The Trade-off Between Static and Dynamic Efficiency in Electricity Markets – A Cross Country Study

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Outline

Why advanced forms of unbundling?

According to the third legislative package of the European Commission in September 2007 advanced forms of unbundling the transmission grid are required in the electricity and gas sector. Countries can choose between three options:

- Full ownership unbundling

- (Deep) independent system operator (ISO)

- Independent transmission operator (ITO)

$\Rightarrow$ Main reasons: stimulation of competition and investments

Ownership unbundling and investments

Trade-off between competition and vertical synergies

- Possible positive effects of ownership unbundling: **enhanced competition** and **less discrimination** among generators
  ⇒ Competition affects investments; inverted U-shaped relation between competition and innovation, Aghion et al. (2005)

- Possible negative effects of ownership unbundling: **double marginalization**, network externalities and **spillovers** can no longer be internalized by the same firm, **coordination failure** may result
  ⇒ These effects can result in lower investment spending

- Theoretical articles: Höffler and Kranz (2011), Cremer et al. (2006), Bolle and Breitmoser (2006)

- Empirical research: Nardi (2010), Alesina et al. (2005)

Regulation and investments

- **Regulation affecting only the market directly**
  - The existence respective non-existence of a liberalized wholesale market ($\Rightarrow$ competition)
  - Minimum consumption threshold of consumers switching their supplier ($\Rightarrow$ competition)

- **Regulation also affecting the incumbent directly**
  - Third party access to the transmission grid ($\Rightarrow$ competition)
  - Type of unbundling, e.g. ownership unbundling

- **Ownership structure** ($\Rightarrow$ X-inefficiency, incentive and objective effects)

Need for high investments and low consumer prices

Trade-off between static and dynamic efficiency

- **Static efficiency** requires low prices

- **Dynamic efficiency**: a higher price implies better investment opportunities and therefore higher investments, Dixit and Stiglitz (1977)

  - Monopoly causes larger mark-ups; uncontested vs. contested monopoly ($\Rightarrow$ "escape competition" effect, Aghion et al. (2005))

  - High prices and investments may be endogenous; especially under cost-plus regulation
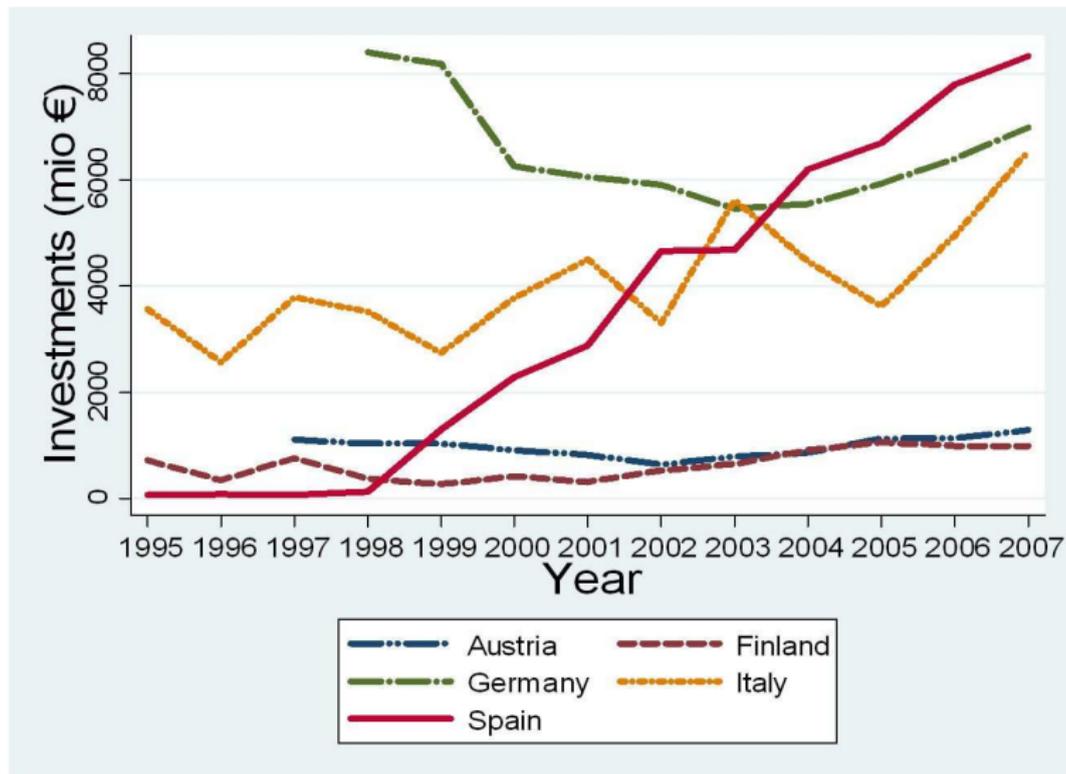
Research question:

**How do final consumer prices, regulatory reform and in
particular ownership unbundling (of the transmission grid)
impact investment spending in the overall electricity
industry?**

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Model
Results
Conclusions

Data
Derivation of the model
Basic model

Data

Unbalanced panel data set with 16 European OECD countries from 1998 until 2007

- Investments and capital stock (perpetual-inventory method, Fazzari et al. (1987)): Eurostat
- Final consumer prices: IEA
- Regulatory variables:
    - Ownership unbundling: self created dummy
    - Third party access, liberalized wholesale market, minimum consumption threshold: OECD Regulation Database
- Public ownership: OECD Regulation Database
- Per-capita consumption of electricity: OECD
- Long-term interest rate: OECD

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Econometric modeling

- Production function with constant elasticity of substitution (σ)

- Long-run relation with **accelerator effect**, Chirinko (1993) and Caballero et al. (1995):
  $K_t^* = \alpha c_t^{-\sigma} Y_t$
  $k_t^* = a - \sigma c_t + y_t$

- Adjustment process following ADL (1,1):
  $k_t = \alpha_1 k_{t-1} + \beta_0 y_t + \beta_1 y_{t-1} - \varphi_0 c_t - \varphi_1 c_{t-1} + u_t$

- Simple **partial adjustment process**:
  $\Delta k_t = \theta(k_t^* - k_{t-1}) + \epsilon_t$

- **Error-correction specification**:
  $\Delta k_t = \theta \alpha_0 - \theta(1 - \alpha_1)\Delta k_{t-1} + \theta \beta_0 \Delta y_t + \theta(\beta_0 + \beta_1)\Delta y_{t-1} - \theta \varphi_0 c_t - \theta \varphi_0 c_{t-2} - \theta(1 - \theta \alpha_1)k_{t-2} + \theta[\beta_1 - \beta_0(1 - \theta \alpha_1)]y_{t-2} + \Psi_t$

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Dynamic investment model

$$\frac{I_{it}}{K_{i,t-1}} = \eta_i + \lambda_t + \rho \frac{I_{i,t-1}}{K_{i,t-2}} + \vartheta_0 p_{it} + \vartheta_1 p_{i,t-1} + \theta_0 \Delta y_{it} + \theta_1 \Delta y_{i,t-1}$$

$$+ \nu_0 k_{i,t-2} - \nu_1 y_{i,t-2} + \tau_0 r_{it} + \tau_1 r_{i,t-1} + \text{regulation} + \text{ownership} + \Psi_t$$

Variables:

I	Overall investments in the electricity industry in country i at year t
K	Capital stock
η_i	Country-specific effects
λ_t	Year dummies
p	Final consumer prices
y	Per-capita consumption of electricity
r	Long-term interest rate
regulation	Vector of regulatory variables
ownership	Public ownership
Ψ	Error term

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Main results
Robustness

Determinants of investment

	FE ECM	FE Without ECM	GMM-DIFF ECM	GMM-DIFF Without ECM
I_{t-1}/K_{t-2}			**0.1809****	**0.2855*****
Log P_{t-1}	0.0159	0.2000	-0.1937*	-0.1265
Log P_{t-2}	0.0215	0.2058	**0.3134****	**0.5349****
OU_{t-1}	0.0041	-0.0435	0.0154	-0.0125
OU_{t-2}	-0.0232	-0.0701***	**-0.0552****	**-0.0552*****
$\triangle$Log Y_t	0.1409	0.4717	0.9507***	0.7235***
$\triangle$Log Y_{t-1}	0.0909	0.1363	0.5476	-0.1278
Log K_{t-2}	-0.1841***		-0.2072***	
Log Y_{t-2}	0.1038		1.1149***	
AR(1) p-value			0.07	0.07
AR(2) p-value			0.15	0.10
Sargan p-value			0.31	0.15
No. of instruments			55	53
Observations	75	79	67	67

- Robust standard errors; $^*p > 0.10$, $^{**}p > 0.05$, $^{***}p > 0.01$
- Hausman test: FE estimates are not significantly different from GMM-DIFF estimates

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Short and long-run effects

	FE ECM	FE Without ECM	GMM-DIFF ECM	GMM-DIFF Without ECM
Short log P	0.0373	0.4057 (p=0.12)	0.1196*	0.4084**
Long log P			0.1461*	0.5716***
Short OU	-0.0191 (p=0.13)	-0.1135*	-0.0398**	-0.0676**
Long OU			-0.0486**	-0.0946***
Short TPA	0.0072	-0.0254	-0.0511*	-0.0412
Long TPA			-0.0624*	-0.0576
Short LWM	-0.0008	0.0700*	0.0193	0.0761***
Long LWM			0.0236	0.1066***
Short MCT	-0.0041	0.0071	0.0125	0.0118
Long MCT			0.0153	0.0166
Short PO	-0.0237*	-0.0931**	0.0398	-0.0308*
Long PO			0.0486	-0.0431

- Short-run coefficient $(\beta_1 + \beta_2)$ for prices; analogous for the other coefficients and variables
- Long-run coefficient $(\beta_1 + \beta_2)/(1 - \alpha_1 - \alpha_2)$ for prices; analogous for the other coefficients and variables
- $^*p > 0.10$, $^{**}p > 0.05$, $^{***}p > 0.01$

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Endogeneity and reverse causality

Granger causality tests to control for bidirectional causality, Granger (1969)

GMM-Diff	p-value	Ho: $v_1 + v_2 = 0$	Answer
P causes I ?	0.004	rejected	Yes
I causes P ?	0.037	rejected	<mark>Yes</mark>
OU causes I ?	0.004	rejected	Yes
I causes OU ?	0.548	Not rejected	No
TPA causes I ?	0.584	Not rejected	No
I causes TPA ?	0.942	Not rejected	No
LWM causes I ?	0.000	rejected	Yes
I causes LWM ?	0.474	Not rejected	No
MCT causes I ?	0.243	Not rejected	No
I causes MCT ?	0.103	rejected	<mark>Yes</mark>
PO causes I ?	0.002	rejected	Yes
I causes PO ?	0.007	rejected	<mark>Yes</mark>

🔵 v_1 and v_2 for prices; analogous for the other coefficients and variables

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Long and short-term results accounting for endogeneity

	GMM-DIFF Without ECM	GMM-DIFF Without ECM	GMM-DIFF Without ECM
	P end.	P, MCT and PO end.	P and all reg. var. end.
Short log P	0.3637*	0.2882*	0.3422**
Long log P	0.5097*	0.4071**	0.4866**
Short OU	-0.0768**	-0.0765**	-0.0662**
Long OU	-0.1076***	-0.1081***	-0.0941***
Short TPA	-0.0563	-0.0571	-0.059
Long TPA	-0.079	-0.0807	-0.0839
Short LWM	0.0725**	0.0770**	0.0656**
Long LWM	0.1016**	0.1087***	0.0933**
Short MCT	0.0161	0.0161	0.0167
Long MCT	0.0226	0.0228	0.0237
Short PO	-0.0313*	-0.0425*	-0.0301
Long PO	-0.0439	-0.0601*	-0.0428

- Short-run coefficient ($\beta_1 + \beta_2$) for prices; analogous for the other coefficients and variables
- Long-run coefficient ($\beta_1 + \beta_2)/(1 - \alpha_1 - \alpha_2)$ for prices; analogous for the other coefficients and variables
- $^*p > 0.10$, $^{**}p > 0.05$, $^{***}p > 0.01$

Conclusions

- Higher electricity end-user prices induce higher investments in the overall sector

  $\Rightarrow$ **Trade-off between static and dynamic efficiency**

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  - Regulation affecting the incumbent directly (OU, TPA) may lead to lower investments

  - Introducing competition via market based measures (LWM, MCT) increases investments

Outlook

Further research:

- Investments should be considered more in detail (firm-level data, networks vs. generation, type of investments)

- How does regulation and in particular ownership unbundling affect investments, by which mechanisms?