disparities in separate waste collection rates, and may act as a driving force for the introduction of systems for measuring municipal waste. In particular, the PNRR envisages an investment of EUR 1.5 billion for measure M2C1.1.1 'Construction of new waste management plants and modernisation of existing plants', under Component 1 'Circular Economy and Sustainable Agriculture' of Mission 2 'Green Revolution and Ecological Transition' (mase.gov.it).

This is a great opportunity for administrations to also equip themselves with systems capable of responding to the service standards mandatorily required by the regulator ARERA with the TQRIF resolution, for the improvement of services, the measurement of deliveries, and the implementation of punctual pricing. Obligations that require economic resources, and which today find their first and important funding.

6. The Experience of Benevento's Municipality

Benevento, a medium-sized city in the south of Italy, has started a trial aimed at introducing the PAYT system as of 2021.

Building a fair and transparent punctual tariff, rewarding those who do the differentiated collection well, is a long and complex path that requires professionalism and high-profile skills. The municipality, together with the operator, is following a step-by-step path in which the choice of the right partners is decisive for success.

To implement PAYT, through the use of PNRR funds, the authority has planned the use of hardware and software for IoT (Internet of Things) applications, such as geolocalisation and transmission of data collected through the use of georeferenced platforms and fleet management models for waste transport vehicles, in collaboration with the University of Sannio.

The first step was the decision to start this virtuous path in an assembly resolution of the managing entity, Asia Benevento S.p.A., an in-house company of the Municipality of Benevento (Donativi, 2016, Presti et Renna, 2018, Lacchini et Mauro, 2017).

This was followed by a series of operational meetings between the municipality, Asia Benevento S.p.A. and the project partners: the University of Sannio for the technical part, the Conai Consortium for the operational and communication part, and the municipality's concessionaire for the management of the tax. The actual implementation necessarily passes through an experimental phase to understand the actual applicability of the system.

The first trial involved about 150 users for a period of one month. At the end, the results were analysed in terms of citizen participation and the technical functioning of the system.

The second trial involved about 3000 users for a period of four months. The analysis of the results was carried out with the actors involved. As a result of what has been done, there is a firm desire to extend the process to the entire city, also acting as a forerunner for other cities in southern Italy.

The PNRR funding obtained by the municipality will allow the process to be implemented and the PAYT to be applied.

If it is necessary to continue from an operational point of view, it is equally necessary to start the administrative process. The main act for the introduction of the PAYT is the municipal regulation to be adopted pursuant to Article 52 of Legislative Decree 446/1997. The regulation will have to regulate all the aspects pertaining to the identification of the elements necessary for the application of the tax and becomes fundamental since paragraph 668 of Article 1 of Law 147/2013 does not provide anything, leaving wide margins of discretion on the calculation method.

On the basis of said regulations, the Economic and Financial Plan and the resolution to determine the rates will be approved annually.

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