Integrating Quality of Service in Incentive Regulation

experience from Norwegian electricity distribution

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agenda

1. Motivation and techno-economic background
2. Electricity market regulation in Norway
3. Dataset and descriptive statistics
4. Model und estimations
5. Results
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Motivation

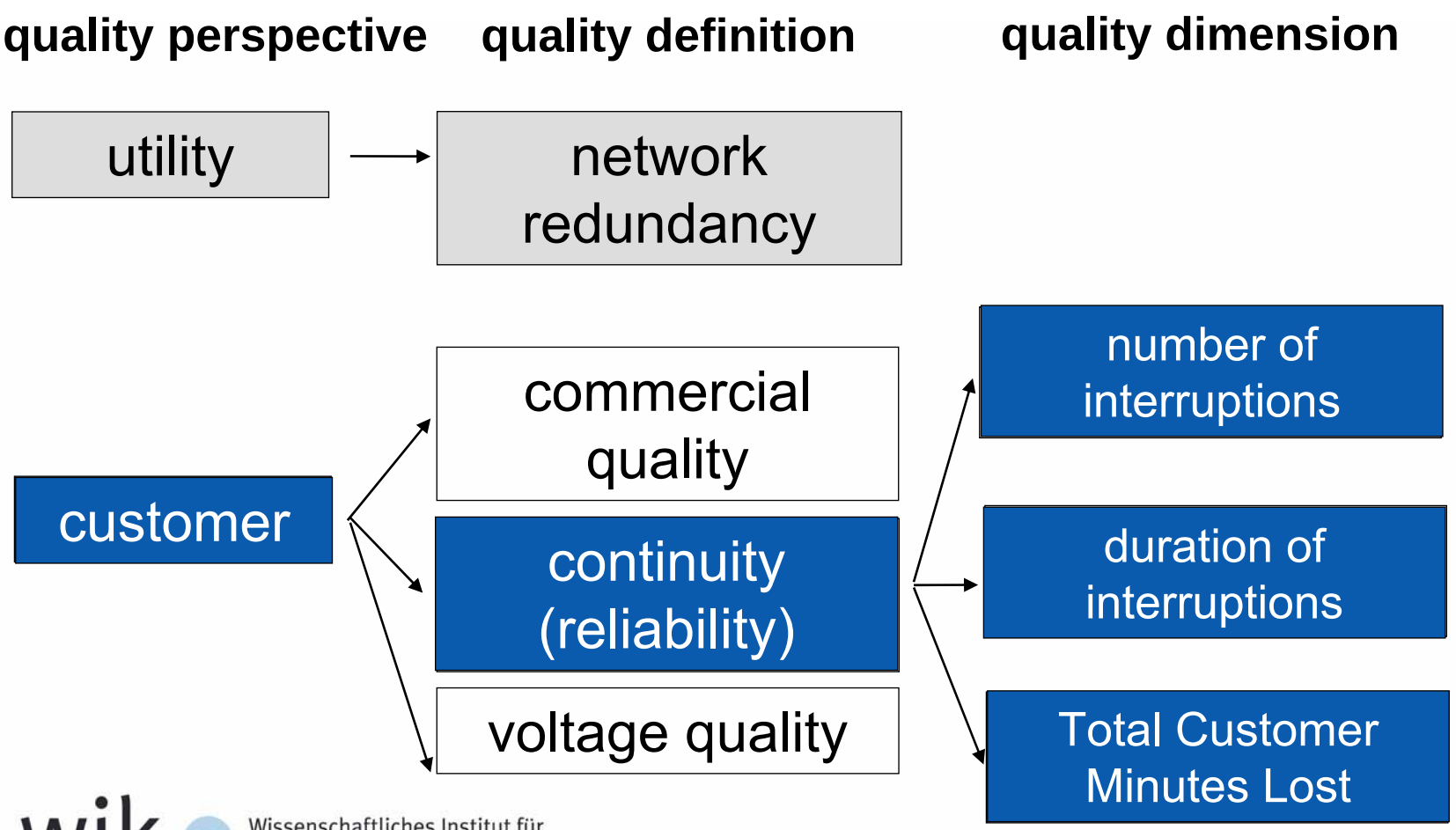
- Incentive regulation in ESI since 1990ies
- Aim: Separation of cost and revenues in natural monopolies (transmission and distribution networks)
- Problem: negative secondary incentives due to
  - reduced maintenance
  - postponed investments

→ regulating quality of service:

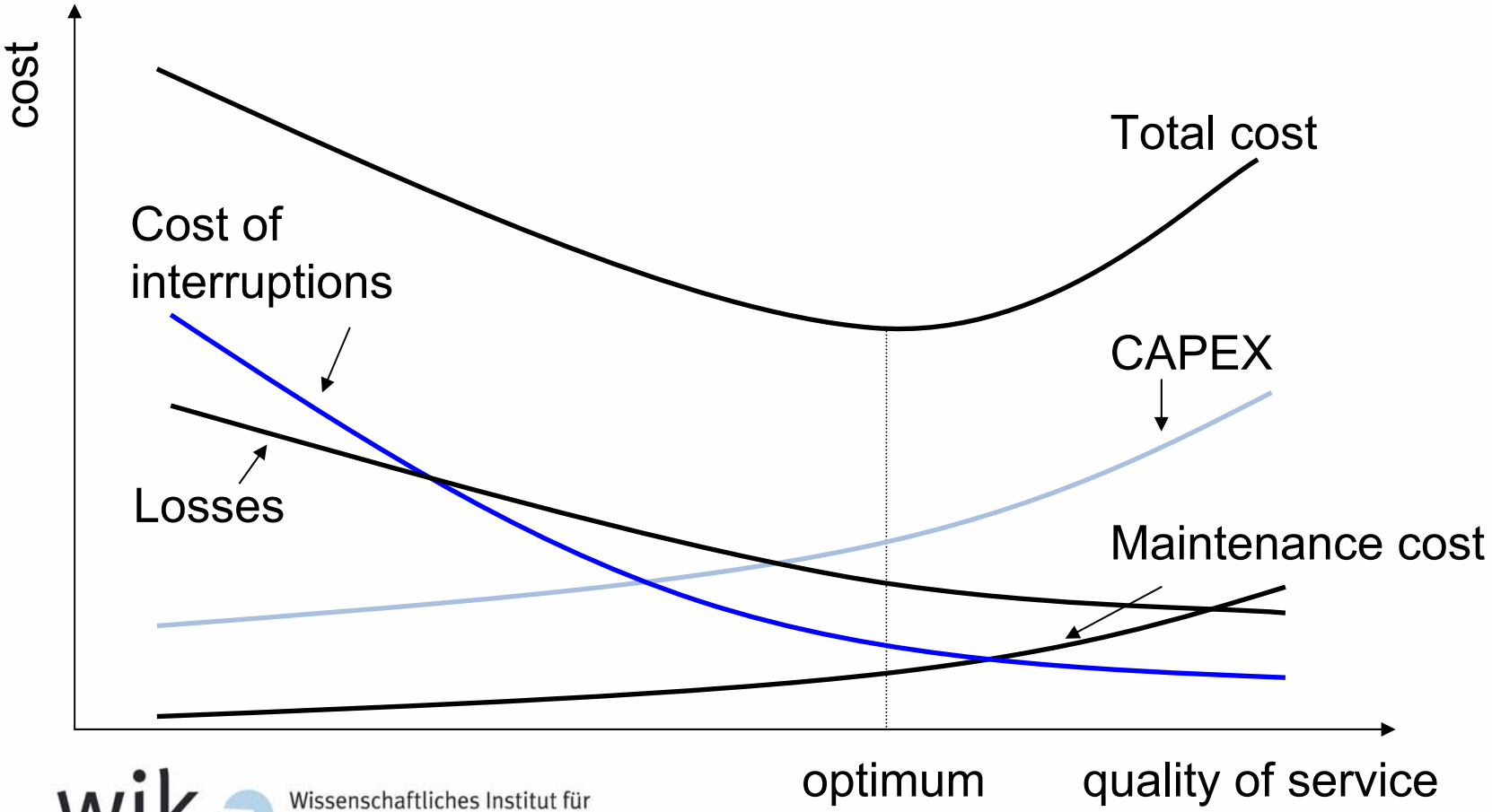
  - to overcome information asymmetries: decentralised
  - to minimize monitoring cost: incentive compatible

→ ‘quality incorporated incentive regulation’

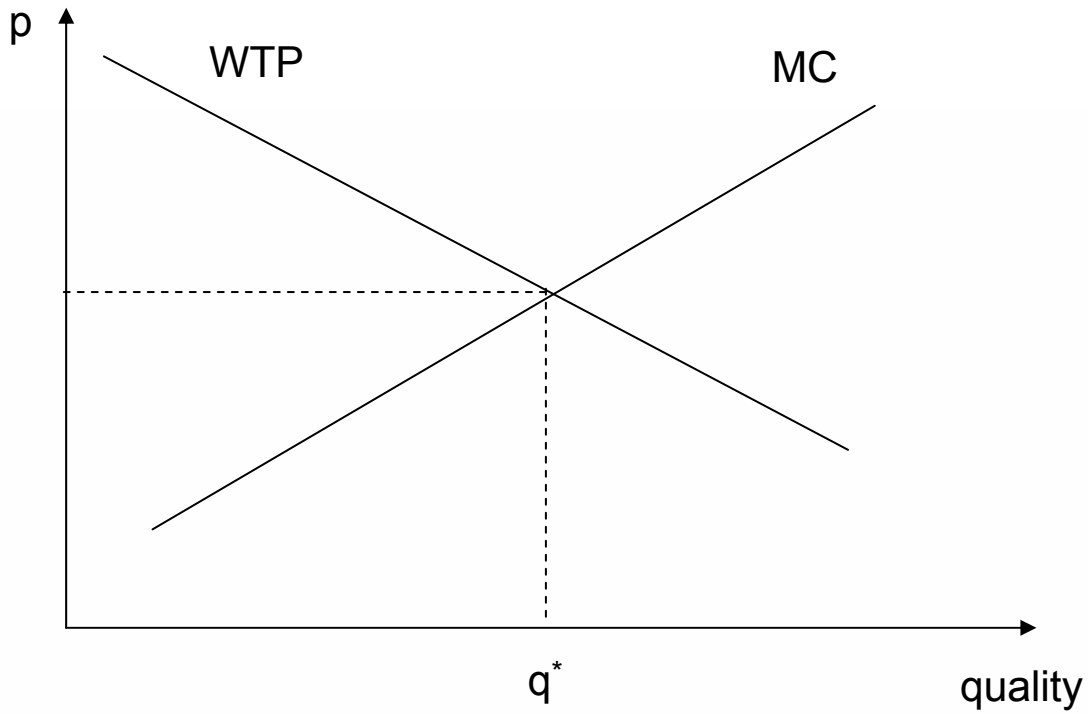
Quality of service in electricity distribution



Private vs. social cost of service quality



techno-economic background III



MC: marginal cost of quality provision (network operator‘s cost)

WTP: Customers‘ willingness to pay for quality of service

Welfare maxisiming level of quality in equilibrium

Energy market regulation in Norway I

Market structure:

- Organisational (Statkraft) or accounting separation of generation and networks
- Wholesale market ‘Nord Pool’
- currently 131 distribution utilities
  - Approx. 20,000 customers on average
  - Publicly owned

Regulation:

- 1991: market liberalisation
- 1997: Introduction RPI-X revenue cap
  - General X-Factor
  - DEA Benchmarking for company individual X-Factor

Energy market regulation in Norway II

- 2001: Introduction ‘Cost of Energy Not Supplied - CENS’
- Aim: avoiding the incentives of cost reductions by quality deterioration by internalising external cost of quality
- Mechanism:
  - Calculation of CENS:
    - WTP via surveys,
    - Differentiated by customer groups
  - Estimation of expected energy not supplied with regard to environmental variables (geographical and climate data)
  - ‘allowed revenue’ increase/decreases by the difference of actual and expected CENS

→ cost savings weighted against revenue reductions

Data set and descriptive statistics

No. of companies	131		
No. of periods	4		
	mean	**min.**	**max.**
Inputs			
Social Cost in €	9,168,757 €	248,862 €	191,866,920 €
Cost of Energy Not Supplied (CENS) in €	280,780 €	0 €	10,615,560 €
TOTEX in €	8,887,977 €	248,862 €	187,337,280 €
Outputs			
Delivered energy in MWh	523,230	7,470	15,482,385
Total number of customers	19,783	429	516,339

Correlation analysis environmental variables

TOTEX		Actual CENS	
Geo-Index1	0.8990	Geo-Index1	0.8227
Geo-Index2	0.9016	Geo-Index2	0.8238
Forest HV	0.8476	Forest HV	0.7252
Temperature HV	0.6637	Temperature HV	0.7201
Slope HV	0.7666	Slope HV	0.6815
z6	0.7067	z6	0.7428
Wind HV	0.6733	Wind HV	0.5634
Wind by sea dist.	0.2330	Wind by sea dist.	0.1490
Density HV	0.8533	Density HV	0.7987
Microgeneration	0.4959	Microgeneration	0.4308
Seacable	0.2883	Seacable	0.2692

Model

$$
\begin{aligned}
&-\ln\left(CENS_{it}\right)= \\
&\alpha_0+\alpha_1\ln ENERGY_{it}+\alpha_2\ln CUSTOMERS_{it}+\frac{1}{2}\alpha_{11}\ln(ENERGY_{it})^2 \\
&+\frac{1}{2}\alpha_{22}\ln CUSTOMERS_{it}{}^2+\alpha_{12}\ln ENERGY_{it}*\ln customers_{it} \\
&+\beta_1\ln(\frac{TOTEX}{CENS}_{it})+\frac{1}{2}\beta_{11}\ln(\frac{TOTEX}{CENS}_{it})^2+\delta_1(\frac{TOTEX}{CENS}_{it})*\ln ENERGY_{it} \\
&+\delta_2(\frac{TOTEX}{CENS}_{it})*\ln CUSTOMERS_{it}+\tau_1 t+\tau_2 t^2 \\
&+\theta_1*z_1+\theta_2*z_5+\theta_3*z_6+\theta_4*z_7+\theta_5*z_8+v_{it}-u_{it}
\end{aligned}
$$

Estimation

-ln (CENS) =			
ln Customer	-0.2785***	t	-0.0695***
ln Energy	-0.3483***	t^2	0.0274***
½ (ln Customer)^2	-0.1624		
½ (ln Energy)^2	-0.3550*		
ln Customer * ln Energy	-0.2497		
ln TOTEX	0.9515***	Geo-Index 1	-0.4546***
½ (ln TOTEX)2	0.0064	Hail	0.0679
ln TOTEX * ln Customer	-0.0069	z6	0.0105
ln TOTEX * ln Energy	0.0032	Wind HV	0.0582
Constant	0.3925***	Wind by sea dist.	-0.0374*
N	131	T	4
Log-likelihood	511.02989	Wald Chi ^{2}	98473.6***

Results

- Environmental variables:
  - Influence productions cost more than CENS (multivariate)
  - Highly correlated

  → estimation of ENS might be misspecified
  - translog-setting: hardly significant
- TOTEX and CENS are substitutes
- Private und social cost have increased over time
- Average efficiency remained constant

Conclusions

- The introduction of CENS has not changed the network operator's average efficiency
- CENS remained constant over time:
  Quality of service has not been increased
- but did not deteriorate either

Prospect research:

- Increase panel duration
- Analysis of relation TOTEX and CENS: substitution elasticity

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