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Wastewater Treatment in European Union's Countries – Economy of Access, Determinants, Legislation and Implications in Urban Areas

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Abstract – The primary purpose of the paper is to present the regulatory framework of wastewater treatment and the cooperation between EU and OECD inside the European Union Water Initiative. We also perform an empirical analysis of wastewater treatment determinants in a set of 28 OECD countries, using annual data for the period 2000 to 2017. The panel data analysis reveals that the access to wastewater treatment services is positively influenced by the level of revenue per capita and by the R&D expenditure. At the same time, the energy prices negatively affect the access to wastewater treatment services. The EU membership has no significant impact on the services access rate.

Keywords: Wastewater management, OECD, EU legislation, water services, access and costs to wastewater treatment

I. INTRODUCTION

The importance of wastewater treatment in the context of circular economy rests not only on economical value. Rather it is regarded by the Organization for Economic Co-operation and Development (OECD), the international organization whose goal is to promote development of human society not only in its member states, but all over the world with the promise of a better future as a key element in realizing a fundamental development goal for mankind: sustainable access to water. Statistics of the United Nations (UN) show that still a significant part of the world's population suffers not only from the lack of access to freshwater resources, but also to sanitation services, that include also the treatment of wastewater.

To mitigate this situation, the UN have declared access to water and, as part of it, to sanitation a sustainable development goal. Subsequent efforts of the international community have materialized in the form of instruments of co-operation between states such as by means of the OECD and by regional organizations such as the EU. While the legal nature of these approaches is different, they all rely on the achievement of the same goal – a functioning water economy, including the aspect of providing wastewater treatment in order to close the cycle of water use. Further, the determinants of the access rate to wastewater treatment services are poorly investigated in the empirical literature. Against this background, our contribution to the literature are twofold.

The first contribution is represented by an overview and analysis of the nature of regulations existing at the transnational level, as a form of co-operation of regulations created by different international organizations, the UN, the OECD and the European Union (EU). While regulation proposed by the UN and the OECD provide for a voluntary implementation by member states or stakeholders, the framework of EU legislation is mandatory in nature, leaving only few aspects to be drawn up by the EU states.

The second contribution is empirical. Different from recent studies that analyze the determinants and implications of wastewater treatment with a focus on emerging economies (i.e. Li et al., 2016; Managi and Kaneko, 2009; Wang and Yang, 2016; Wang et al., 2017) we investigate the determinants of population's access to wastewater treatment services in OECD countries. Likewise, we consider the role of economic development, technological development and energy prices in influencing the access to wastewater treatment services. We perform a panel data analysis for the period between 2000 and 2017 using OECD statistics and we compare three static models, namely an Ordinary Least Square (OLS) regression, a fixed effect model and a random effect model. As dependent variables we consider the percentage of population connected to wastewater treatment services, whereas for robustness purpose, we analyze the determinants of the percentage of urban population connected to wastewater treatment services. Using a dummy variable, we control for the EU membership effect. It

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is well-known that the European Commission has dedicated programs and funds to address environmental issues, including wastewater treatment.

We expect that the economic and technological development to have a positive influence on the access to wastewater treatment services. Further, the increase of energy prices might negatively affect the access to wastewater treatment services. This intuition can be explained by the fact that energy prices are directly transferred to water and wastewater prices, which determines the reduction of consumption. Finally, we expect that the EU membership to have a positive impact on wastewater treatment services inside the OECD group of countries.

The rest of the paper present the regulatory framework and water EU policies (Section 2), data and methodology (Section 3), empirical estimations (Section 4) whereas the last section concludes.

II. REGULATIONS AND INTERNATIONAL COOPERATION FOR WASTEWATER TREATMENT

1. The need of international or transnational regulations for wastewater treatment

By tradition, regulating the public sectors and public services has been regarded as one of the core functions of the modern national state. This doctrine had been holding up until the second half of the last century, when environmental issues started to move into the focus of public conscience and also of the international community.

By the last decade of the 20th century, as awareness of the dimension of various environmental problems was rising, it became clear that solutions to issues of this magnitude could only be found by the common effort of most states around the globe.

The management of water in general, including wastewater, has been included in the objectives of the regulatory goals, as water is regarded as a fundamental resource for humanity and at the same time as a vital element of the natural environment that needs protection.

2. Regulation initiatives at the level of the United Nations

In 2000, the General Assembly of the United Nations (UNGA), adopted by resolution the so-called United Nations Millennium Declaration (UNGA 55/2000) containing the Millennium Development Goals (MDGs) to which the member states pledged themselves. It is to be reminded that UNGA resolutions are usually non-binding and depend upon the will of the signatories to be put in practice while no sanction mechanism is provided. All MDGs are voluntary assumed obligations. Target no. Target 7.C of the goals intended to "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation." As the term sanitation includes the management of wastewater, this resolution can be regarded as the first international regulation referring to this issue at the level of the UN.

In 2015, the year in which the MDGs were to be reached, the UN evaluated the degree of realization of its goals and decided to further them by assuming a second generation of Development Goals, called Sustainable Development Goals (SDGs), by adopting the "2030 Agenda for Sustainable Development" (UNGA 70/2015).

Regarding the water issue, the UN assessed that "the world has met the target of halving the proportion of people without access to improved sources of water, five years ahead of schedule. Between 1990 and 2015, 2.6 billion people gained access to improved drinking water sources. Worldwide 2.1 billion people have gained access to improved sanitation. Despite progress, 2.4 billion are still using unimproved sanitation facilities." (WHO-UNICEF, 2015).

The encouraging results of the implementation of the MDGs has prompted the UN to set the resource water as a separate SDG on its 2030 Agenda. Goal no. 6 "Ensure access to water and sanitation for all" assesses that still "80% of wastewater resulting from human activities is discharged into rivers or sea without any pollution removal" and provides for signatory states that in order to reach the goal by 2030, to "expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies" and to "support and strengthen the participation of local communities in improving water and sanitation management." (UNGA, 70/2015, Goal 6, incl. 6.A, 6.B)

In conclusion, the regulations regarding wastewater management present on UN-level are broad in scope, lack a direct implementation mechanism, constitute voluntary assumed obligations by each member state but represent a set of desirable goals to be attained in order to ensure a better quality of life and environment.

3. Regulation initiatives at the level of the OECD

The OECD is an intergovernmental organization, its membership being based on economic criteria and its goals focused on economic issues. Recognizing however the impact of the MDGs and SDGs on economic issues and based on the fact that its member states are at the same time members of the UN, the OECD supports the 2030 Agenda for Sustainable Development and strives to ensure that the SDGs are reached. This is to be ensured by the OECD Action Plan on the Sustainable Development Goals "Better Policies for 2030" (OECD Action Plan, 2016).

The main approach of the OECD is that of using its instruments ("peer reviews and learning; monitoring and statistical reporting; policy dialogue; soft law") as a means of support and assessment of member and partner states. It is to be noted, that similar to the UNGA resolutions, the regulatory frameworks provided by the OECD are of voluntary nature and are

based on bi- and multilateral treaties enacted by states and not by the organization itself. There are no direct sanctions (hence the soft law approach) if the SDGs are not met within a specified timeframe. Any type of sanctions would materialize only within the relations between states and not with the organization.

Regarding the role of the OECD in the wastewater management process, as specified in the OECD Water Governance Principles (OECD, 2015), the organization intends to provide water governance recommendations for governments "to design and implement effective, efficient, and inclusive water policies." (OECD, 2015). At the present, the OECD states that over 40 states and various stakeholder groups have endorsed the set of 12 principles.

Principle no. 2 "Managing water at the appropriate scale(s)within integrated basin governance systems to reflect local conditions, and foster co-ordination between the different scales" contains under lit. b) the encouragement to ensure a "sound hydrological cycle management from capture and distribution of freshwater to the release of wastewater and return flows" (OECD, 2015), therein also including the management of wastewater.

Starting out with the approach of meeting the SDGs, including the one relating to water by providing tootle for better governance, the OECD has created implementation tools like the Water Governance Indicator Framework and the evolving water governance practices (OECD, 2018). These tools are to be used by the implementing states and stakeholders, like the water service operators, public or private. Wastewater management is put into the context of the circular water economy (OECD, 2018).

To sum up, the OECD provides interested stakeholders, public and private with different tools which by implementation should make water treatment more effective, efficient and inclusive. In contrast to the regulations provided by the UN, they are designed to work both on a policy and administrative level as well as on economic level. While the UN regulations are addressing only states and setting goals, the OECD offers regulations that contain the principles, the policy proposals and the specific tools for implementation and impact measurement.

4. Regulation framework of the European Union

An entirely different type of regulations is provided by the European Union. The EU is a regional supra-national organization which in contrast to the UN and especially the OECD has the means and scope of creating legally binding legislation and implementing it. The EU has also functioning sanctions mechanisms, embedded in its fundamental treaties. EU legislation can be applied directly or by state implementation within all member states and is mandatory.

Wastewater treatment has been the object of EU legislation, even if water management is not included in primary Union law (Voulvoulis, 2018). The first important step in this field was the adoption of the Urban Wastewater Treatment Directive (Council Directive 91/271/EEC), which ensures the treatment of urban wastewater in all Union member states. The effects of the implementation of this directive in different states have been discussed in literature (Kemp, 2001, Wright, 1992). Also, the progress on implementing the Directive is monitored by the European Commission (EC), as with all implementation of secondary EU law. The Commission presents periodic reports on the status of implementation and is monitoring also the effects on the stakeholders and other defined targets (EC Report, 2017).

The Urban Wastewater Directive provides for very specific targets to be met, like the collection and treatment of waste water in all urban agglomerations as defined, secondary and more advanced treatment of all discharges from urban agglomerations, a requirement for pre-authorization of all discharges of urban wastewater, and of industrial discharges into urban wastewater collection systems, monitoring of the performance of treatment plants and receiving waters; and controls of sewage sludge disposal and re-use, and treated waste water re-use whenever it is appropriate.

This last point of the re-use of treated wastewater is also a key objective of the new Union's commitment to support the realization of the UN SDGs. (EC draft Regulation, 2018) This objective is to be reached by the adoption and implementation of a proposed Regulation that would also provide for the details of administrative nature. Also, the objective fits into the action plan for a circular economy adopted by the EC in 2015 as a result of the EU's commitment to the SDGs. (EC, 2015). The Commission regards the concept of a circular economy as essential in its striving towards the realization of the UN SDGs.

While different in the composition of their membership, but also regarding their legal instruments, the OECD and the EU have set up a framework of co-operation which involves the participation of their member states. By this means the European Union Water Initiative (EUWI) has been created by the EU with the aim of strengthening the UN MDGs and SDGs regarding water in developing countries (EC, 2003). The OECD is an implementing partner of the EUWI in the region of Eastern Europe, the Caucasus and Central Asia (EECCA). The OECD helps with the following topics by providing its instruments: transparency of decision-making, coordination across government institutions, coordination of international organizations and donors, resilience to political change and implementation of EU water policy related principles in the EECCA region.

In conclusion, the EU provides the most legally binding regulations of all international organizations, facilitating using its institutional mechanisms their implementation. EU regulations regarding the treatment of wastewater and it's reuse as part of circular economy is a target to which the Union has committed itself by assuming the SDGs adopted by the UN. Member states are directly able to implement these regulations within the Union's framework, while

third states can also benefit by means of the EUWI. Here they are also assisted by the OECD.

III. DATA AND METHODOLOGY

1. Data and general statistics

We use OECD statistics for 28 countries for the period 2000 to 2017. This period allows us to obtain the largest number of observations, given that for the period before 2000, only for few countries we find data for wastewater treatment. The dependent variable is represented by the percentage of total population acceding to wastewater treatment (wwtt) and by the percentage of urban population acceding to wastewater treatment, for robustness purpose (wwtu). The explanatory variables are the GDP per capita in natural log (lngdp), the gross domestic expenditure on research and development, as a proxy for the access to technology (gerd) and the energy price dynamics (energy).

The general statistics and the panel unit root tests are presented in Table 1.

Table 1: Descriptive statistics and panel unit root tests

	wwtt	**wwtu**	**lngdp**	**gerd**	**energy**
General statistics					
Mean	77.46	87.43	10.32	1.721	4.785
Std. Dev.	17.26	14.05	0.423	1.014	8.596
Min	21.00	26.00	9.300	0.310	-14.90
Max	100.0	100.0	11.40	4.550	92.20
Panel unit root tests					
LLC test t*	-5.283 (0.000)	-11.84 (0.000)	-4.372 (0.000)	-0.993 (0.160)	-8.927 (0.000)
Fisher ADF P	137.5 (0.000)	196.5 (0.000)	48.16 (0.762)	33.08 (0.993)	329.2 (0.000)
Notes: (i) for both panel unit root tests the null is the presence of unit roots; (ii) p-values in brackets.					

Table 2: Main results (wwtt)

	Pooled OLS	**Fixed effects**	**Random effects**
c	-108.6*** [16.67]	-36.67 [34.05]	-58.37* [30.07]
lngdp	17.09*** [1.655]	11.18*** [3.257]	13.00*** [2.895]
gerd	4.258*** [0.672]	2.361** [1.198]	2.927*** [1.086]
energy	-0.304*** [0.094]	-0.146*** [0.045]	-0.146*** [0.045]
EU dummy	1.713 [1.285]	-	2.281 [4.998]
R^2	0.463	0.491	0.456
Hausman (recommended)		chi2 = 5.700 (random effects)	
Breusch-Pagan (recommended)		chibar2=2743.5*** (random effects)	
Notes: (i) ***,**,* means significance at 99%, 95% and 90% significance level; (ii) year dummy variable are used for all three specifications; (iii) standard errors in squared brackets; (iv) for the fixed effect model the EU dummy variables is omitted because of collinearity.			

Table 1 shows that the minimum percentage for the overall access to wastewater treatment is 21%, recorded in Chile in 2000. At the same time, the access to wastewater treatment (wwtt) enregisters the highest standard deviation, which signalize the presence of a time trend in the series. We also notice that the panel unit root tests indicate that our series are stationary (an exception is recorded for the gross domestic expenditure on research and development series, result confirmed by both tests).

2. Empirical approach

To analyze the determinants of population percentage connected to wastewater treatment services, we first resort to a simple pooled OLS estimation:

$$Y_{i,t}=\beta_0+\beta_1 X_{i,t}+\varepsilon_{i,t} \quad (1)$$

where: Yit is the dependent variable (wwtt, wwtu); Xit represents the vector of explanatory variables (lngdp, gerd, energy, and the EU dummy variable); β0 is the intercept; εi,t is the error term.

Second, to deal with the omitted variable bias and to consider country-specific effects, we use a fixed effect model:

$$Y_{i,t}=\beta_0+\beta_1 X_{i,t}+\alpha_i+\varepsilon_{i,t} \quad (2)$$

where: αi represents all the stable characteristics of countries.

Third, we run a random effect model to control for all stable covariates:

$$Y_{i,t}=\beta_0+\beta_1 X_{i,t}+\alpha_i+\mu_{i,t}+\varepsilon_{i,t} \quad (3)$$

where: μ represents between-entity errors; εi,t is the within-entity error.

We chose between a fixed effect and a random effect specification based on a Hausman test. However, to see if the random specification is recommended over the pooled OLS regression, we rely on the Breusch-Pagan Lagrangian multiplier test, which indicates the presence of random effects.

IV. EMPIRICAL FINDINGS

1. Main results

Table 2 presents the main findings of the empirical analysis, considering the entire population of selected countries. First, we notice that the influence of the economic development level is significant and very high. Consequently, the access to wastewater treatment services considerably increases with the level of GDP per capita. Second, R&D expenditure in GDP, used a proxy for the technological development, also plays a positive and significant role in enhancing the access to wastewater treatment services. The energy prices have a negative and significant impact on the wastewater treatment and expected. However, although this result is confirmed by all three specification, the effect seems to be marginal compared with that of economic and technological development. Finally, the coefficient of the dummy variable that takes value 1 if a country is an EU member and 0 otherwise, although positive as expected, is not significant. The post-estimation tests indicate the presence of random effects (the Breusch-Pagan test), whereas the random effects model dominates the fixed effects model (the Hausman test). Consequently, the random effect model better describes the analyzed relationship.

2. Robustness analysis

In our robustness check analysis, we focus on the access to wastewater treatment for the urban population only. Table 3 presents the new findings. Like the previous analysis, we observe that the influence of the economic development level (lngdp) is positive, significant and very important for the access to wastewater treatment services for the urban population in the 28-OECD analyzed countries. While the impact of the R&D expenditure (gerd) is positive and significant, the inflation recorded by energy prices has a negative influence, confirming thus the main results of the analysis. We also notice that for the pooled OLS specification, the EU membership has a positive and significant impact on the access rate to wastewater treatment services. However, this result is not confirmed by the fixed and random effects models. Moreover, as in the previous case (Table 2), the Hausman and Breusch-Pagan tests recommend the random effects specification, whereas the explanatory power of the model remains a good one (R2 = 0.46).

Table 3: Robustness results (wwtu)

	Pooled OLS	**Fixed effects**	**Random effects**
c	-68.697*** [13.43]	-132.1*** [30.70]	-117.1**** [25.87]
lngdp	14.54*** [1.333]	21.10*** [2.937]	19.34*** [2.502]
gerd	1.989*** [0.541]	1.840* [1.080]	1.756* [0.945]
energy	-0.369*** [0.075]	-0.137*** [0.040]	-0.145*** [0.040]
EU dummy	5.767*** [1.035]	-	5.397 [3.748]
R^2	0.475	0.449	0.464
Hausman (recommended)		chi2 = 5.650 (random effects)	
Breusch-Pagan (recommended)		chibar2=2367.1*** (random effects)	
Notes: (i) ***,**,* means significance at 99%, 95% and 90% significance level; (ii) year dummy variable are used for all three specifications; (iii) standard errors in squared brackets; (iv) for the fixed effect model the EU dummy variables is omitted because of collinearity.			

V. CONCLUSIONS

The purpose of the paper was to present an overview of the regulatory framework applicable to states in the field of wastewater treatment and to investigate, using data provided by the OECD, as to how these regulations influence wastewater treatment in the field.

Our empirical analysis indicates that the economic development, but also the R&D expenditures used as a

proxy for the technological development, are the main drivers of the population access to wastewater treatment services. At the same time, the dynamics of energy prices have a negative impact on the access rate, whereas the EU membership, contrary to the expectations suggested by the compulsory character of its legislation, has no significant influence. These results are validated by all panel data specifications used in the analysis, although the random effects model is recommended by the post-estimation tests. The findings are robust if we consider the urban population only. Taking the rural population into consideration exceeds the purpose of this paper.

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REFERENCES

[1] European Commission (2003), EU Water Initiative International Cooperation - from knowledge to action, accessed on: https://europa.eu/capacity4dev/file/24615/download?token=ORrvElo9.

[2] European Commission (2017), Communication 'Closing the loop –An EU action plan for the Circular Economy', COM/2015/614, accessed on: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614.

[3] European Commission, Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Ninth Report on the implementation status and the programmes for implementation (as required by Article 17) of Council Directive 91/271/EEC concerning urban waste water treatment COM/2017/0749, accessed on: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2017:749:FIN.

[4] European Commission (2018), Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse, COM(2018) 337 final, accessed on https://ec.europa.eu/environment/water/pdf/water_reuse_regulation.pdf.

[5] Kemp, R. (2001) Implementation of the Urban Waste Water Treatment Directive (91/271/Eec) In Germany, The Netherlands, Spain, England and Wales. The Tangible Results, European Environment 11, 250–264 (2001) DOI: 10.1002/eet.272

[6] Li, T.; Han, Y.; Li, Y.; Lu, Z.; Zhao, P. (2016) Urgency, development stage and coordination degree analysis to support differentiation management of water pollution emission control and economic development in the eastern coastal area of China. Ecological Indicators, 2016, 71, 406–415.

[7] Managi, S.; Kaneko, S. (2009) Environmental performance and returns to pollution abatement in China. Ecological Economics, 2009, 68, 1643–1651.

[8] OECD (2015), OECD Principles on Water Governance, adopted by the OECD Regional Development Policy Committee on 11 May 2015, accessed on: https://www.oecd.org/cfe/regional-policy/OECD-Principles-on-Water-Governance.pdf

[9] OECD (2016), Better Policies for 2030. An OECD Action Plan on the Sustainable Development Goals, endorsed by the OECD Council on 13 December 2016, C(2016)166/REV2.

[10] OECD (2018), Implementing the OECD Principles on Water Governance: Indicator Framework and Evolving Practices, OECD Studies on Water, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292659-en

[11] UN General Assembly resolution 55/2 of 8 September 2000 A/RES/55/2.

[12] UN General Assembly resolution 70/1 of 25 September 2015. Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1

[13] Urban Wastewater Directive – Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment, O.J. L 135, 30.5.1991, p. 40–52

[14] Voulvoulis, N. (2018), Water reuse from a circular economy perspective and potential risks from an unregulated approach, Current Opinion in Environmental Science & Health, Volume 2, Apr. 2018, 32-45. https://doi.org/10.1016/j.coesh.2018.01.005.

[15] Wang, Q.; Yang, Z.-M. (2016) Industrial water pollution, water environment treatment, and health risks in China. Environmental Pollution, 2016, 218, 358–365.

[16] Wang, M.; Shen, W.; Yan, L.; Wang, X-H.; Xu, H. (2017) Stepwise impact of urban wastewater treatment on the bacterial community structure, antibiotic contents, and prevalence of antimicrobial resistance. Environmental Pollution, 2017, 231, 1578–1585.

[17] Wright, P. (1992) The Impact of the EC Urban Waste Water Treatment Directive, Water and Environment Journal, Vol. 6 Issue 2, 675-682.

[18] WHO/UNICEF Joint Monitoring Programme report 2015 Progress on Sanitation and Drinking Water – 2015 update and MDG assessment, Geneva, 2015, ISBN 9 789241 509145, 12-17.