The 5th Atlantic Workshop on Energy and Environmental Economics (AWEEE)

SPANISH RESIDENTIAL ELECTRICITY DEMAND USING AGGREGATE DATA: THE INFLUENCE OF CLIMATE

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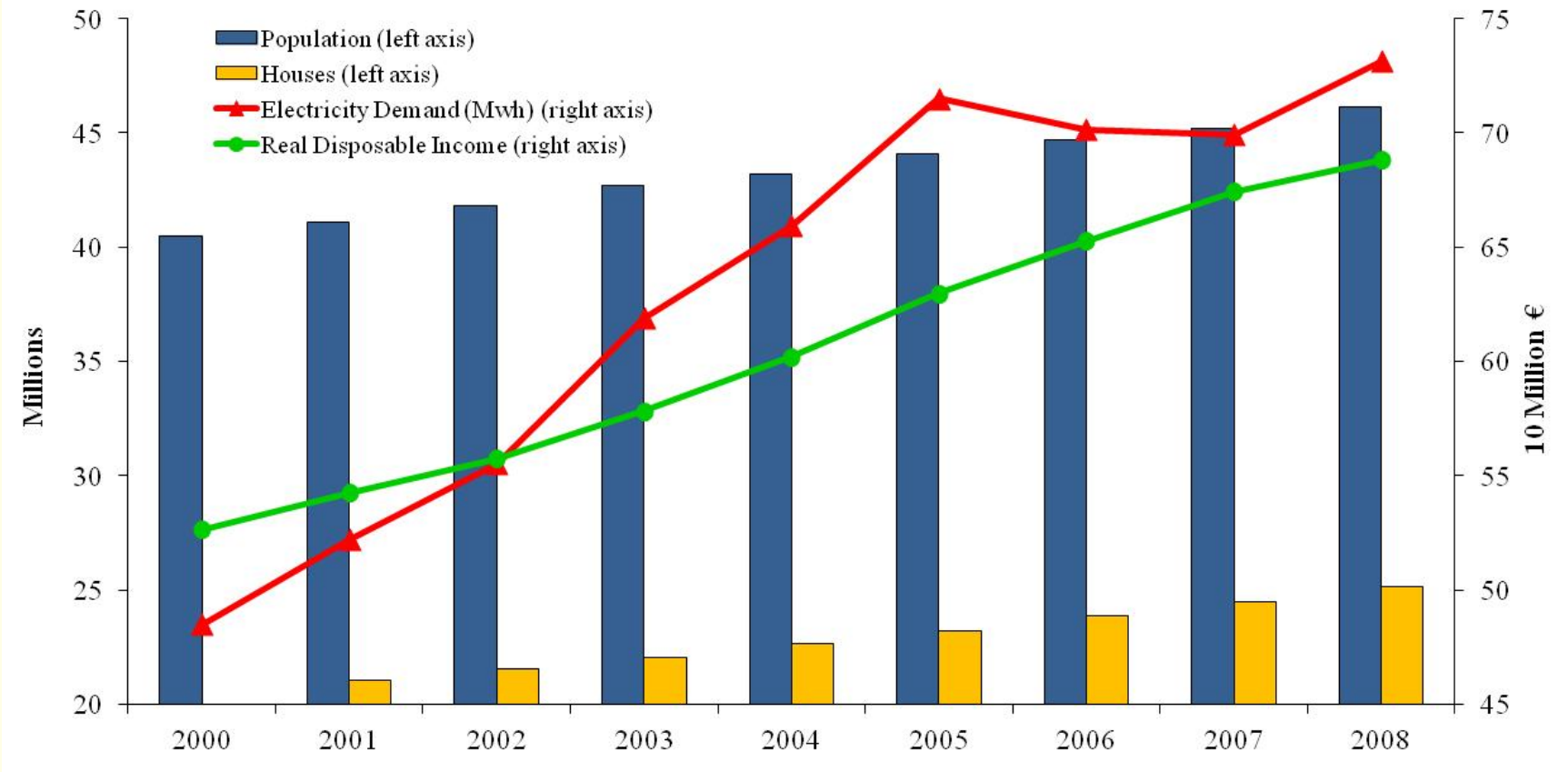
Motivation

- **Changes which have conditioned the increasing Spanish residential energy demand.**

1. **Increasing population and the number of new houses.**
2. **Decreasing household size.**
3. **Convergence with EU in household equipment.**
4. **Long lasting policy of low tariffs.**

Motivation

- **Changes which have conditioned the increasing Spanish residential energy demand:**
  1. Increasing population and number of new houses.
  2. Decreasing household size.



Motivation

- **Changes which have conditioned the increasing Spanish residential energy demand:**

  3. **Convergence with EU in household equipment.**

Percentage of Spanish households	2000	2008
With installed heating system	42.43	65.10
With gas heating**	*38.35*	*45.94*
With electric heating**	*12.01*	*25.60*
Air Conditioning	15.52	35.5
Hot Water	98.77	99.27*
Hot water with electricity**	*12.92*	*14.98**
Independent Dryer	n.d	21.6
Electric Cooker	23.13	39.61*
Dishwasher	24.56	43.50
Freezer	26.55	33.86*
Microwave	54.28	78.01*
Computer	30.54	59.60
Video	70.31	75.70*
Music centre	59.83	64.78*
Video games	n.d	27.70

*Data for 2005.** Share of households with installed heating and hot water.
Source: ECPF and Survey of Households and Environment (Encuesta de Hogares y Medio Ambiente (2008))

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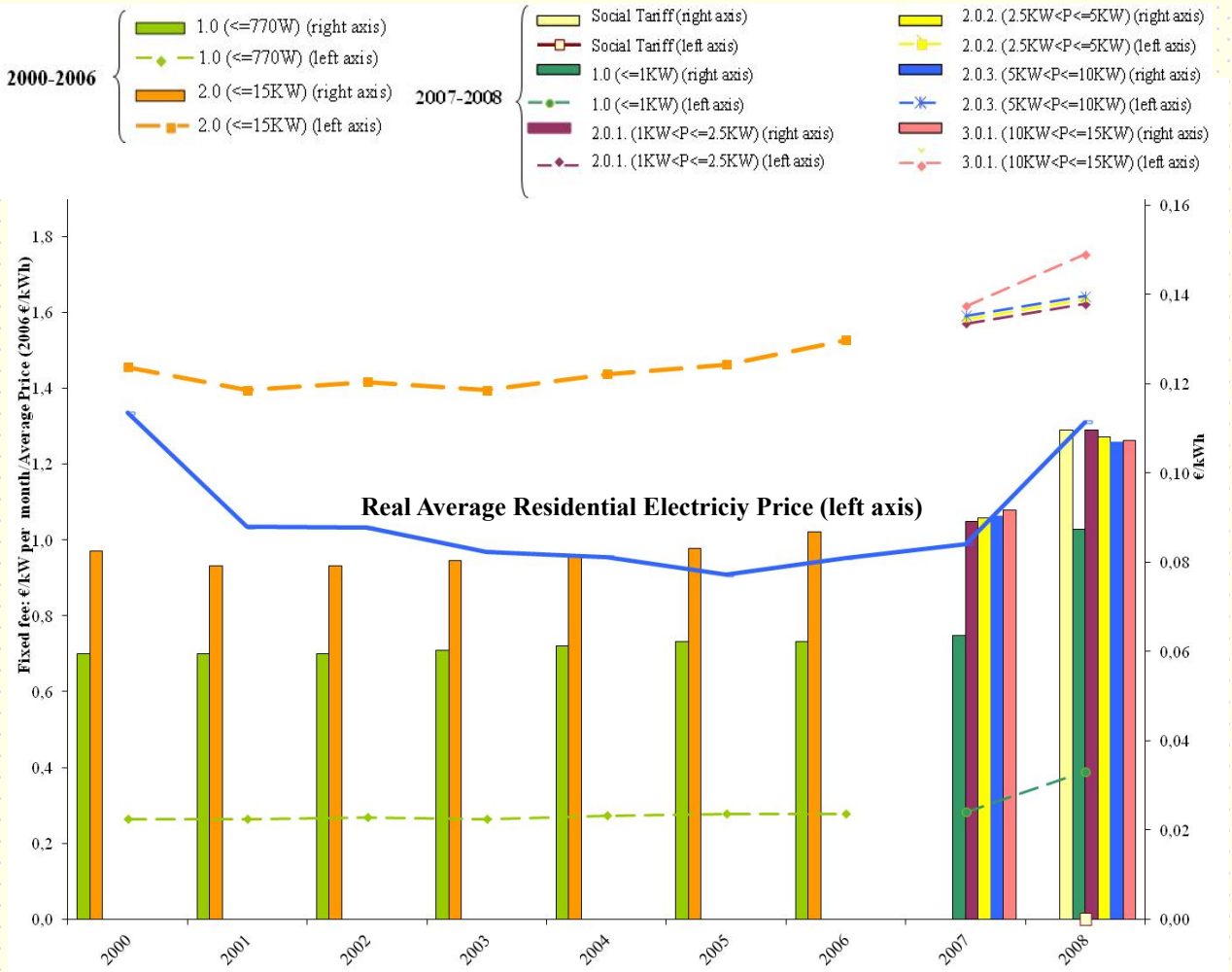

Objectives

- **Estimate Spanish residential electricity demand using an econometric approach:**
  - **Estimation of short and long run price and income elasticities.**
  - **Analysis of the impact of climate on electricity consumption.**

- **Aggregate panel data:**
  - **47 Spanish provinces.**
  - **2000-2008.**

Methodology

- **Household production theory**: household combines electricity with capital equipment to produce energy services.
- **Dynamic partial adjustment model**: Electricity consumption may differ from the long-term equilibrium.

$$\ln E_{it} = \beta_i + \beta_{EP} \ln E_{it-1} + \beta_{PE} \ln PE_{it} + \beta_Y \ln Y_{it} + \beta_{POP} \ln POP_{it} + \beta_{HS} \ln HS_{it} + \beta_{GAS} GAS_{it} + \beta_{HDD} \ln HDD_{it} + \beta_{CDD} \ln CDD_{it} + \beta_{DT} DT_t + \varepsilon_{it}$$

- **Log-Log functional form**.

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Electricity Price

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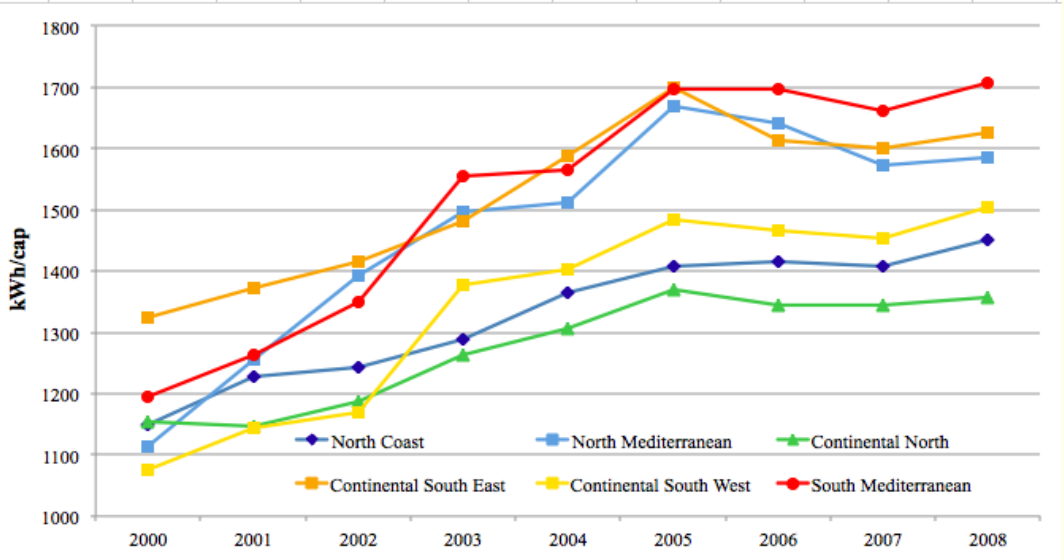
- **The choice of the electricity price variable**:
  1. **To use marginal price and detract the fixed fee from the income.**
  2. **To use an average price**: **Endogeneity**.
     - Mitigated by many different block pricing levels.
     - Exogenous because regulated.

Climate Variables

1. Residential electricity demand depends on weather/climate.

Climate Zones in Spain

Domestic Electricity consumption per capita in Spain per climate zones



Climate Variables

1. **Residential electricity demand depends on weather/climate.**
2. **The response of electricity demand to the outside temperature is clearly non-linear.**
3. **This effect is even more pronounced in Southern countries like Spain.**
4. **Several methods to measure the effect of climate:**

Method	Advantage	Drawback
Average outside temperatures	Easy to use	Non-linear effect not reflected.
Dummy variables for climatic zones	Easy to use	Might also capture other factors.
CDD and HDD	Captures non-linear effect	There is no unique threshold.

Climate Variables

- **Non-linear relationship between demand and temperature: HDD and CDD**

$$HDD = \sum_{nd} T^{*} - T_t ; 0$$ **Heating Degree Days**

$$CDD = \sum_{nd} T_t - T^{*} ; 0$$ **Cooling Degree Days**

Simple approach

T*: Generally used 18°C for HDD and CDD

Complex approach

Finding own T*:

1. Plot total daily electricity demand against daily average outside temperature.
2. Find minimum and comfort zone.

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Model B
Simple approach

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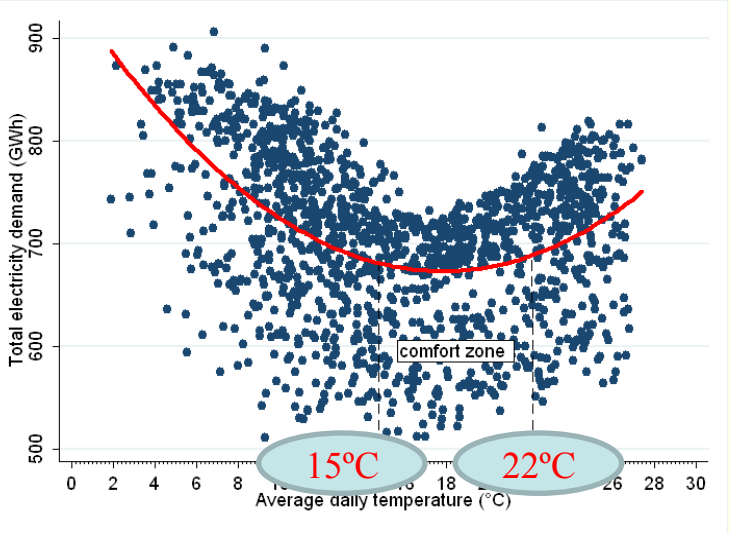

Econometric Approaches

- **Two main problems to solve:**
  - **Unobserved heterogeneity.**
  - **Dynamic model: Endogeneity of the lagged variable.**
- **Possible solutions:**
  - ↳**LSDV, RE:** Unobserved heterogeneity.
  - ↳**GMM**: Endogeneity of the lagged variable.

Econometric Approaches

- Anderson and Hsiao (1982):Simple instrumental variables estimator.
- Arellano and Bond (1991) and Blundell and Bond (1998): two estimators based on GMM.
  - Blundell–Bond (1998) propose a system GMM estimator (GMM-BB), which uses lagged first differences as instruments for equations in level as well as the lag variable in first-difference equations.
- We use: LSDV, OLS (for comparison) and **GMM-BB.**

Estimation Results

Variables	Models A-15°C/22°C						Models B-18°C					
	LSDV		OLS		GMM-BB		LSDV		OLS		GMM-BB	
	Coef.	*t-val*	*Coef.*	*t-val*	*Coef.*	*t-val*	*Coef.*	*t-val*	*Coef.*	*t-val*	*Coef.*	*t-val*
Lnq L1.	0.15635	3.08	0.77970	23.29	0.54660	4.24	0.15539	3.05	0.77910	23.38	0.53333	4.14
Lnp	-0.04927	-1.79	-0.05634	-3.10	-0.11180	-2.07	-0.04739	-1.71	-0.05528	-3.03	-0.11290	-2.05
Lny	0.02081	0.14	0.07189	2.21	0.13507	3.14	0.01728	0.11	0.07348	2.27	0.13775	3.26
Lnpop	0.78419	5.28	0.16144	3.95	0.34858	3.23	0.80053	5.38	0.15966	3.91	0.35673	3.32
Lnhs	-0.13374	-0.8	-0.17413	-3.79	-0.35514	-3.22	-0.17052	-1.02	-0.17225	-3.76	-0.36325	-3.30
Lnhdd	0.06571	1.98	0.00585	0.56	0.03439	2.98	0.06105	1.32	0.01239	0.77	0.05213	2.90
Lncdd	-0.00495	-0.52	0.00730	2.00	0.01111	2.19	-0.03051	-1.42	0.01659	2.14	0.02653	2.57
GAS	-0.15194	-1.39	-0.14092	-3.06	-0.26479	-4.30	-0.15427	-1.41	-0.13929	-3.05	-0.25806	-4.34
cons	5.95897	1.88	0.77009	1.84	1.46018	1.80	6.05042	1.89			1.30661	1.57
Sargan test (p-value)						0.149						0.138
Arellano-Bond AR1 test (p-value)						0.000						0.000
Arellano-Bond AR2 test (p-value)						0.838						0.787

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- **The coefficients of the price variables and lagged variable are significant and carry the expected signs in all models.**
  - The largest difference in coefficients of the lagged dependent variable.

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- **The value of the income coefficient has the expected sign and is significant in the OLS and GMM-BB models.**

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- **Socioeconomic variables (population and household size), as well as the weather variables and the penetration of gas, seem to have an important influence on Spanish residential demand for electricity.**

Estimation Results: Elasticities

	GMM-BB (A) 15°C/22.2°C	
	Short run	**Long run**
Price elasticity	-0.11	-0.24
Income elasticity	0.14	0.30

Concluding Remarks

- Increase in electricity prices will have a modest impact on the residential electricity demand.
  - Higher energy efficiency standards for electrical appliances are necessary.
- Relative higher sensitivity of electricity demand to cold than to hot days.
  - Low impact of the heating degree days on the electricity demand
    - High impact of gas penetration on electricity consumption
  - Low impact of the cooling degree days on the electricity demand: a small fraction of Spanish households are using air conditioning.