Regulatory reforms for incentivizing the investments in innovative Smart Grid pilot projects in Europe: A regulatory factors study

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Research Question

Global Issues: The climate-change and the depletion of energy sources

EU Energy Policy: Wide energy targets for 27% improvements in the efficiency, 27% increase in the share of renewable sources and 40% reduction of the greenhouse gas emissions.

New Investment Needs: Transformation of distribution network into smart grid: €0.5 trillion to renew the electricity networks over the period of 2014 through 2035 (IEA 2014).

DSOs Role: Are the ones expected to carry the main investment burden.

Regulation Role: Regulation can have an important role to set up a favourable framework that fosters investments in smart grids.

RQ : "What are the regulatory factor-levels that can positively affect the investments in SG pilot projects in Europe?"

Study Overview

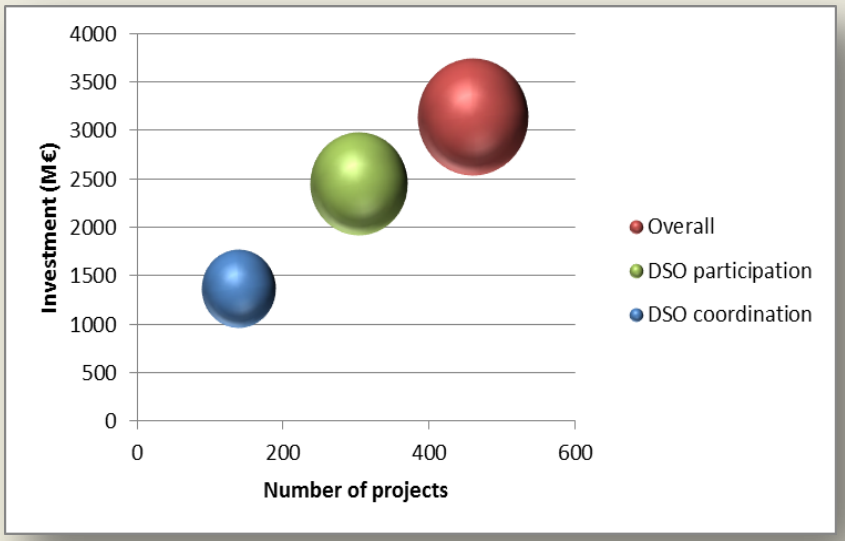
- Among the variety of regulatory factors, the study is particularly concerned with **three**:

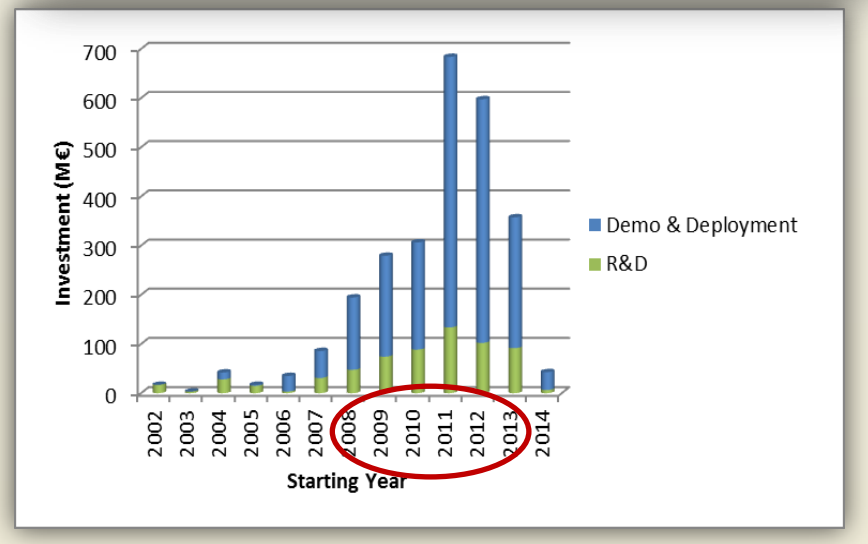
  - **Factor 1**: DSO concentration factor: "how many regional monopolies will serve the overall demand for distributed power in a country's territory?".
  - **Factor 2**: Type of regulation model: regulation models' capacity to induce cost efficiency, by providing relevant incentives to DSOs.
  - **Factor 3**: Specialized Incentives: the stimuli mechanisms designed by regulation authorities for incentivizing innovative SG pilot projects.

- Answering the RQ the study attempts to provide **valuable insights on the perceivable regulation reforms** towards an updated, innovation-friendly regulation framework that will incentivize DSOs' investment activities in Europe.

- Two sets of data:
  - a database with 459 smart grid pilot **Investments** in Europe (EU-28, Switzerland and Norway).
  - a compiled list of **Regulatory factors** in Europe

Smart Grid pilot Investments





❑ **Overall:**
459 projects, €3.15 billion investment

❑ **DSO Involvement:**
303 projects, € 2.46 billion investment

❑ **DSO Leadership:**
138 projects, € 1.37 billion investment

❑ The current study focuses on the analysis of investments that span over 2008-2013

❑ SG investments are not uniformly distributed across Europe.

❑ Different socioeconomic factors affect SG Investments; to allow comparability we use two normalizes:

- ✓ GDP (€/M GDP)
- ✓ Population (€/capita)

Methodology

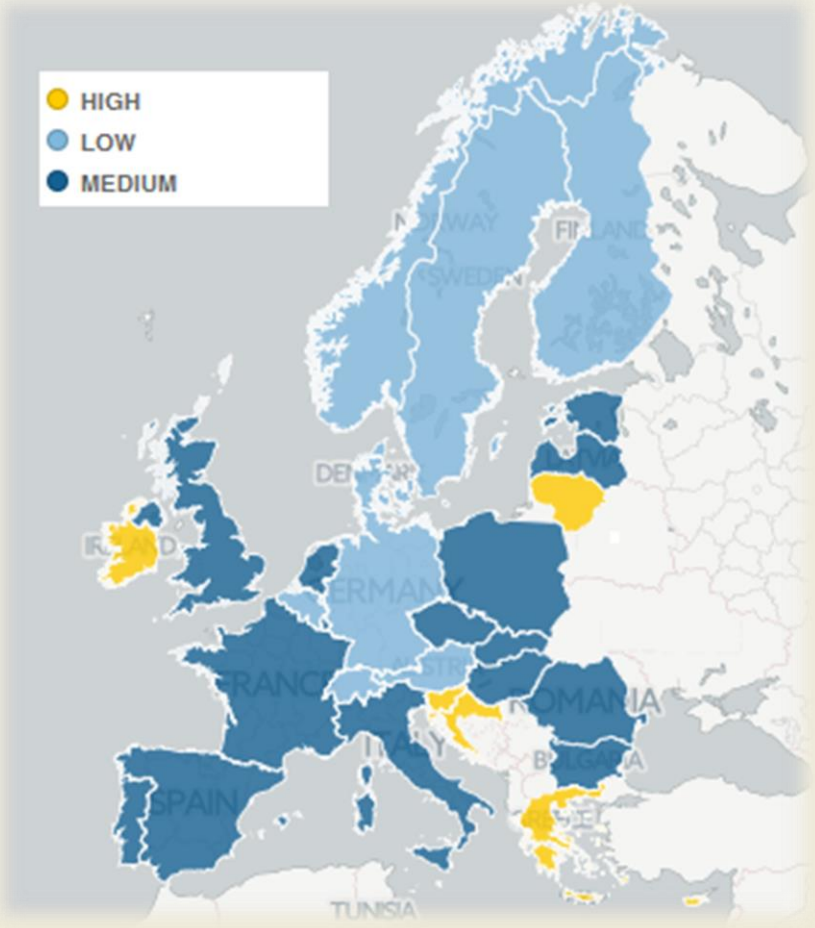
- For each regulatory factor, individual **statistical hypothesis tests** are carried out for discovering the correlation between the level of SG investments in the European countries, and the respective regulatory factor-levels.
- To discover the difference between the groups by **comparing the means of the populations**
- Carrying out a statistical hypothesis test requires the assessment of three **Assumptions** beforehand:
  - *Normal Distribution:* Lack of confidence regarding the existence of normality, it was decided to carry out two different analyses;
    - **a Parametric T-test**
    - **a Non-Parametric U-test.**
  - *Independent observations:* None of the observations in one group is in any way related to the observations in the other groups so **independency** should be considered
  - *Homogeneity of variances:* All the samples have **equal variances** with one exception. In this case, it was applied an adaptation of T-test namely Welch's T-test.

- A **one-tailed test** with two hypotheses has been considered:

- H_0: $\mu_1-\mu_2=0 \iff \mu_1=\mu_2$ (null hypothesis)
- H_1: $\mu_1-\mu_2>0 \iff \mu_1>\mu_2$ (alternative hypothesis)

- The study considers a level of statistical significance **$\alpha=10\%$**

DSO Concentration



- **"High":** One DSO serving 99%-100% of the distributed power

- **"Medium":**

-One dominant DSO, serves at about 80% of distributed power and several smaller DSOs the rest.

-Three largest DSOs serving more than 60% of distributed power and several smaller DSOs the rest.

- **"Low":** Three largest DSOs deliver at about 50% of the distributed power.

Status Quo:

✓ 50% of the European markets are medium concentrated and only six high concentrated.

✓ Over the last years, Split-ups and merges is a common phenomenon(e.g. Romania, Denmark).

Results DSO Concentration

DSO Concentration												
	High (H)		Medium (M)		Low (L)		P-value T-test			P-value U-test		
	$\overline{X}_H$	n_H	$\overline{X}_M$	n_C	$\overline{X}_L$	n_C	μ_L vs μ_M	μ_M vs μ_H	μ_L vs μ_H	μ_L vs μ_M	μ_M vs μ_H	μ_L vs μ_H
€/Capita	2.02	7	2.89	15	8.30	8	1%	21%	2%	1%	40%	0%
€/GDP	103.9	7	120.2	15	206.0	8	6%	35%	10%	9%	35%	10%

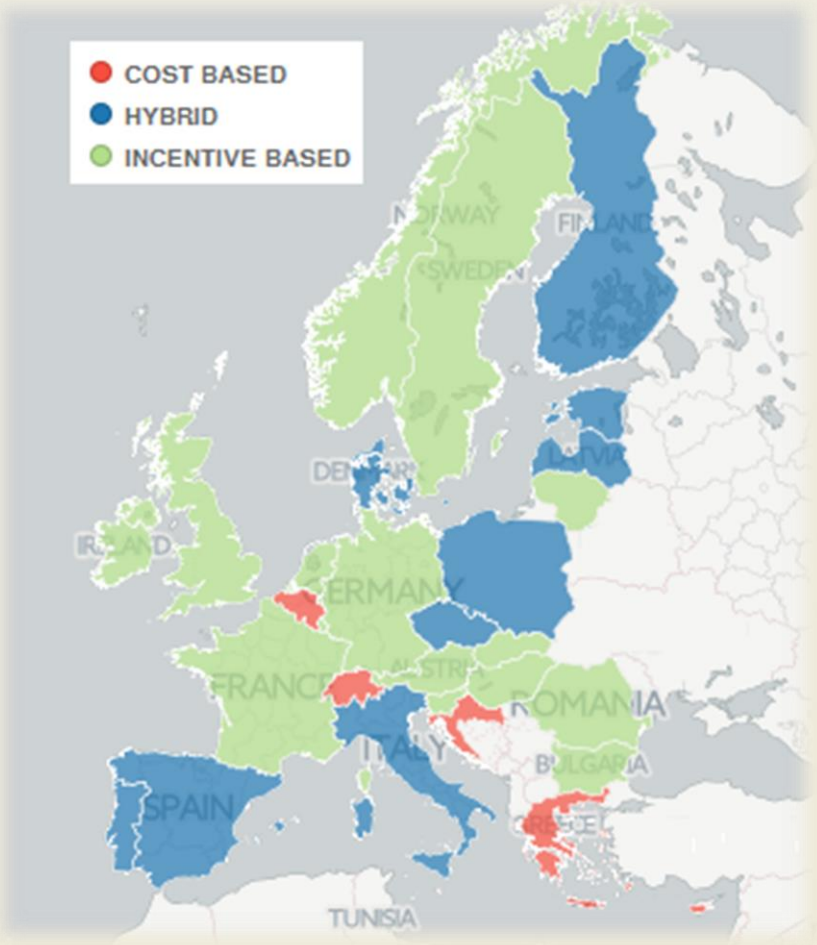
- ***L*** vs ***M*** **and *L*** vs ***H:*** **Strong Evidence,**
  p-values 0%, 1%, 2% when €/Capita
- ***L*** vs ***M*** **and *L*** vs ***H:*** **Moderate Evidence,**
  p-values 6%, 9%, 10% when €/M GDP

REFORMS:

✓Low concentrated distribution markets is expected to effectively induce investment-incentives for the implementation of SG pilot projects.

✓Introduce horizontal unbundling processes may be subject to strong oppositions by DSOs or other energy stakeholders

Type of Regulation Model



- **Incentive-based:** any model where the regulator delegates certain pricing decisions to the firm and that the firm can reap profit increases from cost reduction.

- **Cost-based:** determines an allowed RoR on investment, and adjusts the company's price as its costs change to ensure a reasonable opportunity to earn the authorized return.

- **Hybrid:** Follow a cost-based approach for the treatment of CAPEX and an incentive-based approach for the treatment of OPEX.

Status Quo:

- ✓ 50% of the European countries apply an incentive based model,
- ✓ Only 6 countries apply Cost based regulation, among them Cyprus and Malta

Regulation Model Results

Regulation Model												
	Cost (C)		Hybrid (H)		Incentive (I)		P-value T-test			P-value U-test		
	$\overline{X}_C$	n_C	$\overline{X}_H$	n_H	$\overline{X}_I$	n_I	μ_H vs μ_C	μ_H vs μ_I	μ_I vs μ_C	μ_H vs μ_C	μ_H vs μ_I	μ_I vs μ_C
€/Capita	2.20	6	5.68	9	3.97	15	16%	22%	11%	20%	39%	18%
€/GDP	78.6	6	195.5	9	129.8	15	7%	11%	11%	10%	27%	4%

- In both cases of normalisation, for the great majority of mean comparisons, T and U tests' p-values are high enough and far greater than α=10%. Nevertheless, there are two exceptions:
- ***I*** vs ***C*** : **Strong Evidence,**

  p-value= 4% , in the T test p-value= 11% (close to significant value too)
- ***H*** vs ***C*** : **Moderate Evidence,**

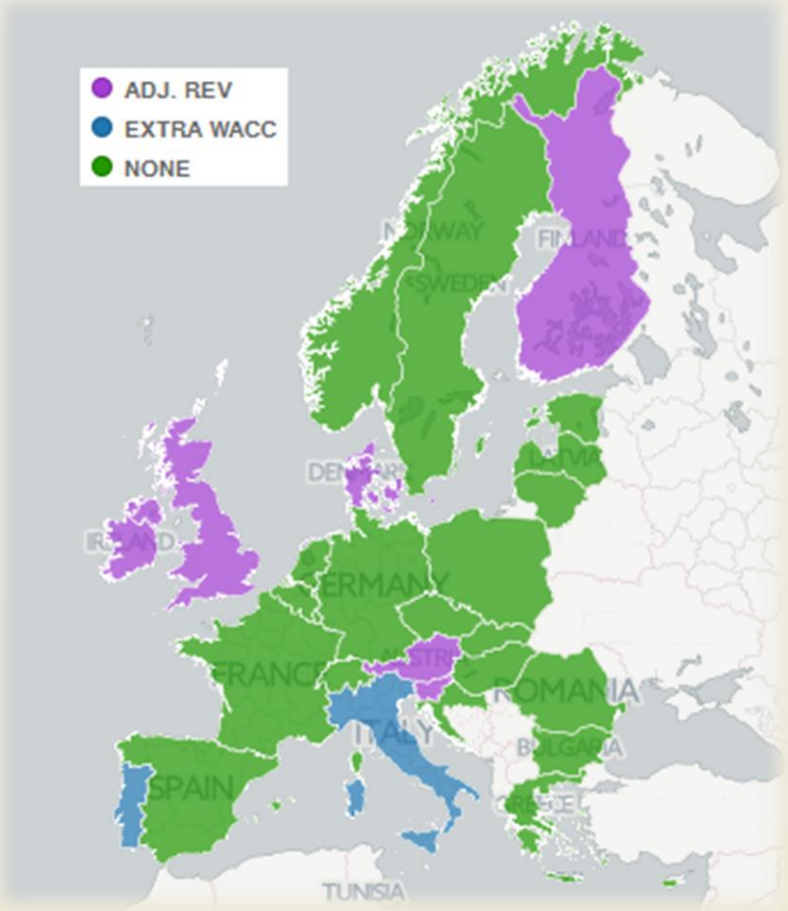
  p-value= 7%, 10%.

REFORMS:

✓ Incentive based regulation may offer the most favourable conditions, spurring the deployment of SG innovations in the network and increasing the corresponding investments.

✓ A hybrid model could be also effective for providing investment-incentives in SG but not as powerful as an incentive based scheme.

Specialized Incentives



- **None:** Countries where the SG investments are treated like other costs
- **Extra WACC:** The provision of higher rate of return: adding an extra component to the regulatory WACC
- **Adj. Revenues:** The provision of extra allowance or the adjustment of revenues within the regulation period.

Status Quo:

- ✓ Only 8 countries apply specialized Incentives
- ✓ Italy and Portugal are the only countries applying Extra WACC

Specialized Incentives Results

Specialized Incentives						
	Yes (Y)		No (N)		P-value T-test	P-value U-test
	$\overline{X}_Y$	n_Y	$\overline{X}_N$	n_N	μ_Y vs μ_N	μ_Y vs μ_N
€/Capita	8.13	8	2.67	22	0%	0.2%
€/GDP	259.6	8	95.5	22	1%	0%

- For both cases of normalisation the p-values are extremely low and no more than 1%. Thus the samples provide strong evidence against rejecting the null hypothesis of equality of population means

REFORMS:

- ✓ The adoption of specialised incentive mechanisms by regulation (such as the adoption f an extra WACC or adjusted revenues) is rather successful in triggering SG investments.

Limitations & Future Work

1. **Limit.**: The study is based on the actual European countries situation thus it can be considered to be valid in short term horizon.

2. **Limit.:** The tests results pointed out the sensitivity of the analysis in the factors employed for the normalization of SG investments

FW: Performance of an identical analysis but with the use of technical normalizing factors : electricity consumption (TWh) or the length of the electricity grid (km)

3. **Limit.:** Lack of accurate data about the precise contribution of DSOs in the budget of SG projects, we use the overall budget of Smart grid project at country level

FW: Consider the DSOs' contribution in SG projects for the values as main dependent variable.

Thank you

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