

**Livorno , 11-13 September 2017**

**Determinants of residential water demand and  
social sustainability of integrated water service:  
analysis and proposals based on  
administrative data of a Tuscan municipality**

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# Context and motivations

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- In the last 15 years **household water expenditure strongly increased in Tuscany**
- Our research aims at studying the economic impact of water tariff on households by using **administrative data of a Tuscan municipality**, Empoli
- The town of Empoli belongs to a territory managed by **Acque Spa**, where the regional regulator is **AIT** (Autorità Idrica Toscana)
- **AEEGSI** (Autorità per l'Energia Elettrica il Gas e il Sistema Idrico) is in charge on defining the method on which **AIT establishes the tariff**
- The current tariff is composed of 2 parts: a **fixed part**, independent on consumption, and a second part based on an **IBT (Increasing Block Tariff)** with prices increasing with blocks of consumption

# Aims

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- **To analyze the determinants of residential water demand**
  - Econometric estimation of determinants of consumption
  - Price and income elasticity
  - Estimation of an equivalence scale
  
- **To analyze the distributive impact of the current water tariff**
  - Distributive impact of the water tariff in force in 2014
  - Distributive impact of changes in 2015 with respect to 2014
  - Identification of households with affordability problems
  - Analysis of current social benefits
  
- **To evaluate different hypothesis of reforms of the current water tariff**
  - Simulation of different hypothesis of reforms
  - To improve horizontal equity, vertical equity and affordability, taken into account operational feasibility.

# Data

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- **Civil registry of residents in the municipality** (years 2011, 2012, 2013, 2014).
- **Database on consumption of water services for each user** in the town of Empoli, given by Acque Spa (years 2011, 2012, 2013, 2014).
- **Tax records of residents in Tuscany** Regione Toscana (years 2010, 2011, 2012, 2013).

# Matching of data

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- **Identification of domestic consumption**
  - Users of non-domestic consumption are excluded
  - Users with more contracts are excluded
  - Users with seasonal consumption are excluded
  
- **Matching of data**
  - For many users there is not a matched household in the register of residents

# The determinants of residential water demand

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- The **observed consumption** is the result of **the matching between supply and demand**
- **Random effects panel model**
  - **About 11.000 HH for 4 years**
  - **Balanced panel**
  - **Log-log model**
  - **Dep var: logarithm of total household annual consumption**
  - **Indep vars: logarithm if continuous**
- **Indep vars :**
  - **Average price of the year before to check for endogeneity + Mundlak procedure**
  - **Family size** (economies of scale)
  - **Age and type of work of the Householder**, number of children and old people.
  - **Income and real estate** (not dwelling houses)
  - **Characteristics of houses** (floor and water pressure)
  - **Environmental aspects** (precipitation and temperature)

	Model 1	Model 2
Log of average price at t-1	-0,52***	-0,13***
Mean of average household price in the 4 years		-1,28***
Family size	0,40***	0,33***
Sq. family size	-0,03***	-0,02***
Age class: 35-45	0,03*	0,04**
Age class: 45-55	0,06***	0,08***
Age class: 55-65	0,10***	0,12***
Age class: 65-75	0,07***	0,09***
Age class: Oltre 75	0,06**	0,08***
Number of children	-0,08***	-0,08***
Number of old people	0,03***	0,02***
Citizenship of the head of HH (italian=base)	0,06*	0,06**
Ownership of other houses	0,01*	0,01**
Log of household eq. income	0,04***	0,03***
Type of work/income: retired	0,01	0,00
Type of work/income: self employed	0,04***	0,04***
Floor	-0,05***	-0,02***
Log of pressure	0,08***	0,07***
Average temperature	0,01*	0,00
Average precipations	-0,00***	0,00***
Constant	3,46***	4,39***
R-sq: Within	0,0228	0,0218
R-sq: Between	0,4735	0,5279
R-sq: Overall	0,4266	0,4831

\*\*\*Significance of 1%, \*\* Significance of 5%, \* Significance of 10%

# The distributive evaluation of the current water tariff

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- **Horizontal equity**, with respect to the family size
- **Vertical equity**, through inequality indices
- Assess of water **affordability**
  - *Share of households with incidence of expenditure on income higher than **3%***
  - *Differentiated by level of consumption*



# The water tariff in 2014

	Block	Aqueduct (price for mc)	Sewage (price for mc)	Water treatment (price for mc)
Discounted	Until 80 mc	1.189	0,153	0.598
Basic	80 - 200 mc	1.586	0.203	0.797
First over-consumption	200 - 300 mc	2.155	0.277	1.084
Second over-consumption	Over 300 mc	2.586	0.332	1.300
Fixed part	40.931			

**Average annual household expenditure  
(euro)**

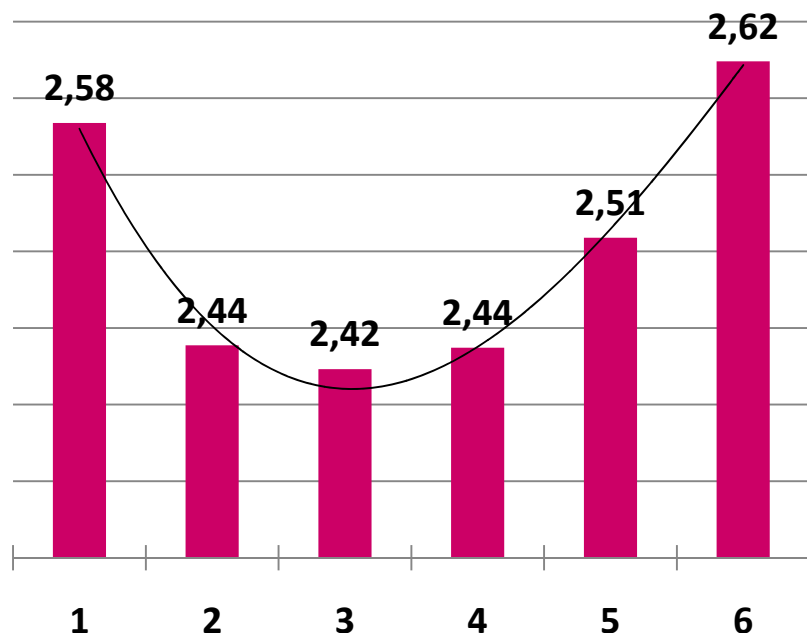
Quintile /family size	1	2	3	4	5	6+	Total
1	187	237	294	343	410	500	286
2	188	247	294	348	411	607	272
3	182	258	311	350	437	532	275
4	180	255	301	357	464	474	279
5	195	275	346	417	565	650	302
Total	186	255	310	361	440	530	283

**Average annual per capita expenditure  
(euro)**

Quintile /family size	1	2	3	4	5	6+	Total
1	187	118	98	86	82	73	117
2	188	124	98	87	82	95	126
3	182	129	104	88	87	84	128
4	180	127	100	89	93	76	124
5	195	137	115	104	113	101	141
Total	186	128	103	90	88	81	127

# The distributive evaluation of the current water tariff

Price for cubic meter by family size (euro)



Share of households at risk of affordability

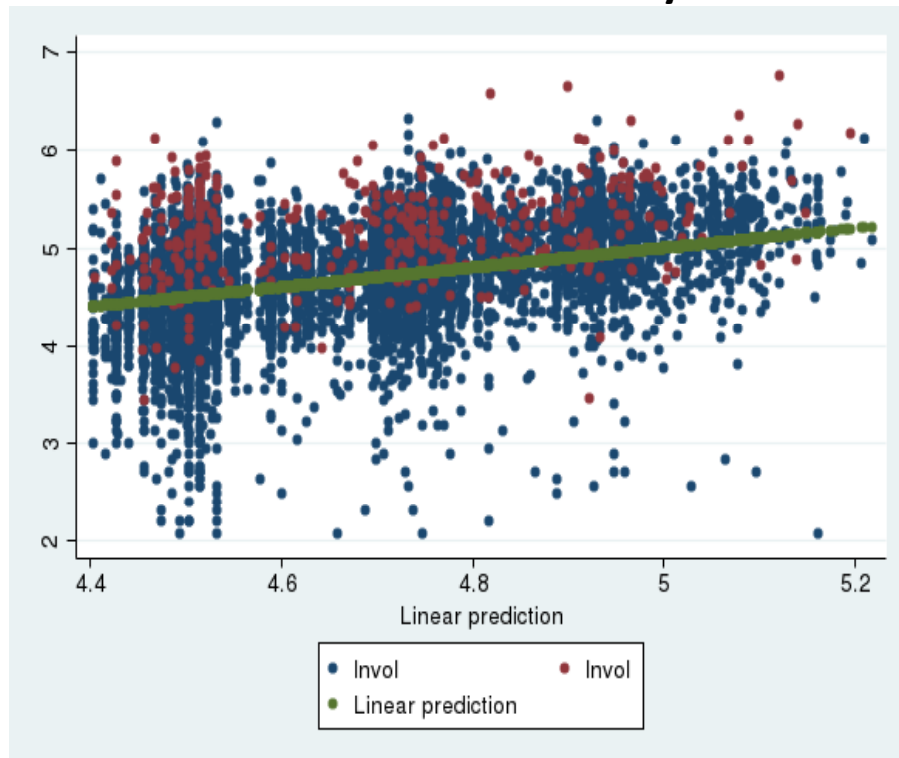
Quintile	Family size						Total
	1	2	3	4	5	6+	
1	30%	18%	22%	22%	24%	26%	23%
2	8%	3%	0%	1%	0%	2%	3%
3	2%	1%	0%	0%	0%	4%	1%
4	1%	0%	0%	0%	0%	0%	1%
5	1%	0%	0%	0%	0%	0%	0%
Total	8%	4%	5%	5%	8%	14%	6%

Inequality indices

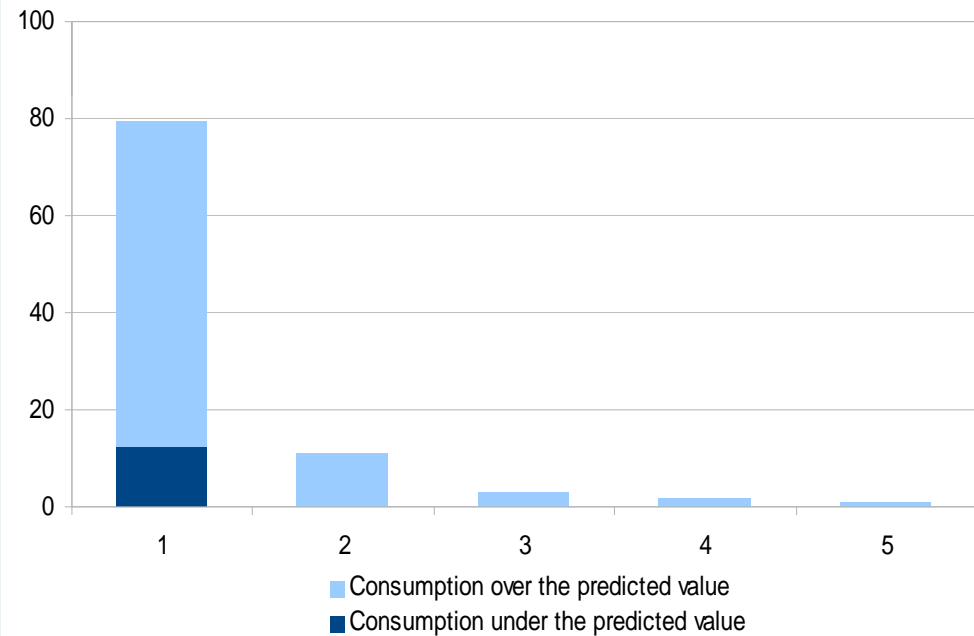
Pre-tax Gini	0,27903
Post-tax Gini	0,28141
Reynolds-Smolensky net redis. effect	-0,00238

# Risk of affordability and consumption

Observed and predicted consumption for households at risk of affordability



Share of households at risk of affordability by consumption level and quintile



# What about the current social benefits?

- Current social benefits provide a reimbursement if:
  - ISEE < 8.500 euro
  - ISEE < 11.000 euro with particular conditions
- But, only a few households ask and obtain the reimbursement (about 0,85%)

Variation of the share of HH at risk of *affordability* (p.p.)

Quintile/ Family size	1	2	3	4	5	6+	Total
1	-20,8	-14,2	-18,3	-19,7	-18,1	-31,0	-18,8
2	0,2	2,8	2,7	2,3	3,2	12,2	2,3
3	2,8	1,2	1,6	0,8	0,0	0,0	1,5
4	1,2	0,3	0,8	0,0	0,0	0,0	0,6
5	0,4	0,4	0,2	0,3	0,0	0,0	0,3
Total	-2,8	-1,3	-2,7	-3,8	-5,6	-13,1	-2,8

If all potential beneficiaries would ask and obtain the reimbursement



Inequality indices

	Before	After
Pre-tax Gini	0,27903	0,27903
Post-tax Gini	0,28141	0,28034
Reynolds-Smolensky net redis. effect	-0,00238	-0,00131

# Hypothesis of reforms of the current water tariff

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- **Aim:** improve horizontal equity, vertical equity and affordability, taken into account the operational feasibility
- Invariance of revenue and absence of behavioral changes
  1. **A tariff by family size**
  2. **Free minimum consumption**
  3. **A tariff by family size + social benefits by ISEE**

# Results of testing alternative water tariffs

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## Tariff by family size (equivalence scale)

- A tariff based on the number of components of household improves horizontal equity but results in worsening vertical inequality and produces an increase in the proportion of families at risk of affordability. These effects depend on the weak link between consumption and income but also by the fact that the families who lose, single-components are the most present in the population.

## Free minimum consumption tariff

- None of the simulations improves the vertical equity of the tariff, as the benefit does not take into account the level of income of different households. Increases the proportion of families at risk of affordability.

## Tariff by family size + social benefits by ISEE

- horizontal equity improves and there is a relevant reduction of households at risk of affordability.

# A tariff by family size

## The tariff in force in 2015

Aqueduct	Block	Price for mc (euro)
Discounted	Until 30 mc	0.2
Basic	30 - 90 mc	1.534
First over-consumption	90 - 200 mc	2.175
Second over-consumption	Over 200 mc	3.058
<b>Sewage</b> (Price for mc - euro)		0.207
<b>Water treatment</b> (Price for mc - euro)		0.809
<b>Fixed part</b> (euro)		49.778



## The reformed tariff (our hypothesis)

Aqueduct	1 comp.	2 comp.	3 comp.	4 comp.	5+ comp.	Price for mc (euro)
Discounted	Until 27 mc	Until 37 mc	Until 45 mc	Until 52 mc	Until 59mc	0.223
Basic	27 - 63	37 - 86	45 - 106	52 - 122	58 - 134	1.713
First over-consumption	63 - 120	86 - 165	106 - 203	122 - 233	134 - 257	2.430
Second over-consumption	Over 120	Over 165	Over 203	Over 233	Over 257	3.415

# A tariff by family size

## Var. % HH expenditure

Quintile	HH size						Total
	1	2	3	4	5	6+	
1	13,1	3,2	-2,7	-6,8	-9,6	-7,8	-1,6
2	13,1	3,5	-2,8	-6,7	-9,8	-6,6	0,2
3	12,3	3,5	-2,3	-6,6	-9,9	-7,2	0,2
4	12,0	3,5	-2,4	-6,3	-9,4	-9,2	-0,4
5	13,1	4,3	-1,4	-5,1	-7,5	-6,5	1,5
Total	<b>12,7</b>	<b>3,7</b>	<b>-2,3</b>	<b>-6,3</b>	<b>-9,4</b>	<b>-7,6</b>	<b>0,0</b>

## Variation of the share of HH at risk of *affordability* (p.p.)

- **TOTAL +0,6 p.p.**
- First quintile +
- Second quintile +
- Last quintile +

## Inequality indices

	Before	After
Pre-tax Gini	0,27903	0,27903
Post-tax Gini	0,28164	0,28168
Reynolds-Smolensky net redis. effect	-0,00262	-0,00265



# Free minimum consumption: yes, but how?

## For everybody or only to household with lower incomes?

- Disegno di legge under discussion in Senato (N. 2343), art. 7
- Collegato ambientale, Legge 221/2015, art. 60

<p><b>How much for each HH?</b></p> <p><b>How is computed?</b></p>	<p>The minimum of consumption is inside the tariff</p>	<p>The minimum is not computed in the total consumption</p>
<p><b>Minimum consumption for user</b> 18 mc for each user/HH</p>	<p><b>Hp 1</b></p>	<p><b>Hp 2</b></p>
<p><b>Minimum consumption per capita</b> -18 mc for HH with 1 person -36 mc for HH with 2 people -54 mc for HH with 3 people -72 mc for HH with 4 people -90 mc for HH with 5+ people</p>	<p><b>Hp 3</b></p>	<p><b>Hp 4</b></p>
<p><b>Minimum consumption per capita, with economies of scale</b> -18 mc for HH with 1 person -25mc for HH with 2 people -30 mc for HH with 2 people -35 mc for HH with 4 people -40mc for HH with 5+ people</p>	<p><b>Hp 5</b></p>	<p><b>Hp 6</b></p>

# Free minimum consumption

		Hp 1	Hp 2	Hp 3	Hp 4	Hp 5	Hp 6
Lost revenues		2%	20%	20%	50%	4%	33%
Var. expenditure for single-person households		-0.9%	-4.8%	8.1%	17.6%	12.8%	15.6%
Var. expenditure for large households		0.6%	4.6%	-8.9%	-9.8%	-9.7%	-9.7%
Share of HH at risk of <i>affordability</i>	7,06%	7.11%	7.40%	7.71%	8.67%	7.75%	8.47%
Post-tax Gini	0.28164	0.28164	0.28160	0.28164	0.28164	0.28168	0.28168

# A tariff by family size + reimbursement by ISEE

## A tariff by family size

Aqueduct	1 comp.	2 comp.	3 comp.	4 comp.	5+ comp.	Price for mc (euro)
Discounted	Fino a 27	Fino a 37	Fino a 45	Fino a 52	Fino a 59	0.223
Basic	Tra 27 e 63	Tra 37 e 86	Tra 45 e 106	Tra 52 e 122	Tra 58 e 134	1.713
First over-consumption	Tra 63 e 120	Tra 86 e 165	Tra 106 e 203	Tra 122 e 233	Tra 134 e 257	2.430
Second over-consumption	Oltre 120	Oltre 165	Oltre 203	Oltre 233	Oltre 257	3.415



## Social benefits by ISEE

- ISEE < 4000 euro
- ISEE < 5000 euro se figli minore ed un solo genitore
- ISEE < 5000 se tutti i componenti hanno più di 60 anni

Coherent with Collegato ambientale, Legge 221/2015, art. 60

# A tariff by family size + reimbursement by ISEE

## Var. % HH expenditure

Quintile	HH size						Total
	1	2	3	4	5	6+	
1	-16,3	-12,6	-19,2	-22,6	-34,0	-37,5	-21,6
2	17,8	8,4	2,1	-1,9	-5,1	-1,1	5,1
3	17,5	8,7	2,8	-1,9	-5,1	-1,9	5,2
4	17,1	8,6	2,6	-1,3	-4,3	-3,9	4,7
5	18,6	9,7	3,8	0,3	-2,2	-1,0	6,8
Total	11,6	5,7	-1,2	-5,7	-13,9	-18,3	0

## Variation of the share of HH at risk of *affordability* (p.p.)

- **TOTAL -1,3 p.p.**
- First quintile -
- Second quintile +
- Last quintile +

## Inequality indices

	Before	After
Pre-tax Gini	0,27903	0,27903
Post-tax Gini	0,28164	0,28121
Reynolds-Smolensky net redis. effect	-0,00262	-0,00219

# Conclusions

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- Water consumption is **anelastic with respect to price** and **income elasticity is low**. Further, it depends significantly by factors that are out of control of households.
- **A water tariff by family size not necessarily improve vertical equity and affordability. Free minimum consumption is inadequate to give** a real support to water poors.
- The best way to improve vertical equity and affordability is to **improve and make effective social benefits that already exist**.
- **Further developments:** a survey to a sample of household to ask information about cultural aspects and energy efficiency of houses that could help explain household consumption.

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