

# **ICT and productivity in European energy and water supply industries: A dynamic panel estimation**

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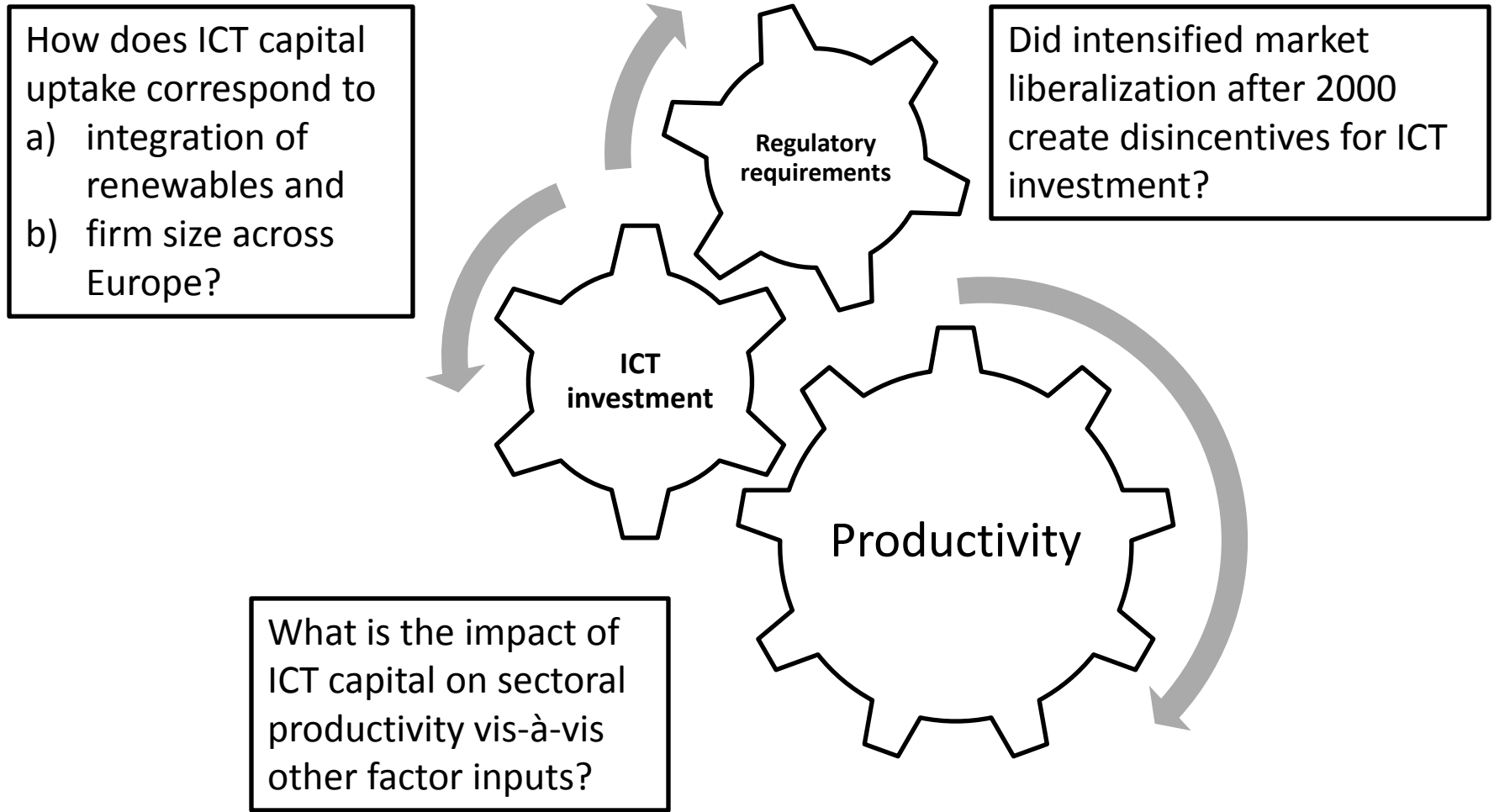
Matthias Wissner

Infraday Berlin, 2010

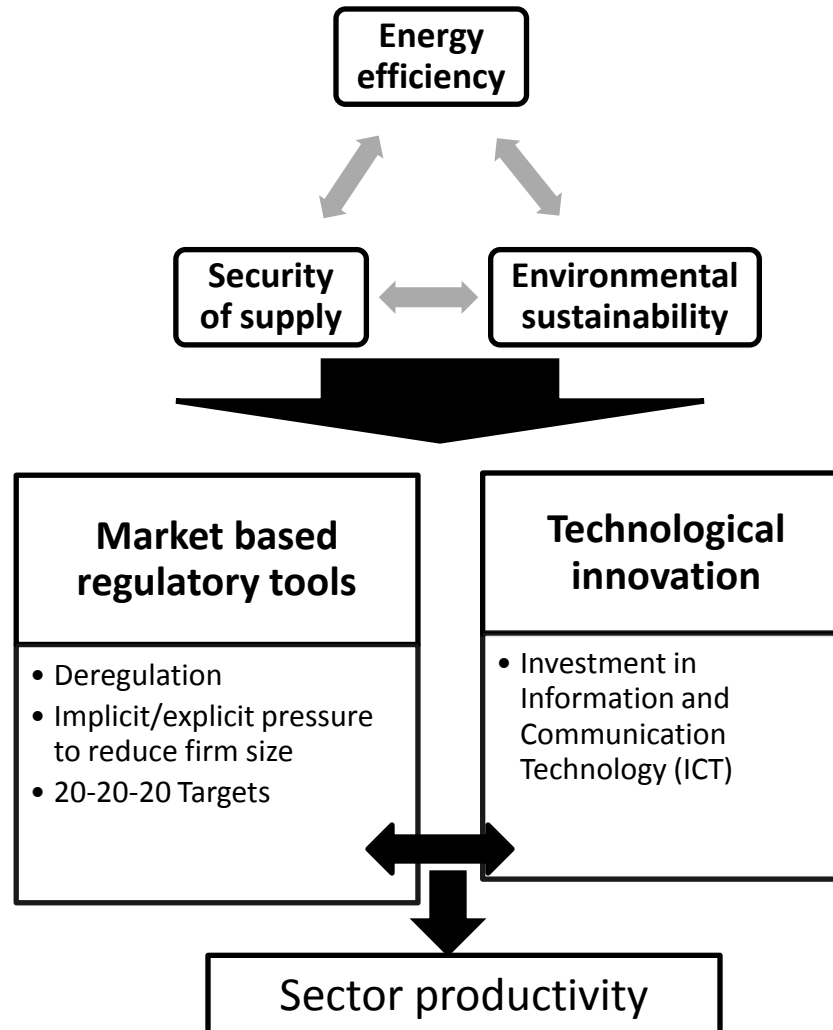
# Outline

- Research question
- Industry profile
- Theoretical consideration
- Empirical estimation
  - Data
  - Descriptives
  - Method
  - Results
- Conclusion

# Research questions



# Context for ICT adoption



# Industry profile

## Electricity, gas and water supply industry (NACE category E)

### High productivity

- European more competitive than North American economies (Morrow et. al. 2009)
- Sectoral share in the non-financial business economy in 2006 (EU-27):  
Employment 0.9%  
Value added 3.2%

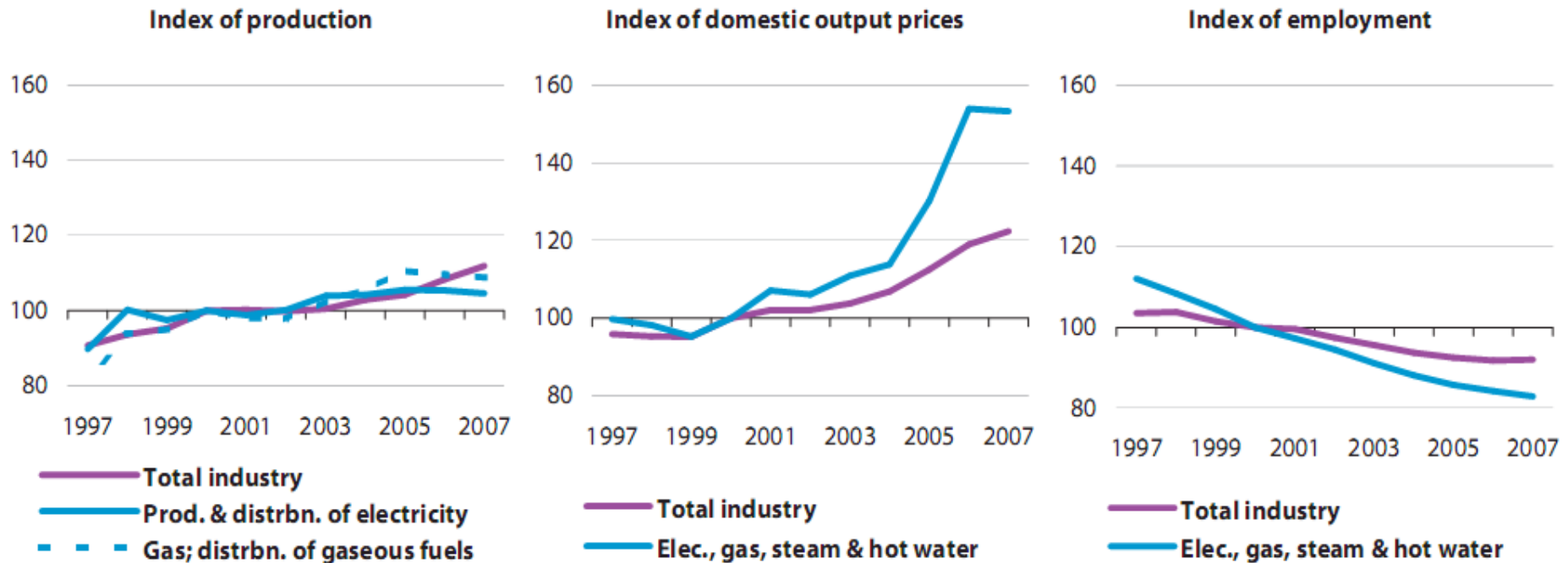
### High capital intensity

- Grew to twice the manufacturing industry average in 2009 (European Commission, 2009).
- Increasing skill requirement

### Industrial Taxonomy

- “Non-ICT industries” alongside construction, mining and quarrying sectors (O’Mahony & van Ark 2003)
- However, “Dynamic IT user with a high and growing IT-labor intensity”
- Requiring “High-intermediate skills”

# Industry profile



Electricity, gas, steam and hot water supply (NACE Division 40)

Evolution of main indicators, EU-27 (2000=100)

(Source: Eurostat, 2008)

# ICT investment amidst regulatory changes

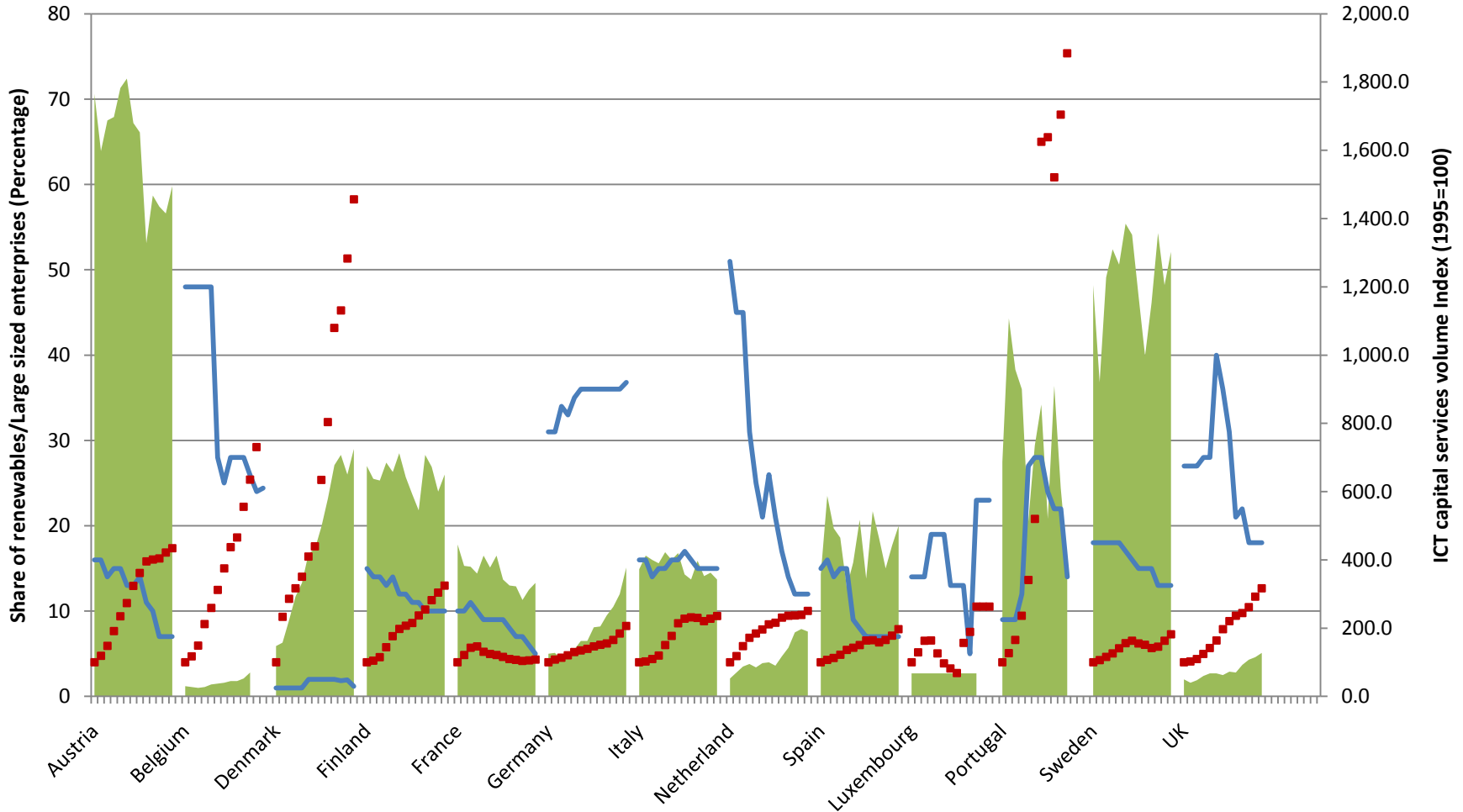
- ICT as enabler of innovation and market liberalization
  - Technology driven decline in quality-adjusted price of ICT
  - Ideal platform for innovation in process, product across value chain
  - Important role in creating a smooth transition from regulated, vertically integrated markets towards deregulated markets with competitive segments
- ICT as a factor input for productivity growth
  - Relationship not straight forward
  - Involves significant costs that go beyond the price of ICT hardware and soft ware
  - Pace and trajectory of the existing market liberalization efforts strengthen/attenuate ICT's impact on productivity

# ICT investment amidst regulatory changes

- Competitive and sustainable energy supply industry creates demand for ICT investment
  - Coordinate complex interaction between increased market players (wholesale energy market, TPA)
  - Establishment of renewable target (distributed electricity generation, intermittent renewable energy sources)
  - More and more (non-network) segments in utility value chain exposed to competition, greater need to innovate (falling quality adjusted ICT prices – substitution away from labour, non-ict capital)



# ICT, share of renewables and firm size

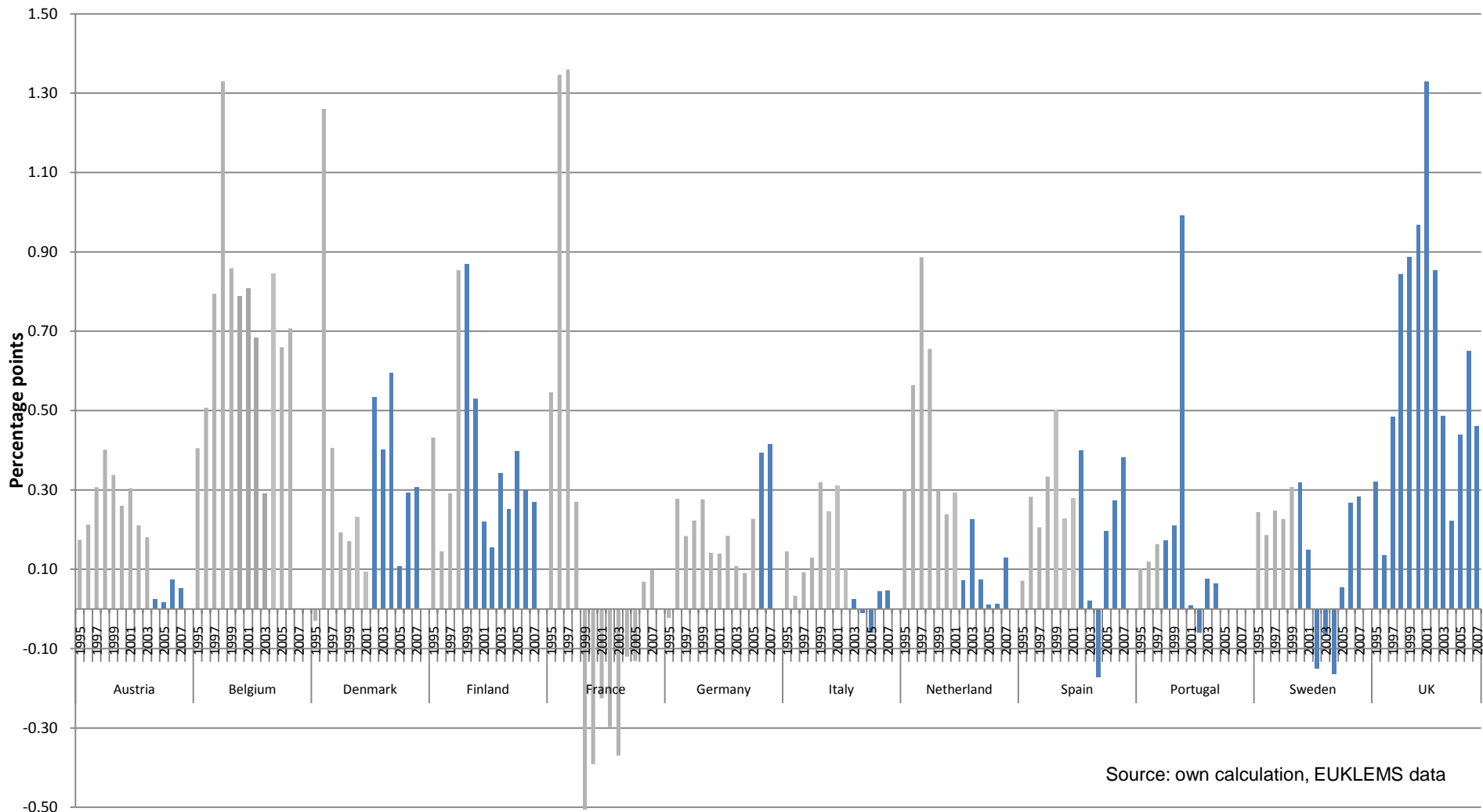


- Share of renewables in electricity consumption
- Share of Large enterprises (> 20 employees)
- ■ ICT capital services volume index (1995 = 100)

# ICT investment amidst regulatory changes

- Liberalization policies like vertical unbundling and privatization can also reduce ICT investment in the short run
  - Regulatory uncertainty
  - Reduced share of captive markets that would let firms recover unprofitable investments
  - Rents from innovation generated by a higher productivity may not be entirely earned by the monopolist spillovers to adjacent segment, reduced incentive to innovate

# ICT investment in utilities before after start of liberalization



Source: own calculation, EUKLEMS data

Start of regulated TPA as indicator of start of first concrete steps in liberalization

No regulated TPA

Bars: Contribution of ICT capital services investment to value added ALP growth (percentage points)

# ICT and regulation

## Summary of descriptive results

- **ICT adoption associated with**
  - Higher share of renewables in electricity consumption
  - Countries with increasing market players (lower share of large enterprises)
- **Impact of network access regulation**
  - Introduction of regulated Third Party Access in electricity coincides with falling ICT investment
  - ICT investment grew up after 2005

# Empirical estimation

## Specification

- Balanced panel
- 17 EU countries
- Period considered: 1995-2007
  - Coverage of periods both before and after liberalization steps
- Dynamic approach using Least Squared Dummy Variable (LSDV) estimator developed by Bruno (2005)
  - Allows for inclusion of lagged dependent variable
  - Corrects for unobserved country-specific heterogeneity
  - Corrects for small sample bias

# Empirical estimation

## Variables and data sources

	Variables	Sources
<b>Dependent Variable</b>	Gross value added per hour worked volume index (1995 = 100)	EU KLEMS Groningen Growth Development Center
<b>Factor input variables</b>	ICT capital services volume index (1995 = 100) Non ICT capital services volume index (1995 = 100) Labour services volume index (1995 = 100) Value added Total Factor Productivity index (1995 = 100)	
<b>Human capital variables</b>	-% of hours worked by high skilled workers -% of hours worked by medium skilled workers -% of hours worked by low skilled workers	
<b>Market structure and regulatory indicators</b>	-% of large enterprises (> 20 employees) -% of small enterprises (< 20 employees)	OECD SDBS Structural Business Statistics
<b>Regulatory indicators of electricity sector used as a proxy for all three sectors</b>	-Barriers to entry (0 = Regulated TPA, Liberalized wholesale market)) -Vertical integration (0 = Legal unbundling, vertically separate companies) -Public ownership (0 = Private ownership)  -Share of renewables in electricity consumption, GDP	OECD indicators of regulation in non- manufacturing sectors  Eurostat

# Empirical estimation

## Descriptive statistics

Variables	Obs	Mean	Std deviation	Min	Max
Gross value added per hour worked volume index	218	128.44	28.05	72.40	224.70
ICT capital services volume index	217	285.68	372.91	57.00	2242.50
Non ICT capital services volume index	217	105.95	20.15	50.27	180.02
Labour services volume index	217	83.78	24.21	7.90	116.50
Value added Total Factor Productivity index	217	109.39	19.21	63.40	173.70
% of large enterprises	218	23.43	17.01	1.00	80.00
% of hours worked by high skilled workers	216	12.89	8.04	3.00	36.00
% of hours worked by medium skilled workers	216	65.97	20.11	12.70	94.00
Barriers to entry	216	2.00	2.35	0.00	6.00
Vertical integration	216	2.35	2.13	0.00	6.00
Public ownership	216	3.87	1.98	0.00	6.00
Share of renewables in electricity consumption	213	17.76	17.60	0.70	72.40
GDP per capita	213	26503.08	13163.09	4420.62	80840.61
Year	221	2001	3.75	1995	2007

Source: own calculation

# Model specification

- Fixed effect:

$$Y_{i,t} = \beta_0 + \beta_1 F_{i,t} + \beta_2 H_{i,t} + \beta_3 R + \beta_4 C_{i,t} + \eta_i + \varepsilon_i$$

- LSDVC estimation:

$$Y_{i,t} = Y_{i,t-1} + \beta_1 F_{i,t} + \beta_2 H_{i,t} + \beta_3 R + \beta_4 C_{i,t} + \eta_i + \varepsilon_i$$

- Cobb-Douglas production

- *Y is log-gross value added per hour for country i in period t*
- *F log of current labour, capital and residual factor inputs*
- *H is log of human capital variable*
- *R is log of regulatory variables*
- *C is log of control variables*



# Empirical estimation: Result

Dep Var: Grossvalueadded/ hour Index	Log Linear regression	
	Fixed effect (cluster robust error)	Xtlsdvc (bootstrapped SE)
Lagged Dependent variable		0.1144***
ICT capitalservices volume index	0.036*	0.0256**
Non ICT capital services volume index	0.570***	0.5428***
Total Factor Productivity index	0.966***	0.88778***
Labour services volume index	-0.526***	-0.5055***
%of hours worked by high skilled labour	0.125**	0.1345***
% of hours worked by medium skilled labour	-0.089	-0.0824
Share of large enterprises (>20 employees)	0.004	0.0016
Barriers to entry (electricity)	-0.047	-0.0554**
Public ownership (electricity)	-0.011	0.0072
Vertical integration (electricity)	0.024	0.0237
Share of renewables in electricity consumption	0.006	0.0012
Gdp	0.017	0.0236
year	1.162	-5.0944
R-sq	0.97	
corr(u_i, X)	0.87	
Arellano-Bond AR(1) test		0.1767
Arellano-Bond AR (2) test		0.0651
Saragan test for overidentifying restrictions		
Number of observations	211	179
Number of Groups	17	17

# Empirical estimation – result for dynamic specification

- Gross value added productivity increases by:
  - 0.03% when ICT capital service volume increases by 1%
  - 0.6% when non-ICT capital service volume increases by 1%
  - 0.13% when share of hours worked by High skilled workers increases by 1%
  - 0.06% when barriers to entry decreases by 1%

# Conclusion

- The results of our estimation are largely shaped by the choice of our dependent variable.
- Gross Value Added per hours worked excludes intermediate inputs, focus on the share of incomes earned by the factor inputs.
- Increasing sectoral capital intensity → high skilled positive predictor, volume of labour service negative predictor

# Conclusion

- Result for ICT capital surprising:
  - Starting at the same point (1995=100) ICT capital service volume doubled, non-ICT capital grew by only 5 index points (1995-2007 panel average)
  - ICT still much smaller predictor than non ICT – Solow paradox?
  - Could be explained by the significant negative coefficient on “barriers to entry”
  - Implication: Focus shift from higher ICT investment to turning investment to productivity gain by removing technical, economic, legal barriers to entry

- Thank you for your attention