Papeles de Trabajo

IMPACT EVALUATION OF WASTEWATER TREATMENT WORKS FINANCED BY EU FUNDS ON THE WATER QUALITY IN SPAIN (2007-2010)

Autores: *Ignacio Moral-Arce*[1]
Instituto de Estudios Fiscales
Maria Gorriti[2]
Ministerio de Hacienda y Administraciones Públicas

P.T. n.º 8/2014

1. Dirección de Estudios, Instituto de Estudios Fiscales, Ministerio de Hacienda y Administraciones Publicas, 28035, Avenida Cardenal Herrera Oria, 378, Madrid. Spain. Ignacio.moral@ief.minhap.es

2. Dirección General de Fondos Comunitarios, Ministerio de Hacienda y Administraciones Publicas, 28071. P.º de la Castellana, 162 Madrid. mgorriti@comercio.mineco.es

Acknowledgements: We thank several contributions that improve considerably this paper. Special mention to Adolfo Galvez of the Ministry of Agriculture, and the cooperation of Spanish Statistical Institute (INE), highlighting the collaboration of Fernando Celestino Rey. Without them this work would have been impossible

N.I.P.O.: 634-14-027-1

INSTITUTO DE ESTUDIOS FISCALES

N. B.: Las opiniones expresadas en este documento son de la exclusiva responsabilidad de los autores, pudiendo no coincidir con las del Instituto de Estudios Fiscales.

Edita: Instituto de Estudios Fiscales
I.S.S.N.: 1578-0244
Depósito Legal: M-23771-2001

INDEX

ABSTRACT

This paper studies the effects that wastewater treatment projects financed by EU funds have had on water quality in the years 2007-2010.Using Spanish municipalities' data, we have made a descriptive analysis of the evolution of EU Structural funds for wastewater treatment projects. Then, we studied the impact that EU fund has had on water quality indicators by means of combining the Propensity Score Matching techniques and the difference in differences approach (DID). The first step is an estimation of a multilevel logit model that evaluates the probability that a municipality conducts a waste water treatment project using EU structural funds. Then, taking into account the PSM value we calculated the effect that the completion of such projects has on our variable of interest. The results show that the observable characteristics, both municipal and regional, have a great effect on the probability of a municipality participating in a wastewater treatment project. It is worth noting that the implementation of this type of work considerably improves the sanitation of water.

Keywords: impact evaluation, propensity scores matching, DID, Sewage, water sanitation.

JEL Code: C01, E32, H43, Q25, Q53.

1. INTRODUCTION

The Spanish economy had experienced a rapid economic growth that led to a general increase of the GDP per capita until the recent economic crisis that hit it so badly. This positive economic trend together with an uncontrollable urban growth had provoked to an increase in the demand for energy and infrastructures, with the subsequent remarkable impact on the environment. Both factors had notably influenced water consumption, as this element is not only a natural resource but also a receptor of environmental impacts.

The deterioration of water quality is largely caused by discharges from urban agglomerations. Most rivers in Spain face problems related to high population density, especially near the coast, and the growing number of these agglomerations, with the corresponding increase in the pollution load, makes the self-purification capacity of streams insufficient. It is therefore increasingly necessary to treat wastewater before discharge. The use of wastewater, given that the entire surface and groundwater resources are already committed, seems to be the only way to increase the quantity of this resource. Therefore, the implementation of wastewater treatment projects is a key element in the strategy of improving the efficient management of water resources as they serve to minimize the environmental impacts of contamination[1].

A good qualitative and quantitative status of all water bodies has become an essential objective of the European Union policy, and is considered a key aspect of the EU Cohesion Policy. The implementation of actions to protect the environment has become a priority for the Spanish Cohesion Policy. The wastewater treatment measures are essential in order to maintain a good ecological water quality. That is why we are conducting a study on the current situation of water in Spain and on the factors that influence it, in particular, the investments financed through EU structural funds. Taking this into account, the main goal of this paper is to answer the following question: Has the performance of wastewater treatment works in Spain had an impact on the quality of its water? Or in other words:

- Has there been an increase in the amount of water treated in those municipalities that have undertaken waste water treatment works in comparison to those municipalities which hadn't invested in those types of projects?
- The performance of sanitation works financed by EU Funds has had an impact on reused water volume?
- How much has water quality been improved (measured by the amount of nitrogen, suspended solids, etc.) thanks to the implementation of wastewater treatment works?

There are many studies that analyze the results of implementing political programs aimed at improving the water quality, such as Newman and others (2002), Pattanayak and others (2005), Blum and Feachem (1983) and Curtis and Cairncross (2003) among many more. However, as these studies are mainly conducted in developing countries the results on water quality of wastewater treatment plants are part of a set of intermediate outcome variables. The main objective that the papers had was to evaluate the impact that water policies have had on the possibility of a diarrheal disease, changes in mortality rates and behavior modifications in cleaning habits.

Taking into account that public policies emerge in order to address society needs, we expect that developing countries, with high mortality rates associated with the quality of the water used by the population, consider the reduction of mortality rates as their target variable (impact variable). In this regard, an increase in water quality is only an intermediate target required to achieve the ultimate goal of reducing the disease prevalence –being ill– and finally died.

However, in developed countries like Spain the objective of the water policy is not the reduction of mortality rates, since water has acceptable levels of quality, but the improvement of its quality and the expansion of water reuse. In this sense, the work we present is original in two ways: First of all, we have not been taken into consideration the same impact variables as in previous works and, secondly, the geographical area of the analysis is completely different.

[1] Another element to be considered for a complete study of water treatment is the analysis of the the evolution, both temporally and geographically, of the treated water, showing that there is a recurring problem in diverting for irrigation instead of returning to its natural cannel.

The main objective of this work is to investigate whether those municipalities that have received EU structural funds for the construction of wastewater treatment plants have achieved better environmental results than those municipalities that haven't received any European financial assistance. In addition, we will evaluate whether the improvement in water-related environmental variables of these municipalities is due to the completion of these works or to other factors. The second objective of the study is to analyze whether the regional context matters when building wastewater treatment works financed by EU Structural Funds.

To do this research we propose a two-stage estimation: first of all, we specify a multilevel logit model in order to estimate the probability of participating in a wastewater treatment project co-financed by the EU Structural Funds, taking into account a set of observable variables which include information at both the municipal and the regional level. This multilevel approach will allow us to properly control the existence of possible regional heterogeneity. It can be done when there is a hierarchical structure in the data, in which the dependent variable is measured at the lowest level of disaggregation. One of the great advantages of these models is their ability to explore variations in each hierarchical level after controlling for the most important explanatory variables. Therefore, multilevel regression models are one of the best approaches to study environmental factors.

In the second stage of our estimation method, we evaluate the effects that wastewater treatment projects financed by EU Funds have on water quality by simultaneously using propensity score matching methods and difference in differences techniques. The advantages of using PSM are that the estimated sample of control and treatment groups, conditioned to observable variables, is balanced. The second advantage is the common support condition, so that we only consider the treatment group municipalities for which we can find similar municipalities in the control group – in terms of probability of participation. The third strength is that it is a flexible technique that requires few assumptions about the functional form of the equations that determine the outcome variable. Regarding the approximation of DID, its great advantage is that it eliminates the bias due to unobserved variables.

The work is divided into the following sections: In the next section we present the importance that both the European Union and Spain attach to achieving high quality water standards. In Section 3 we analyze the indicators used to assess the impact of this public policy. Section 4 focuses on the econometric techniques applied for the evaluation. The results of the analysis are shown in Section 5. The last section is devoted to our main conclusions.

2. IMPORTANCE OF WASTEWATER TREATMENT PROJECTS AND REUSE IN EUROPE AND SPAIN

The ecological status of waters has become an essential objective of the European Union, especially since the publication of the Water Framework Directive. The environment is considered a key aspect of the EU economic, social and territorial cohesion policy as it is included in the Community Strategic Guidelines and, as a result, in the National Strategic Reference Frameworks (NSRF) that ensure consistency of Structural Funds interventions with them.

The main lines of this strategy were set out in the conclusions of the European Council in Goteborg (2001). This Strategy is of special relevance, because it added the environmental dimension to the Lisbon objectives, highlighting a shift of focus in the development of EU policies.

The economic, social and environmental effects of all policies are examined in a coordinated manner and they all have to be taken into account in the decision processes[2]. Thus, the environmental pillar can be considered an instrument to change society's behavior. This study focuses on the major challenges of sustainability, which include the rational use of natural resources, with special emphasis on the prevention and reduction of pollution.

2 The EU legislation on issues of water use and sanitation includes the Directive 91/271/EEC of the European Union for the treatment of urban waste water, adopted in May 1991 that defines the collection systems and treatment and discharge of urban waste water. This Directive lays down measures that Member States have to adopt to ensure that urban wastewater is adequately treated before discharge. It also establishes the obligation to adapt the treatment and purification systems for all populations over 20,000 population equivalent discharging to inland waters and estuaries, and over 10,000 population equivalent discharging to coastal waters. These targets must be met between 1995 and 2005. Furthermore, Directive 2000/60/EC establishing a framework for Community action in the field of water policy objectives include achieving good ecological and chemical status of all water bodies in 2015 [transposed into Spanish law by Article 129 of Law 62/2003.

At national level, the "Spanish Sustainable Development Strategy", adopted by the Council of Ministers in November 2007, is part of the strategic vision of the European Union. It encourages an integrated approach that takes simultaneously into account the economic, social, environmental, global and sustainability features of development[3]. Finally, although Spain is increasingly incorporating a sustainability approach while drafting and adopting economic policies, it still faces some difficulties in meeting some of its fundamental challenges, among others:

- The availability of water resources, in terms of quantity and quality;
- Waste management goals and objectives;
- The prevention of natural disasters, especially in regard to the prevention and control of forest fires.

In conclusion, the principle of environmental protection is a priority to Spanish Cohesion Policy. To have enough and efficient wastewater treatment plants is essential to maintain good ecological water quality, meet the objectives of the Water Framework Directive by the 2015 deadline and obtain high levels of reuse. The implementation of the National Sanitation and Purification Plan, started in 1995, has been a remarkable progress in the field of wastewater treatment, but it has been insufficient to meet the targets set up by EU legislation.

Thus, to conduct an impact study on the environment effect of Structural Funds investments was considered necessary in order to study the implementation of the principle of environmental protection and the integration of this horizontal policy in other policies. Concerning the evaluation of the effect of EU funds on environmental sustainability, there has been some previous papers like the "Evaluation of the unitary regional policy 2007-2013 Valle d'Aosta" (Ongoing evaluation) or "Ex-post evaluation of Operational Programmes 2000-2006 of Umbria Region" among others. Unfortunately none of them include an impact evaluation on EU funds.

Table 1

2007-2013 EU STRUCTURAL FUNDS INVESTMENTS IN WATER

			Programado		Ejecutado (AC+DE)		%ejecución	
Fondo	Objetivo	PO tema	Ayuda	Gasto	Ayuda	Gasto	Ayuda	Gasto
Cohesión	Cohesión	44	304.425.239	380.531.564	136.917.874,18	171.147.342,67	44,976%	44,976%
		45	456.876.085	571.095.117	167.886.287,95	209.857.860,16	36,747%	36,747%
		46	1.063.962.748	1.329.953.462	500.137.005,53	625.171.257,12	47,007%	47,007%
		Resto	1.717.948.936	2.147.436.117	1.411.930.098,29	1.764.912.622,96	82,187%	82,187%
		Total	**3.543.213.008**	**4.429.016.260**	**2.216.871.265,95**	**2.771.089.082,91**	**62,567%**	**62,567%**
		%44 s/Total	8,592%	8,592%	6,176%	6,176%		
		%45 s/Total	12,894%	12,894%	7,573%	7,573%		
		%46 s/Total	30,028%	30,028%	22,560%	22,560%		
FEDER	C Pura + Phasing out + Phasing In	44	100.063.288	123.666.870	35.512.158,01	43.961.718,52	35,490%	35,549%
		45	1.420.433.170	1.773.641.576	638.963.659,87	798.704.574,44	44,984%	45,032%
		46	940.762.164	1.175.952.706	418.384.380,00	522.980.475,22	44,473%	44,473%
		Resto	18.664.362.605	23.721.565.978	9.622.581.943,56	12.386.945.200,60	51,556%	52,218%
		Total	**21.125.621.227**	**26.794.827.130**	**10.715.442.141,44**	**13.752.591.968,78**	**50,722%**	**51,326%**
		%44 s/Total	0,474%	0,462%	0,331%	0,320%		
		%45 s/Total	6,724%	6,619%	5,963%	5,808%		
		%46 s/Total	4,453%	4,389%	3,904%	3,803%		
FEDER	Competitividad	44	2.000.000	4.000.000	0,00	0,00	0,000%	0,000%
		45					0,000%	0,000%
		46					0,000%	0,000%
		Resto	1.925.050.402	3.869.293.556	942.524.194,11	1.926.138.097,86	48,961%	49,780%
		Total	**1.927.050.402**	**3.873.293.556**	**942.524.194,11**	**1.926.138.097,86**	**48,910%**	**49,729%**
		%44 s/Total	0,104%	0,103%	0,000%	0,000%		
		%45 s/Total	0,000%	0,000%	0,000%	0,000%		
		%46 s/Total	0,000%	0,000%	0,000%	0,000%		
	TOTAL	44	406.488.527	508.198.434	172.430.032,19	215.109.061,19	42,419%	42,328%
		45	1.877.309.255	2.344.736.693	806.849.947,82	1.008.562.434,60	42,979%	43,014%
		46	2.004.724.912	2.505.906.168	918.521.385,53	1.148.151.732,34	45,818%	45,818%
		Resto	22.307.361.943	29.738.295.651	11.977.036.235,96	16.077.995.921,42	53,691%	54,065%
		Total	**26.595.884.637**	**35.097.136.946**	**13.874.837.601,50**	**18.449.819.149,55**	**52,169%**	**52,568%**
		%44 s/Total	1,528%	1,448%	1,243%	1,166%		
		%45 s/Total	7,059%	6,681%	5,815%	5,467%		
		%46 s/Total	7,538%	7,140%	6,620%	6,223%		

Source: Directorate General for Community Funds.

[3] As regards the national level, Directive 91/271/EEC was transposed into Spanish law by Royal Decree Law 11/1995, Royal Decree 509/1996, which develops and RD 2116/1998 amending the previous one. In addition, the need to comply with EU requirements assuming approval of the National Water Quality: Treatment and Purification 2007-2015, adopted on June 8, 2007 by the Council of Ministers with an estimated cost of EUR 19.007 million . The Quality Plan is launched as a way to achieve in 2015 the environmental parameters of the Water Framework Directive, meet new investments arising from the review of sensitive areas (200 agglomerations affected by the resolution of July 2006) and facilitate the reuse of treated water to levels that can reach 3,000 cubic hectometers.

The importance of investments co-financed by the EU Structural Funds is due to the strategic and economic importance of water as it is a renewable natural resource and an strategic element in any long term planning. The large volume of investments in the sectors is shown in Table 1.

3. DATABASE

In order to estimate the impact that the use of EU funds has on the quality of water we used two information sources. On the one hand, an EU Funds file at the Spanish Ministry of Finance and on the other hand, a water survey conducted by the Spanish Statistics Institute (INE).

In regards to the administrative file conducted and managed by the Directorate General of Community Funds, it contains information on beneficiaries of EU funds, dates of transfers and implementation, financial amount of the project, amount of EU financial assistance and so on. This database is an administrative census file which records all the data on the projects and on the beneficiaries which have received ERDF funds for any given operation. It has information of the 2000-2006 programming period as well as of the 2007-2013 programming period, which are both crucial for the management and certification of payments claims. Table 2 shows a summary of the wastewater treatment projects financed by ERDF Funds completed during the period of 2003 until the latest available year, aggregated per type of regions according to the Convergence objective and name of the region.

Table 2

SUMMARYOF COMPLETED WASTEWATER TREATMENT PROJECTS FINANCING WITH ERDF FUNDS

Year of completed work		2003	2004	2005	2006	2007	2008	2009	2010	2011
competitiveness	Aragón		1	3		2	8	6		3
	Baleares					1	1			
	Cantabria	3	3	3	9	8	1			1
	Cataluña		3	1	1	3	13	1	5	9
	Madrid			22	26		1	2	2	2
	Navarra								1	
	País-Vasco			2	6	6		2		
	Rioja					6	8			
convergence	Andalucía	3	26	10	3	34	17	19	10	5
	Cast-Mancha	12	5	1	4	7	2		1	2
	Extremadura		1		1	1	10	1	5	3
	Galicia	3	5	7	4	12	15	6	6	10
phasing-in	Canarias	3	3	3	13	6	6	1		
	Cast-Leon	7	8	6	14	24	2	1	2	15
	C. Valenciana	2	4	3	6	11	12	4		3
phasing-out	Asturias	5	3	1		2	6	1	7	1
	Murcia	2		5	1	5	2	9		
Totally completed		40	62	67	88	128	104	53	39	54

Source: Directorate General of Community Funds.

Despite the extraordinary information related to the management of ERDF funds contained in this administrative file, it does not provide any kind of information on our variables of interest, i.e. the impact variables needed to study the effectiveness of public interventions. Due to the previous reason and also due to the absence of a control group, i.e. a set of municipalities that did not complete any wastewater treatment work, necessary for an impact evaluation analysis, explains why we need another source of statistical information. Both files will lately be integrated by means of matching techniques.

The second source used in this work is a Survey on Water Supply and Water Treatment designed and managed by the Spanish Statistics Institute (INE), from 2007-2010 that provides yearly data of the water use. This data is very reliable from a statistical point of view. The main objective of the survey is to quantify in physical units, as well as in economic magnitudes, the activities related to the water cycle, in the areas of water supply and sanitation (sewage and wastewater). One of the great advantages of this survey is that, in regards to different integrated water cycle services; it covers almost 85% of the Spanish population. This statistical file provides information on:

- Types of water distinguishing between surface waters, groundwater, water from desalination and others.
- Total volume of water supplied to the public system, water volume recorded and distributed by type of user.
- Total volume of water recorded in the distribution network, real losses, and apparent losses.
- Wastewater treatment, sewage, biochemical oxygen demand (BOD5) and Chemical Oxygen Demand (COD).

The final file used in the calculation of the impact effect that is generated by performing an exact match at microdata level between the beneficiaries file provided by the Ministry of Finance and the statistical file managed by the INE. The matching variable is the municipality identifier, a 5 digit code unique to each municipality. After completing this process, the INE provides an anonymzed microdata file from 2007 to 2010 which contains information on different variables.

Table 3 shows the number of common municipalities (appeared in both files), which will be our treatment group, and the mismatched control groups between the two files for different years:

Table 3

MATCHING BETWEEN THE DIRECTORATE GENERAL OF COMMUNITY FUNDS FILE AND THE INE WATER SURVEY

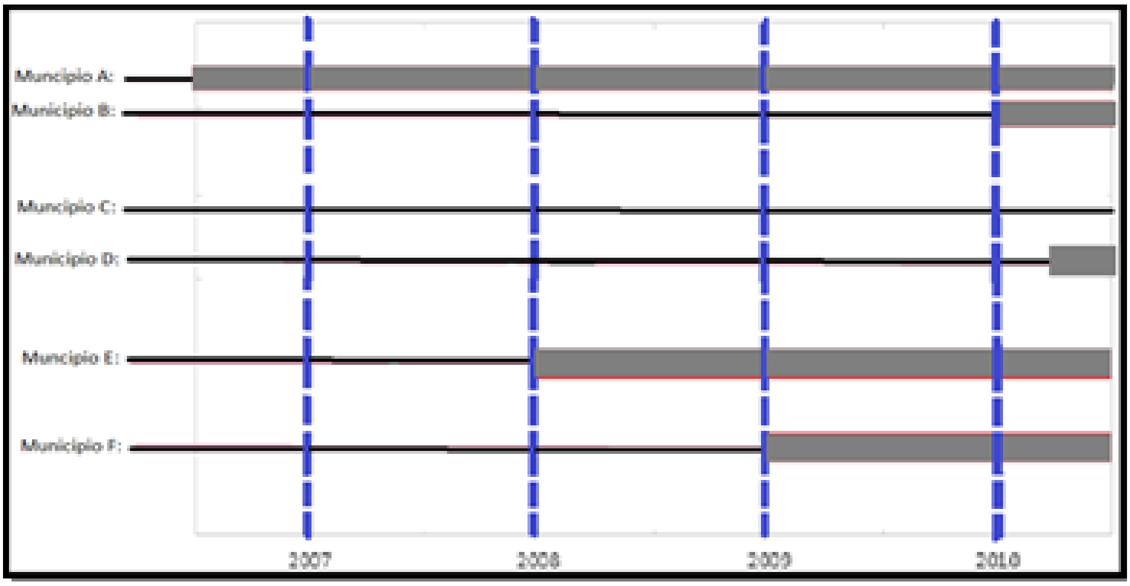
Type of municipality after matching	year 2007	year 2008	year 2009	year 2010
Treatment group (in both files)	584	470	471	550
Only in Ministry of Finance file	539	538	651	538
Control group (only in INE survey)	1623	1366	1441	1514
Related Spanish population ($x10^6$)	37.89	36.14	36.32	38.05

Source: Own elaboration.

With the information provided in the final file, INE provides a micro database containing municipalities of the control and treatment groups that allow us to conduct an impact assessment study. However, it is necessary to make a statistical depuration effort of this initial database because these two groups may not be correctly identified, and it is necessary to locate exactly what municipalities were to be placed in the control and treatment groups. The reason for this second step is that the administrative file available in the Directorate General of Community Funds of the Ministry of Finance shows confounding data (bearing in mind that the INE provides information only for the years from 2007- 2010):

Figure 1

TYPE OF MUNICIPALITIES (CONTROL AND TREATMENT GROUPS) BASED ON THE AVAILABLE INFORMATION AND YEAR OF COMPLETION OF WASTEWATER TREATMENT WORK



Source: Own elaboration.

It is important to remember that the period of study is from 2007 to 2010. In Figure 1, the vertical dashed lines show the INE data available. We have four yearly data information for each municipality. The horizontal lines show the moment of time in which a municipality completes the wastewater treatment project. The black line indicates that the project is still in progress (or has not yet started), while the thick gray line indicates that the project is completely finished. In this situation, we have 6 alternatives:

Municipalities in which investments ended before 2007 (they belong to the treatment group but the works ended before the baseline), or municipalities in which the investment is completed in 2010. Since the INE provides annual information we cannot know how much of the impact variable information relates to the period after (or before) the wastewater treatment work has already ended. These two options (A and B) are discarded for the study. The municipalities C and D are included in the control group, while municipalities E and F belong to the treatment group.

In addition to the information shown in Table 3, we are taking into consideration the previous figure which determines the municipalities that belong to the control or the treatment groups. We have to apply another filter to clean the final microdata file in order to overcome the problem of municipalities that were erroneously assigned to the control group (but who hadn't undertaken any investment in wastewater treatment). This is because the administrative data file used in this work (that of management of EU Funds of Ministry) has available information only for those municipalities that invest in project co-financed by European Structural Funds, but there is no information on those municipalities that complete some wastewater treatment projects using other non-European financial assistance (national or regional).

We consider this kind of municipality as an individual in the control group while, in fact, it has undertaken some sanitation work. Therefore, without eliminating the existence of these fake control municipalities, our data sample may create distortions in the results. Due to this reason we have requested to the Ministry of Agriculture (MAGRAMA) a census file of the municipalities that have undertaken any wastewater treatment project during the years of this study, regardless of the source of their funding. Once we got this information, we proceeded to remove from our database those municipalities that wrongly appeared in our initial control group after the matching with the administrative file of the Directorate General of Community Funds and the INE survey, but which had done some work according to the information of the Agricultural Ministry file.

Next, we analyze the different indicators and variables for those municipalities in order to perform the impact assessment.

3.1. Impact Indicators - Variables

We need to identify and measure the specific pollutants discharged into the water in order to determine the quality of the water and the need for treatment. Water pollutants can be divided into two groups: dissolved contaminants and suspended solids[4]. With this in mind, the variables we consider as "impact indicators" to assess whether the wastewater treatment project assisted with ERDF funds have had effects are the following (looking at the reasons for including those variables of interest):

— Water flow (divided in primary, secondary and tertiary treatments) is the indicator of the volume of wastewater that is treated with the intention to reuse it or return it to nature.

— Water Flow (quantity measure of m3) of water reused is the indicator of the volume of wastewater that is reused.

— Biochemical oxygen demand (BOD) and Chemical Oxygen Demand (BOD): Both are indicators of the degree of contamination that is present in wastewater. It measures the amount of dissolved oxygen consumed under specific conditions for the biochemical oxidation. The wastewater characteristics are measured in mg / liter and they refer to the annual weighted averages existed in the actual flow when it enters into each sewage treatment plants. COD and BOD are used to determine the amount of material organics present in water mainly from sewage discharges. The first determines the amount of biodegradable organic matter and the second one measure the total amount of organic matter. Increasing the concentration of these parameters affects the reduction of the amount of dissolved oxygen in water bodies with the consequent negative effect on aquatic ecosystems.

— Suspended Solids: The SS are originated in wastewater and soil erosion. An increase in the SS level makes the water lose the ability to protect its variety of aquatic life. These parameters allow recognition gradients ranging from a relatively undisturbed condition or without the influence of human activity to signs of municipal sewage discharges as well as areas with severe deforestation.

— Total Phosphorus: The phosphates and phosphorus compounds are found in natural waters in small concentrations. Phosphorus compounds found in wastewater or discharged water come from fertilizers removed from soil by water or wind, human and animal excreta, and detergents and cleaning products. Phosphorus compounds are considered important plant nutrients, and lead to the growth of algae in surface waters. This element is usually the factor in an ecosystems that limits plant growth, as a large increase in its concentration can cause eutrophication. Phosphate concentration in natural water is essential to assess the risk of eutrophication. So Phosphates are directly related to the eutrophication of rivers, lakes and water reservoirs.

— Nitrogen: The nitrogen that can be found in the aquatic environment can exist in four different forms: organic nitrogen, ammonia nitrogen, nitrite-shaped compound and compounds in the form of nitrates. In an untreated wastewater the first two are present. Decomposition by bacteria easily transforms organic nitrogen into ammonia. The relative amount of ammonia in water is an indicator of the wastewater age. In nature, in the presence of oxygen, ammonia nitrogen is converted to nitrate, which is the most oxidized form which is the nitrogen in the water. When deciding to treat wastewater the amount of organic materials and ammonia is calculated. Nitrogen maybe toxic to fish. In the form of nitrite nitrogen is even harmful to mammals.

— Heavy metals: The presence of certain heavy metals such as mercury, cadmium in water is an environmental problem of global significance. These metals are highly toxic to humans and to the environment, being able to generate very serious effects even at very low concentrations.

[4] Also, the quality of the water can be measured by a series of laboratory analysis, such as the pH, the total solids (TS), the conductivity and microbial contamination. The pH is the value that determines whether a substance is acidic, neutral or basic, depending on the number of hydrogen ions present. It is measured on a scale from 0 to 14; the substance is neutral when its value is 7. Total solids (TS) are the sum of all dissolved and suspended solids in the water. ST can be both organic and inorganic substances, microorganisms and larger particles such as sand and clay. Microbial contamination is divided into contamination by organisms that have the ability to reproduce and multiply and others that cannot. Microbial contamination can be contamination by bacteria, which is expressed in colony forming units (CFU), a measure of the bacterial population.

3.2. Explanatory Variables and Geographical Level of Information

Adding to the different dependent variables of the impact analysis, we need to incorporate some other control variables. In this study, we are able to gather information at both the municipal and the regional level.

MUNICIPALITY INFORMATION LEVEL

Apart from the impact variables introduced in the previous subsection, that are obtained at the municipal level (information being provided by the INE) while determining the participation variable in wastewater treatment project there are other municipal-level variables that could affect the impact variable such as:

- Population of the municipality.
- Location of the municipality: Dummy variable that takes value 1 if the municipality is on the coast, 0 otherwise.
- River district: We have considered six major river basins: Guadalquivir, Guadiana, Jucar, Tajo, Duero and Ebro generating six dichotomous variables. Each dummy variable associated with each basin takes the value 1 if the municipality belongs to the river area and 0 otherwise.
- Proportion of women to the total municipality population.
- Percentage of people aged 16-65 years old in the total population of the municipality.
- Percentage of foreigners in the total population of the municipality.
- Sensitive Zone: If the municipality is located on a "sensitive area" is set to 1, otherwise zero.
- Infraction: If the municipality has received or is in the process of receiving some kind of sanction related to water. In this case dummy variable takes the value 1. Otherwise it is zero.

REGIONAL INFORMATION LEVEL

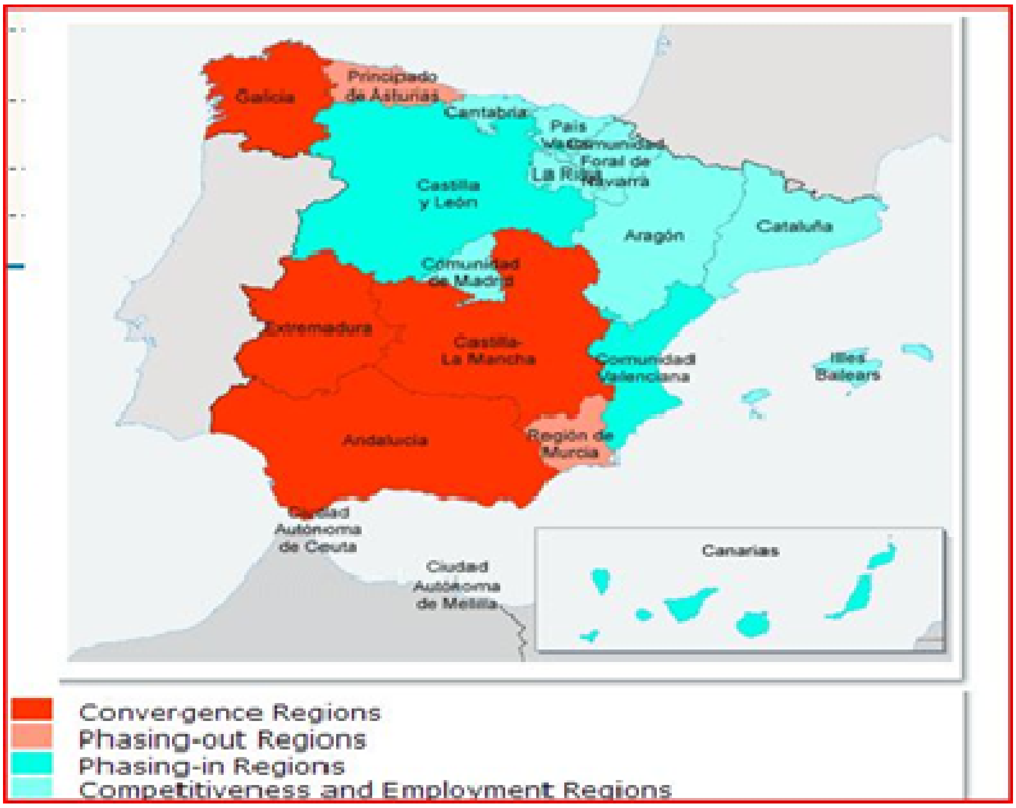
One of the main characteristics of this work is that it takes into account the effect that a regional context study has on the impact of EU funds. In other studies of investment financial assistance, like Decastris and Pellegrini (2007) and Gadd, Hansonn and Mansonn (2009), they didn't include any geographical and spatial dimension in their analysis. For that reason, this study aims at investigating whether the regional environment has any effect in waste water treatment projects financed by EU Funds.

One of the most relevant variables to consider at the regional level is the co-financing rate for regions according to their level of relative wealth. In the 2007-2013 programming period there were four different types of regions with different co-financing rates:

- Convergence regions: 80% of ERDF co-funding.
- Regions of phasing in: 80% of ERDF co-funding.
- Regions of phasing out: 80% ERDF co-funding.
- Regions competitiveness: 50% of ERDF co-funding.

The following figure shows how the regions are distributed in Spain from 2007-2013 based on their relative wealth.

Figure 2
SPANISH REGIONS ACCORDING TO THE LEVEL OF COMPETITIVENESS. PERIOD 2007-2013



Other regional explanatory variables considered in this work can be separated into four distinct areas:

— Type of region according to EU funds:

Three Dummy variables: Takes value 1 if the region where the municipality belongs is considered phashing-in, phashing-out or convergence, and 0 otherwise.

- Climate Variables
  - Annual hours of sunshine.
  - Annual volume of rainwater.
  - Annual average temperature.
- Economic variables
  - Gross Value Added of the economy.
  - GDP by economic sectors: industrial, agricultural sector, energy sector, construction sector.
- Agricultural Variables
  - Area devoted to pasture, crop and forestry.

In the following table, we have taken into account all of these regional characteristics and municipality variables in order to obtain descriptive statistics of the selected data set for the control and treatment groups.

Table 4
DESCRIPTIVE STATISTICS OF THE VARIABLES USED IN THE STUDY

	Control group				Treatment group			
	mean	**min**	**max**	**variance**	**mean**	**min**	**max**	**variance**
Population	18.10	0.045	1595.11	5047.42	49.46	1.413	322.67	4186.08
Municip-Coast	0.49	0	1	0.25	0.62	0	1	0.24
Region-coast	0.16	0	1	0.13	0.30	0	1	0.21
EU converg región	0.21	0	1	0.17	0.33	0	1	0.23
Phahing-out región	0.03	0	1	0.03	0.12	0	1	0.10
Phahing-in región	0.23	0	1	0.18	0.27	0	1	0.20
% female	0.49	0.00	1.67	0.00	0.50	0.47	0.54	0.00
% 16-65 population	0.67	0.00	2.20	0.00	0.68	0.60	0.77	0.00
% foreign	0.09	0.00	0.76	0.01	0.10	0.00	0.51	0.01
Pasture	300073.7	2912	1040309	6.22E+10	333568.6	2912	951721	8.04E+10
Crop	106602.2	30	1112461	2.89E+10	109126.4	30	811900	2.05E+10
Forestry	224683.8	12271	600599	1.01E+10	218356.5	55850	426448	1.26E+10
GDP agricultur	633524.5	153703	1308366	9.05E+10	722349.7	230351	1308366	9.48E+10
GDP industr	7768909	251750	28400000	7.6E+13	6313846	641468	28400000	5.9E+13
GDP servi	33600000	1725514	128000000	1.53E+15	28200000	3156886	128000000	9.89E+14
GAV region	48300000	3184129	167000000	2.8E+15	40800000	5015611	167000000	1.87E+15
Hourssun	2560.30	1453	3120	179336	2634.233	1453	3120	169812.3
Temperatura	15.95	10	21.6	4.37	16.98	11.8	21.6	4.245116
Rain	589.17	135.9	1536.1	67796.42	554.09	202.3	1536.1	54882
Guadalquivir river	0.06	0	1	0.06	0.15	0	1	0.13
Guadiana river	0.06	0	1	0.05	0.03	0	1	0.03
Jucar river	0.17	0	1	0.14	0.20	0	1	0.16
Tajo river	0.11	0	1	0.09	0.05	0	1	0.05
Duero river	0.02	0	1	0.02	0.00	0	0	0.00
Ebro river	0.15	0	1	0.13	0.03	0	1	0.03

Source: Own elaboration.

Taking into account that this research is a cuasi-experimental analysis we have to consider the possibility of existence of a selection bias in the municipalities. In the next section we propose an estimation method to sort out this problem.

4. ECONOMETRIC MODEL

In this paper we will use a combination of the two most common techniques used in impact assessment studies, such as the Propensity Score Matching method and the "difference in-differences approach". The general idea of the PSM method is simple. In the absence of an experimental design treatment, the allocation of participation units is performed in a non-random way. Therefore, participants in the treatment and control groups can vary not only in terms of being or not being participants, but also in other characteristics that may affect both their participation and the outcome of the evaluation. To avoid this bias, matching methods try to find an untreated unit "similar" to a participating unit. This method enables us to estimate the impact of the intervention by calculating the difference in results between a participant and a non-treated unit who belongs to the control group. By calculating the average of all "participants and non-participants matched", this method provides, through mean difference, an estimate of the average impact of the program for participants. There is a wide literature on the implementation of the PSM technique in the evaluation. For example, Heckman, Ichimura and Todd (1998), Lechner (1999), Dehejia and Wahba (2002) . Also Smith and Todd (2005) use PSM techniques to estimate the impact of the labor market and training programs on income, while Jalan and Ravallion (2003) use them to evaluate employment programs and the fight against poverty.

The other method implemented in this research is the difference-in-difference technique, that gives us the estimate of the impact by combining the difference before *vs* after the implementation of the public program (first difference), and the distance between the control and treatment group (second difference). Its great advantage is that it eliminates the bias that unobserved permanent variables have on the control and treatment groups.

From a technical point of view, the PSM is an algorithm that matches participants and nonparticipants in a program based on the conditional probability of their participation (PS), given a set of observable characteristics. When the results do not depend on participating, conditional on observable variables, the comparison group obtained in this way enables us to get an unbiased estimator of the average impact of the program. This technique is divided into two stages:

In the first stage we estimate a multilevel logit model in order to obtain the predicted probability of participating in a wastewater treatment project co-financed by the EU Structural Funds, taking into account a set of observable variables that includes information at municipal and regional level. This multilevel approach allows us to properly control the existence of a possible regional heterogeneity. This type of multilevel approach is performed when there is a hierarchical structure in the data, and in which the dependent variable is measured at the lowest level of disaggregation. In our case we have the municipality at the bottom level and the region at the top level. One of the great advantages of these models is their ability to explore variations at each hierarchical level after having controlled for the most important explanatory variables. Therefore multilevel regression models are one of the best approaches to study environmental factors. This heterogeneity is estimated by "random effects" because it is an efficient way to calculate the impact of the municipalities and regions, assuming that municipalities are grouped into regions. The estimated model for calculating the probability that a municipality participates in a waste water treatment project is given by the following equation:

$$f(\eta_{ij}) = \beta_0 + \sum_{h=1}^{r} \beta_h x_{hij} + u_{0j} \qquad (1)$$

Where $\eta_{ij} = Pr(y_{ij} = 1 | x_{ij}, u_{0j})$. With "j" referring to the regions (j = 1, ...,17) and "i" refers to municipalities (i = 1, ..., n), where municipalities are nested in regions (j sub index).x_{hij}. Represents the control variables (h = 1, .., r) that explain participation in the public project or not.y_{ij} is a dummy variable that takes the value 1 if the municipality i in region j has made a waste water treatment work and 0 otherwise. The function $f(\eta_{ij})$ is a nonlinear function, which in our case, it is a logistic, that ensures that the estimates of the probabilities of participation are bounded between 0-1. In equation (1) parameters β_h are interpreted in the usual way, andu_{0j} is the error term, with zero mean and constant variance given by $Var(u_{0j}) = \sigma_{ou}^2$. If the estimated variance of the random effect at regional level σ_{ou}^2 is statistically different from zero then it follows that there is regional heterogeneity.

This multilevel logit estimation enables us to obtain a binary dependent variable indicating the probability of receiving treatment (in our case, participation in a wastewater treatment project co-financed by EU structural funds) based on a number of explanatory variables. The Propensity Score value calculated by this equation is an estimated probability of participating in treatment, conditional on the X variables, which facilitates the generation of a counterfactual.

In the second stage we calculate the impact of the policy. There are basically two types of matching algorithms: the nearest neighbor matching which matches a unit in the treatment group with the unit in the comparison group that has the closest PS. The second approach in PSM techniques are the kernel based methods, which matching each participant with a score calculated as a weighted average of all Kernel non participants results.

In this work we have opted for the second option. The kernel matching is a nonparametric matching estimator that compares the outcome of each treated unit with a weighted average of the results of all units in the comparison group, using the highest weights for units with PS more likely to be compared. This approach has the advantage of a lower variance; however, a disadvantage is that some matching can occur with units that are not similar. When applying this approach, we need to be sure that the degree of compliance with the common support assumption is high. In the common support, the effect of treatment, in combination with the DID approach is written as:

$$DD_{ATT}^{PSM} = \frac{1}{N_T}\left[\sum_{i\in T}\left(Y_{i10}^T - Y_{i07}^T\right) - \sum_{i\in C} w(i,j)\left(Y_{j10}^C - Y_{j07}^C\right)\right] \quad (2)$$

Where Y_{it}^T and Y_{it}^C, t=[2010,2007] are the outcome variables related to units in the treatment and control group for each period "t". The function "w" is a kernel weight function given by:

$$w(i,j)_K = \frac{K\left(\frac{P_j - P_i}{a_n}\right)}{\sum_{k\in C} K\left(\frac{P_j - P_i}{a_n}\right)} \quad (3)$$

With "Pj" is the propensity score value for each unit in the common support. The function K(.) is a kernel or weight function in our case a Epanechnikov kernel. Finally, "a" is the bandwidth of the kernel (for more details in nonparametric methods see Hardle and others, 2004).

In the next section we show the results of the estimation of impact assessment by PSM technique at various stages.

5. IMPACT EVALUATION RESULTS

In this section we present the results of the two step procedure estimation. First we show the Logit estimation, indicating the most important characteristics of the municipalities that influence the realization of a wastewater treatment work. Then we present the testing results of the two hypotheses needed in the PSM technique: common support and balancing test. Finally, in the second step, we show the results of the impact evaluation estimator.

5.1. Estimation of multilevel logit

Table 5 shows the results of the multilevel logit model that estimates the probability that a municipality undertakes a work of sanitation and water treatment work co-financed by EU structural funds.

Table 5

LOGIT MULTINIVEL ESTIMATION

Variable	Coefficient	Standard Error	P>z
Population	0.002	0.001	0.143
Municip-Coast	-1.044	0.904	0.248
Region-coast	0.685	0.356	0.054
EU converg region	0.881	0.677	0.193
Phahing-out region	1.730	0.797	0.030
Phahing-in region	0.516	0.751	0.492
% female	-0.321	5.089	0.950
% 16-65 population	2.707	3.744	0.470

(Continue)

(Continuation)

Variable	Coefficient	Standard Error	P>z
% foreign	1.440	1.571	0.359
Pasture	1.61E-06	1.59E-06	0.311
Crop	1.87E-07	1.35E-06	0.890
Forestry	4.11E-06	2.46E-06	0.095
GDP agricultur	-6.21E-07	9.37E-07	0.508
GDP industr	-4.13E-08	3.12E-07	0.895
GDP servi	2.48E-07	3.90E-07	0.525
GAV región	-1.72E-07	3.28E-07	0.600
Sensi	0.590	0.441	0.181
Infraction	0.212	0.851	0.803
Sunshine hours	-0.001	0.001	0.467
Temperature	0.323	0.231	0.162
Rain	0.001	0.001	0.433
Guadalquivir river	-1.035	0.857	0.227
Guadiana river	-2.240	1.183	0.058
Jucar river	-0.475	0.717	0.508
Tajo river	-2.897	2.311	0.210
Duero river	-23.892	152.400	1.000
Ebro river	-1.523	1.019	0.135
Constant	-9.010	3.967	0.023
$1/\log(\sigma^2_{ou})$	-14.581	44.851	
σ_{ou}	0.001	0.015	
ρ	1.41E-07	6.34E-06	

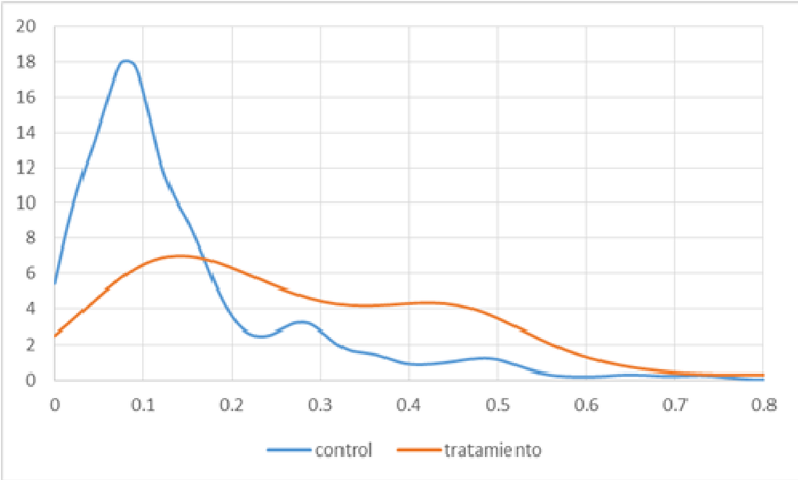
Source: Own Elaboration.

Concerning the variables related to municipality, it seems that the size of the population and their coastal location have a positive influence on conducting a sanitation project, while if the municipality is located in the Guadiana basin it is probable that it does not invest in this type of infrastructure.

In relation to those regional variables that have the most remarkable effect, it is worthy to highlight that if it is a "phasing-out" region, it will positively promote the completion of a wastewater work. The same effect is obtained for investments where there are large forest areas or regions with high average temperatures. Unfortunately, there are plenty of variables in our analysis that do not appear to be representative in statistical terms. In particular, the values related with the variables "sensible" and "infraction" are not statistically significant. The estimated variance of the random intercept at the municipality level is not significantly different from zero, so we conclude that there is not municipality heterogeneity in the data.

Having calculated the estimators of the PS, we need to check the two assumptions for the good properties of this approach (common support and balancing test). The first one is the common support assumption of the treatment and control group. The following figure provides the nonparametric estimation of the density function for both groups.

Figure 3
PSM DENSITY - CONTROL AND TREATMENT GROUP



Source: Own elaboration.

It is observed that in both groups are municipalities between 0 and 50% chance to participate in a wastewater treatment plant investment. It looks like there is little common support for higher values 0.7 of this probability.

Finally, the second assumption tested is a balancing-test for different explanatory variables used in the estimation of the PSM regression. Table 6 shows the mean value of the characteristics, the difference, and the statistical test with null hypothesis of "no statistical significant difference between the two means" (dif-mean = 0) for both, the treatment and the control groups.

Table 6
BALACING TEST – TREATMENT AND CONTROL GROUP

	Average control	Average treatment	% diference	t-test
Population	20.59	49.46	140.21	0.25
Municip-Coast	0.58	0.62	7.05	0.54
Region-coast	0.19	0.30	56.17	0.30
EU converg región	0.24	0.33	38.81	0.10
Phahing-out región	0.03	0.12	277.33	0.26
Phahing-in región	0.25	0.27	6.43	0.78
% female	0.49	0.50	1.94	0.22
% 16-65 population	0.67	0.68	2.16	0.09
% foreign	0.09	0.10	8.06	0.96
Pasture	285470.00	333568.00	16.85	0.17
Crop	97086.90	109126.40	12.40	0.59
Forestry	227846.10	218356.50	-4.16	0.50
GDP agricultur	664666.70	722349.70	8.68	0.17
GDP industr	8443317.00	6313846.00	-25.22	0.08
GDP servi	3.34E+07	2.82E+07	-15.57	0.08
GAV region	4.79E+07	4.08E+07	-14.82	0.07
Hourssun	2559347	2634233	2.93	0.36
Temperatura	16.43	16.97	3.29	0.23
Rain	5892845	5540867	-5.97	0.44
Guadalquivir river	0.08	0.15	99.20	0.29
Guadiana river	0.06	0.33	450.41	0.39
Jucar river	0.20	0.20	-1.33	0.96
Tajo river	0.11	0.05	-52.83	0.17
Duero river	0.02	0.00		
Ebro river	0.15	0.03	-77.13	0.82

Source: Own elaboration.

It is observed that the null hypothesis of no significant difference between the variables of the control and treatment populations is not rejected in every case with a 5% alpha criterion and it is not rejected in most cases if you use the alpha=10%.

Therefore, once estimated the probability of participating for the municipalities as a function of a number of observable explanatory variables, and studied that crucial assumptions for applying this approach (common support and balancing-test) are verified, now we can estimate whether there are significant differences in water quality observed between municipalities that do participate in a wastewater treatment project co-financed with EU funds and those municipalities that don't participate.

5.2. Estimation Average Treatment effect on Treated (ATT)

Using the estimated probabilities obtained in the previous stage of multilevel logit we show in this section the results of the program's impact on relevant indicators that measure the activities of sanitation and wastewater treatment. We use the propensity score matching method developed by Rosenbaum and Rubin (1983).Table 7 shows the effect that the activities of sanitation and treatment have on the total treated water and the amount of water.

Table 7

AVERAGE EFFECT PSM PROGRAM TREATMENT (ATT) IN REUSED AND TREATED WATER

	Average treatment	Average control	impact (ATT)	t-test
$Reusewater_{10}$-$reusewater_{07}$	0.015	0.399	0.362	2.98**
$treatedwater_{10}$-$treatedwater_{07}$	0.114	0.219	0.083	0.796

Source: Own elaboration.

The results show that there is no statistically significant effect on the amount of water treated (the t-statistic has a low value). However, the implementation of sanitation and water treatment projects co-financed with EU funds has a significant effect on the amount of water reused, increasing the amount available in 36 log points.

Regarding the quality of the water, the study analyze three different types of wastewater treatment procedures, considering the analysis of “primary” treatment plants (physc-chemical water treatment), “secondary” treatment plants (physc-chemical and biological water treatment) and “tertiary” treatment plants(physical-chemical + biological + more advanced water treatment). The results presented in the following table are divided into two types of information:

First, the variable "dif" shows the difference between the 2010 and 2007 water quality after the treatment process in the plant. It is an indicator of the quality of water that is released after being treated. For example, "difbod" measure the difference "dbo10a-dbo07a", that is, the difference between the biochemical oxygen demand in the water after being treated in 2010 minus the biochemical oxygen demand in the water after treatment in 2007. So that a negative sign of this difference indicates an improvement in water quality in this period of 3 years.

Variable "dif-dif" indicate the difference between the years 2010-2007 of the difference between the quality of water before being treated compared to after treatment. It indicates the intensity of cleaning in the treatment plants of the waste water, by means of the difference between the quality of water after and before treatment in the waste water plant. For example, "difficult-difbod" measure the double difference "(bod10a-bod10b) - (bod07a-bod07b)", so that a negative value in this variable is an indication higher intensity in cleaning water in 2010 compared to 2007.

Table 8 shows the results for plants with primary treatment (columns 2-5), primary and secondary treatment (columns 6-9) and the effect in "primary, secondary and tertiary" treatment plants (columns 10-13).

Table 8

IMPACT EVALUATION ON WATER QUALITY – WASTEWATER TREATMENT PLANTS WITH PRIMARY, SECONDARY AND TERTIARY TREATMENT

	Primary treatment				Secondary treatment				Tertiary treatment			
	Average control	Average treatment	ATT	t-test	Average control	Average treatment	ATT	t-test	Average control	Average treatment	ATT	t-test
wáter treated	-0.228	-0.307	-0.072	-0.531	-0.028	-0.03	-0.005	-0.036	0.685	0.922	0.186	0.901
difCOD	-83.85	-0.320	80.39	1.047	-16.43	-21.03	-3.43	-1.065	-1.770	-3.394	-2.257	-0.867
difBOD	-17.17	8.780	25.53	1.607*	-3.455	-5.256	-1.20	-1.04	-1.327	-1.212	-0.242	-0.354
difSS	-50.73	-65.030	-11.87	-0.902	-4.983	-5.368	0.151	1.907**	2.093	2.485	0.313	0.293
difNitro	-3.500	5.100	8.245	1.907**	-0.502	-0.698	-0.23	-0.104	1.612	1.358	0.082	0.05
difPhospho	-0.322	0.660	0.975	1.474	-0.387	-0.032	0.342	1.901**	-0.448	-0.297	0.152	0.752
difMetal	-0.011	0.000	0.014	1.179	-0.070	0.011	0.108	1.323	0.000	0.000	0.000	1.038
Dif-difCOD	132.06	55.270	-81.58	-1.697	120.43	111.65	-20.77	-0.672	-5.163	11.164	-20.104	-3.028**
Dif-difBOD	37.28	10.630	-26.27	-2.023**	67.04	22.23	-39.65	-3.486**	46.428	25.364	14.966	1.252
Dif-difSS	75.87	26.940	-54.18	-1.897*	74.74	177.80	89.75	1.737*	-612.510	-566.988	60.113	1.091
Dif-difnitro	4.45	1.060	-2.991	-2.427**	24.10	20.13	-3.34	-1.62*	28.244	26.988	-2.009	-0.781
Dif-difPhosp	0.611	0.100	-0.497	-2.036**	4.78	4.47	-0.15	-0.246	4.596	4.727	0.082	0.114
Dif-difmetal	0.000	0.000	0.000	.	0.11	0.00	-0.16	-1.032	0.031	0.000	-0.024	-1.652*

Source: Own elaboration. COD: chemical oxygen demand. BOD: biochemical oxygen demand. SS: suspended solids, Nitro: total nitrogen. Phospho: total phosphorus. Metal: heavy metals (mercury, lead, cadmium, etc).

The results in Tables 8 show both positive and negative results. Analyzing the "water quality after treatment" (variable diff) shows that those municipalities that made sanitation and water treatment projects show a deterioration in the quality of its waters, increase in the amount of biochemical oxygen demand and nitrogen in primary plants, or the amount of phosphorus and suspended solid in secondary treatment plants, So the implementation of wastewater treatment project co-financed with EU funds didn't improve the water quality measured after the wastewater treatment in the new plants (compared with municipalities with no projects), and when the value is statistically significant, it shows more contaminated waters in the treatment group than the values of the control group.

On the other hand, the good news are that if we analyze the variable of "water quality before and after treatment" (variable diff-diff), the results indicate that treatment group municipalities that have undertaken a sanitation and water purification work were much more intensive than in the control group. We get statistically significant values (t-test value>1.65 or 1.96 in absolute terms) for most of the plants analyzed for primary treatment, and biochemical oxygen demand, suspended solids and total nitrogen in the water in the secondary treatment plants, and very positive effect for chemical oxygen demand and heavy metals in case of tertiary treatment plants.

Combining both results it seems that we may draw the conclusion, not initially highlighted in the study, that the municipalities that have done work on sanitation co-financed with EU structural funds, compared to the control group, have initially highly polluted water. However, they have processes that clean the water much more powerful than those where the municipalities that do not implement any public project.

However, this greater intensity in water purification in municipalities with EU co-financed projects doesn't achieve, after undertaking the wastewater treatment, water as "clean" as those in the municipalities that do not have EU projects, which can be interpreted as a clear indicator of the need for carrying out works in these municipalities.

6. CONCLUSIONS

In this paper we study the effect on water quality of conducting sanitation works been financed by EU funds in the period 2007-2010. Using data from Spanish municipalities, we make a descriptive

analysis of the trend of EU Structural funds for wastewater treatment. Afterwards, we study the impact that EU funds have had on water quality by means of a combination of the propensity score matching technique and the difference in differences approach. Initially we estimate a multilevel logit model that evaluates the probability that a municipality conducts a wastewater treatment project using European structural funds. At a later stage, taking into account the value of the PSM we calculate the effect that the completion of such EU co-financed projects have had on our variable of interest. The results show that both the municipal and regional observable characteristics have a great effect on the probability of participating in a wastewater treatment project. It is worth noting that carrying out sanitation works significantly has an impact on the amount of reused water, which increases considerably. Adding to this, the implementation of this type of works considerably improves the cleanliness of the water.

REFERENCES

BLUM, D. and FEACHEM, R. G. (1983): "Measuring the Impact of Water Supply and Sanitation Investments on Diarrheal Diseases: Problems of Methodology". *International Journal of Epidemiology*, 12(3), 357-65.

CURTIS, V. and CAIRNCROSS, S. (2003): "Effect of Washing Hands with Soap on Diarrhea Risk in the Community: A Systematic Review". *Lancet Infectious Diseases*, 3(5), 27581.

DEHEJIA, R. H. and WAHBA, S. (2002): "Propensity Score Matching Methods for nonexperimental causal Studies". *Review of economics and statistics*, 151-161.

EUROPEAN COMMISION (2000): Directiva 2000/60/CE, Marco comunitario de actuación en el ámbito de la política de aguas.

— (2013): "Evaluation of the unitary regional policy 2007-2013 valle d'Aosta" DG Regio. Evaluation Dept.

— (2013): "Expost evaluation of operational programme 2000-2006 of Umbria Region". DG Regio. Evaluation Dept.

EUROPEAN UNION (1991): Directiva 91/271/CE de la Unión Europea sobre el tratamiento de las aguas residuales urbanas.

GADD, H.; HANSONN, G. and MANSSON, J. (2009): "Evaluating the impact of firm subsidy using a multilivel propensity score approach". *Working center series. Center for labor market policy research,* n.º 3.

GOBIERNO DE ESPAÑA (2007): Plan Nacional de Calidad de las Aguas: Saneamiento y Depuración 2007-2015.

HÄRDLE, W.; MÜLLER, M.; SPERLICH, S. and WERWATZ, A. (2004): *"Nonparametric and Semiparametric Models*". Springer Verlag Berlin Heidelberg.

HECKMAN, J.; ICHIMURA, H. and TODD, P. (1998): "Matching as an econometric evaluation estimator: evidence from evaluating a job training programme". *Review of economic studies*, 64. 4. 605-654.

JALAN, J. and RAVALLION, M. (2003): "Does piped water reduce diarrhea for children in rural India?" *Journal of econometrics*, 112(1). 153-173.

LECHNER, M. (1999): "Earnings and Employment Effects of Continuous Off-the-Job Training in East Germany after Unification," *Journal of Business & Economic Statistics*, American Statistical Association, vol. 17(1), 74-90.

— (1999): "Nonparametric bounds on employment and income effects of continuous vocational training in East Germany," *Econometrics Journal, Royal Economic Society*, vol. 2(1), 1-28.

NEWMAN, J.; PRADHAN, L.; RAWLINGS, G.; RIDDER, G.; COA, R. and EVIA, J. L. (2002): "An impact evaluation of education, health and water supply investments by the Bolivian Social Investment Fund". *World Bank Economic Review*, 16, 241-274.

PATTANAYAK, S. K.; VAN DEN BERG, C.; YANG, J. C. and VAN HOUTEN, G. (2006): "the use of willingness top ay experiments: estimating demand for piped water connections in Sri Lanka" *World Bank Research working paper*, n.º wps3818.

PATTANAYAK, S. K.; PATIL, J. C.; POULOS, S.; JONES, C.; KLEINAU, K.; COREY, E. and KWOK, R. (2005): "environmental health impacts of water supply, sanitation and hygiene interventions in rural mahrashtra, India". *World Bank Review*.

PELLEGRINI, G. and DE CASTRIS, M. (2007): "Identification of the spatial effects of industrial subsidies" *Paper presented at the joint congress of the European regional science association* (47th congress). Paris, France.

RODRÍGUEZ, M. (2012): "Técnicas de evaluación de impacto: propensity score matching y aplicaciones prácticas con stata". *Documento de trabajo*, n.º 2/2012. Instituto de Estudios Fiscales.

ROSENBAUM, P. R. and RUBIN, D. B. (1983): "The central role of the propensity scores in observational studies for causal effects". *Biometrika*, 70, 41-55.

SMITH, J. A. and TODD, P. E. (2005): "Does matching overcome La Londe's critique of non experimental estimators?" *Journal of Econometrics*, 125, 205-353.