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Newts microsimulation model for an informative and co-creative public-decision making

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THE NEWTS PROJECT

The research program addresses the issue of household water demand management. Prima facie, it aims to provide a socio-economic assessment of green nudging policies, focusing on water consumption controlling and proper understanding of the charging system by the households, taking into account adjustments in the pricing policy that nudges may generate (in view of their effects on water demand functions). From an operational

point of view, it consists in developing a micro-simulation model, based on econometric estimates of household water demands, to assess the socio-economic returns of mix policies, combining nudges and pricing instruments, and identify financially sustainable DSM (demand-side management) policies to improve current water utility tariffs.

SOCIAL INCENTIVE PRICING POLICY

- Affordability**
- Incentive Pricing**
- Equity**
- Full Cost Recovery**
Including Environmental Costs
- Financial Stability**

STUDY SITES

Gijón, Spain
271,000 inhabitants:
Three-blocks water tariff; Special tariff for households living in buildings with a collective metering system (two-blocks); High percentage of water billed to households with collective meters (57% in 2017); Income public policies supporting basic supplies; Pending investments in sanitation systems.

Sfax, Tunisia
900,000 inhabitants:
Semi-arid climate; Very high mobilization cost of water resources; Super-progressive pricing (all the water use is charged at the marginal price); High disparity in regular access to water; Insufficient water supply; High demand of water.

Cape Town, South Africa
4 million inhabitants:
Water crisis (Day Zero); Water restrictions; Green nudges campaign (2015-2016); Free Basic Water Policy; Substantial increases of tariff rates (13.52 €/M (water + sanitation) for consumption slightly above 10.5 M/month).

Saint Paul, France
110,000 inhabitants:
Insufficient resources (because of a dry season); High water consumption; High poverty rate (35%); Strong degree of progressivity of water tariff; Mounting deficits; Unpaid water bills; Legal prohibition of water cuts.

THE SCIENTIFIC PROJECT

1 LINKING NUDGES AND WATER DEMAND FUNCTIONS

Econometric estimate of local water demand functions

Nudges campaign / Randomized control trials / Impacts on water consumption (treatment effects)

Econometric estimation of resulting changes in local water demand functions

Identification of transmission channels:
- decrease in captive consumption?
- greater price-sensitivity?
- improved perceptions of tariffs?

2 DSM POLICY DESIGN

Socio-economic evaluation of local current water tariffs (through a dashboard of appropriate indicators, in each area of the EDF for water, making use of the information provided by econometric estimates of water demand functions)

Assessment of the contributions of nudges to the socio-economic performance of local current water tariffs.

Simulations of mixed programs, combining nudges and tariff instruments, making use of estimated econometric models and relied data sets.

3 ADVANCING RESEARCH IN BIS

Lab experiments to deal with time dimension and spillover effects (social interactions)

Improving the information conveyed by benchmarking and social normal information treatments (large consumer vs. over-consumer)

The use of smart technologies (nudges design, static vs. dynamic infographics, dark patterns)

Nudges perception (additional feedbacks from the field with local public consultation, local stakeholder consultation and focus groups)

GENERAL ARCHITECTURE

"Policy makers and water professionals often rely too heavily on their intuition to assess how changes in water tariff regimes affect financial self-sufficiency, equity, and economic efficiency. Quantitative assessment of these impacts requires the specification of a set of nonlinear relationships with numerous parameters, and then formal simulation procedures to analyze how changes in the tariff structure and price levels affect outcomes of policy

interest. Intuition is an unreliable guide for understanding the behavior of systems of nonlinear equations."

Nauges C. & Whittington D. [2017], Evaluating the Performance of Alternative Municipal Water Tariff Designs: Quantifying the Tradeoffs between Equity, Economic Efficiency, and Cost Recovery, World Development, 91, pp. 125-143

POPULATION MODULE

describes the population of households with regard to some relevant variables for calculation and decomposition of (i) consumption, (ii) bills and (iii) indicators making up the dashboard.

PRICING MODULE

describes the tariff system (based on French regulation) that applies for the households listed in the Population Module.

- In the case of IBTs: fixed part, number and size of consumption blocks, unit prices within each block, VAT rate and environmental charges for water service and wastewater service.
- The user is also asked to provide information on service costs (fixed charges, number of subscribers, unit variable cost of production for, successively, water and sanitation) and environmental costs (if available).

DEMAND MODULE

makes use of the econometric model to calculate for each household in the Population module:

- its water consumption $q_i = q_i^c + q_i^f$
- the related captive part and the size of its basic consumption like:
 $\ln q_i = -2.56 + 0.48 \cdot \ln N_i + 0.44 \cdot \text{SNWA}_i$
(for instance ; captive part is reprocessed by the user).

INVOICE MODULE

- computes the water bills with $T_i = T(q_i)$
- breaks down the water bill into a minimum basic type part (for water) $T_i^{\text{min}} = T(q_i)$ and a non-basic type part $T_i - T_i^{\text{min}}$
- reconstructs the amount of invoice by distinguishing different subsidies and contributions to service funding (with reference to a structurally balanced two-part tariff $(F, \pi) = (\frac{CF}{N}, c)$)

EVALUATION MODULE

includes a scoreboard and about fifty indicators (for level 1 information) allowing to measure the socio-economic performance of the pricing policy in the 5 fields of analysis set by E-WFD. These indicators correspond:

- to those commonly used in academic literature on water;
- to other measures commonly used in other fields of Economics (Poverty Economics, Production Economics, Tax Economics, Banking and Finance ...) that are thought to be relevant for the field of analysis considered.

EVALUATION MODULE NEWTS DASHBOARD

More information:
CAR by income decile • PAR by income decile...

PAR by standard of living decile:

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
HR RATE	1	1	0.957	0.822	0.478	0.5	0.378	0.109	0	0
MEAN	50.32	44.65	36.97	32	21.62	15.87	9.05	2.13	0	0
MEDIAN	33.77	30.68	34.8	30.43	27.04	19.95	16.12	6.46	0	0
STD	35.24	40.67	16.84	24.7	0	0.06	0	0	0	0

More information:
Lambert & Aranson sub-group decomposition

	GINI INDEX	WITHIN	BETWEEN	TRANSVARIATION
TBSE	-	-	-	-
IBT	-	-	-	-

Confusion Matrix

	D+	D-	
T+	$O_{11}=6024.5$	$(O_{12})=6507.7$	$O_{13}=12532.2$
T-	$O_{21}=2396.7$	$(O_{22})=1159.3$	$O_{23}=3556.0$
	$O_{31}=8421.2$	$O_{32}=7667.0$	$O_{33}=16088.2$

TPR: 71.5% • Miss Rate: 28.5% • TNR: 15.1% ... DOR: 0.448
Kappa score: -0.137 • Cohen Ratio: -0.288

AFFORDABILITY	INCENTIVE EFFECT	ECONOMIC EFFICIENCY	EQUITY	FUNDING
Mean	CAR 2.7% (1.2%) PAR 1.2% (1.2%)	Consumptions 45.12 Service level First best 0'	Gini Index Household income	
AV TBSE	+1.3 +0.6	TBSE 34.98 IBT 0	IBT 0 TBSE	
Median	2.7% (1.2%)	PP IBT: 38.00	PP IBT: 0	
Std dev	3.4 4.1	Effective overconsumptions Full TBSE 0	0	
Incidence		Household 14.2	Actual TBSE 0	
Household	CAR 0.628 PAR 0.424	Per capita 2.7	Gap (en %) ...	
Individual	0.649 0.556	Std dev IBT 11.87	RS Index	
Child	0.884 0.507	Std dev PP IBT 8.4	Pfähler Index	
Intensity EHAD		Std dev TBSE 12.57		
Mean	40.58 +7.2	Invoices (euros per trim.)	Change in Agg. Surplus IBT ΔF_{t-1}	Per capita income
Median	33.78 +3.4	IBT 167.33	Full TBSE ΔF_{t-1}	
Std dev AD	29.78 -8.07	PP IBT 129.12	Actual TBSE ΔF_{t-1}	
Inequality		TBSE 141.04	Change in consumer (household) surplus (first rank) IBT ΔU_{t-1}	
Gini Index	0.410 0.405		PP IBT ΔU_{t-1}	
Schutz Index	0.217 0.220	Mismanagement costs (effective) Household 14.25		
Decile ratio	6.1 4.7	Per capita 4.01		
Decime ratio	8.2 5.9			

Funding (Cost Recovery) - Operating result

	S'	T'	A _q	S'	T'	A _q	A _q	Access Fee	Δ_{DM}
d_1	S'_1	T'_1	A_{q1}	S'_{q1}	T'_{q1}	A_{q1}	A_{q1}	$H_{11} \Delta_1$	Δ_{DM1}
d_2	S'_2	T'_2	A_{q2}	S'_{q2}	T'_{q2}	A_{q2}	A_{q2}	$H_{21} \Delta_1$	Δ_{DM2}
\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\vdots	\vdots
d_{10}	S'_{10}	T'_{10}	A_{q10}	S'_{q10}	T'_{q10}	A_{q10}	A_{q10}	$H_{10} \Delta_1$	Δ_{DM10}
	S_q	T_q	A_q	S_{q1}	T_{q1}	A_{q1}	A_q	$H_{10} \Delta_0$	Δ_{DM}

Funding Structure

	FIXED	VARIABLE
REVENUES	$nF + R(Q_0)$	$R(Q - Q_0)$
COST	$CF + cQ_0$	$c(Q - Q_0)$
	π_0	π_1

Operating Result Sensitivity

	Revenues	Cost </th <th>Operating Result</th>	Operating Result
	$\Delta R_0 = \dots$	$\Delta C_0 = \dots$	$\Delta \pi_0 = \dots$
	$\Delta R_1 = \dots$	$\Delta C_1 = \dots$	$\Delta \pi_1 = \dots$
	$\Delta R = \dots$	$\Delta C = \dots$	$\Delta \pi = \dots$

Taxation

	VAT	GREEN TAXATION	ENVIRONMENTAL COST	REMAINING BALANCE
d_1				
d_2				
\vdots				
d_{10}				

IMPACT LARGE CONSUMERS

FUTURE DEVELOPMENTS

Specific improvements with:

- Consideration of the amenities (for the measure of the environmental cost);
- Additional indicators related to Political Economics (polarization index) and social part of the water pricing policy;
- Assistance program module for means-tested measures (e.g. aid for unpaid bills, water vouchers, water cheque rebate);
- Decision support Module with reinforcement learning algorithms (artificial intelligence);
- Efficient digital environment (dashboard design, data visualization, information depth, usability engineering ...)
- Up-scaling at the basin level (for integrated management of water resources) with the setting of an aggregated dashboard, mapping of the socio-economic performance of decentralized water DSM policies and spatial inequalities, and integration into a CGE Model (and WEFE nexus)

Participant organisation name	Acronym	Country
International Office for Water (CO)	OiEau	FR
University of La Réunion	UR	FR
ETIFOR Valuing Nature	ETIFOR	IT
University of Rouen Normandy	URN	FR
EURECAT	EUT	ES
SIWI	SIWI	S
REKK Energiapiaci Tanacsado Kft	REKK	HU
West country River Trust	WRT	UK
Association of European Regulators in the drinking water and wastewater sector	WAREG	IT
European University Institute	EUI	IT
Middle Tisza Water Directorate	KÖTIVIZIG	HU
Consiglio Bacino Brenta	CBB	IT
Ajuntament de Figueres	FIGUERES	ES

INN WATER Pillars

- Improved water governance assessment framework
- Quintuple Helix and Social Engagement
- Improved economic and financial tools design for basin authorities and utilities

supporting InnWater cross-sector and multi level governance platform for improving water governance and policy recommendations

