Durham University Business School

Susgrid Workshop
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Economics of Sustainable Networks:

Public Engagement and Investment

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About us

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- Durham Energy Institute
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- Durham University Business School
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  - ➢ Rahmat Poudineh

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Public Engagement in Network Development

A New Institutional Economics View
Beauly-Denny Project, Scotland

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Economic features of grid development

- Large sunk costs
- Numerous different stakeholders
- Public goods
- Externalities
- Incomplete contracts
- Information asymmetries

Beauly-Denny project: Facts

- High Voltage Transmission line between Beauly, near Inverness, and Denny, near Stirling
- Ten year planning process between 2002-2012
- **220km long**, 600 steel pylons between 43 and 65m tall.
- Total Investment: Over £750m
- Key infrastructural development to connect renewable energy generation in the North to the network
- Over 20,000 objections from mainly Scotland but also other parts of the world
- **Longest ever public inquiry in Scotland**

Theoretical approach: New Institutional Economics

- Neoclassical Economics assumes costless transactions, rational actors and perfect information → Unrealistic

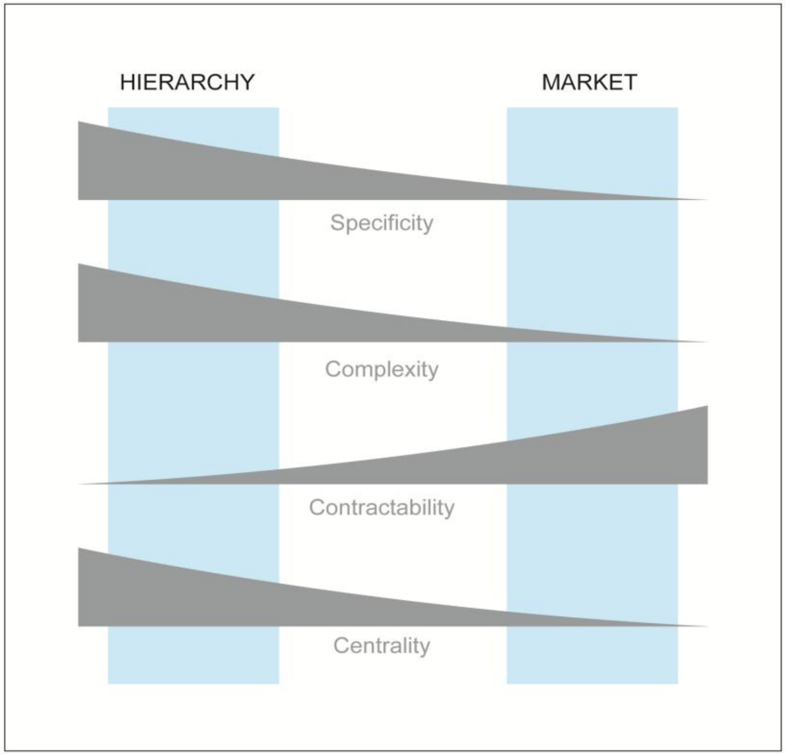
- New Institutional Economics central concepts
  - Transaction cost
  - Property-rights
  - Principal-Agent relationships
  - Market failure

- The concepts are connected through the costs of transacting
  - Uncertainty, opportunism, incomplete contracts, ill-defined property rights and miscommunicated principal-agent relationships increase these costs

Conceptual governance model

- Market based or non-market based
  - ➢ Coase (1937), Williamson (1979)

- The optimal (cost minimizing) governance structure determined from the characteristics of a specific activity



Public engagement

Current	Suggested future
▪ Characterised by one-way communication ▪ Limited ▪ Unstructured ▪ Ineffective downstream in decision-making process ▪ Non-integrated market based	▪ Two-way discussion ▪ At a place upstream in decision-making process ▪ Integrated non-market based ▪ Clear, uniform framework to limit opportunism, uncertainty, information asymmetry, and thus transaction costs ▪ Increased transparency

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Using Supervised Environmental Composites in Production and Efficiency Analyses: An Application to Norwegian Electricity Networks

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EWI Working Paper
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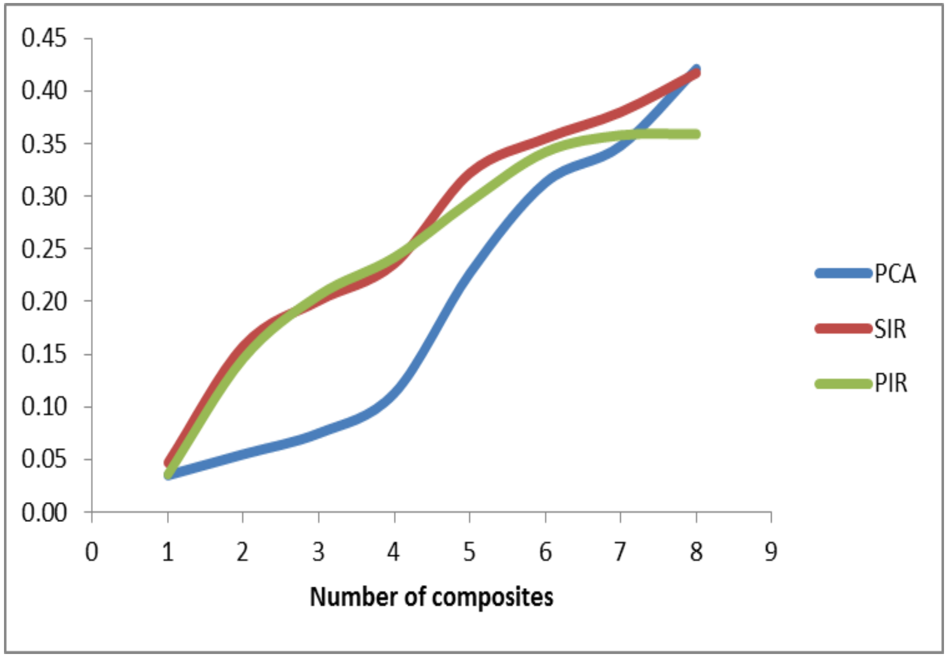
Introduction

- New technologies allow researchers to collect and analyze large amounts of data at relatively low cost.
  - Computational biology, climatology, geology, neurology, health science, economics, and finance.
- Reducing the dimensions of data is a natural and sometimes necessary manner in order to proceed with massive data analyses.
- The action of replacing a set of regressors with a lower-dimensional function is called dimension reduction.
- The reduction is labeled as sufficient or supervised when this reduction is achieved without loss of information (Fisher ,1922).
- Li (1991) introduced the first method for sufficient dimension reduction, i.e. sliced inverse regression (SIR).
  - **not used in production economics and efficiency analysis.**

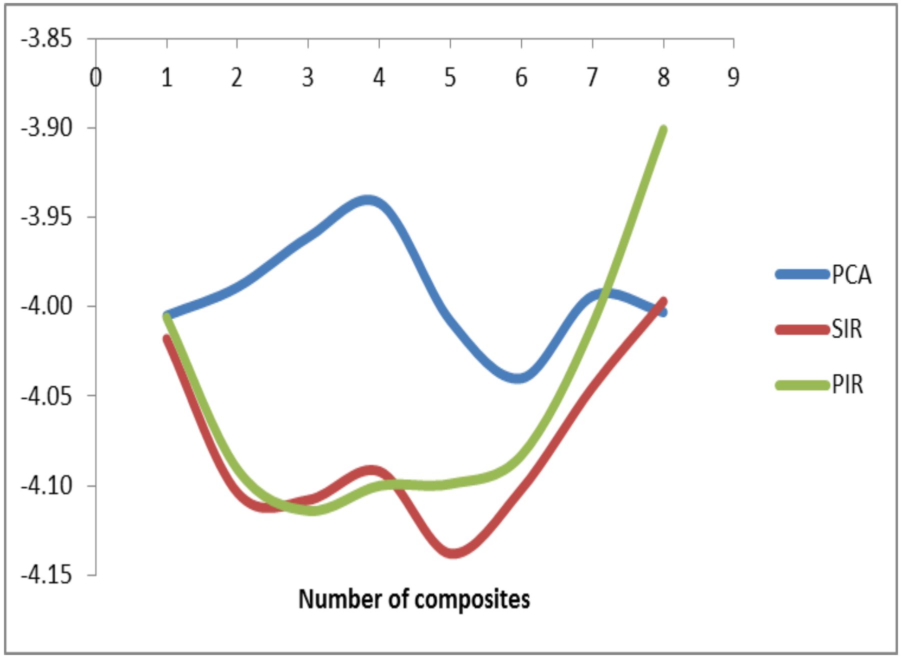
- We apply these techniques to a dataset of Norwegian electricity distribution networks, which are regulated using **incentive regulation** schemes based on efficiency analyses.
- **Weather and geographic conditions** are the most commonly factors perceived to be affecting the performance of electricity networks.
- To reduce the dimensions of the environmental variables we use two **supervised** methods:
  - SIR = sliced inverse regression
  - PIR = parametric inverse regression.
- We use the most commonly **unsupervised** method (e.g. PCA) as a benchmark.
- We also examine whether **efficiency analyses** are robust with respect to using one or other type of methods.

Partial goodness-of-fit

Partial R^2



Partial BIC



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Investment and Efficiency under Incentive Regulation:

Analysis of Norwegian DNOs

Rahmat Poudineh

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- We use a dataset comprising a balanced panel of 129 distribution companies from 2004 to 2010
- The inputs are capital expenditure (In) and other costs (C_1)

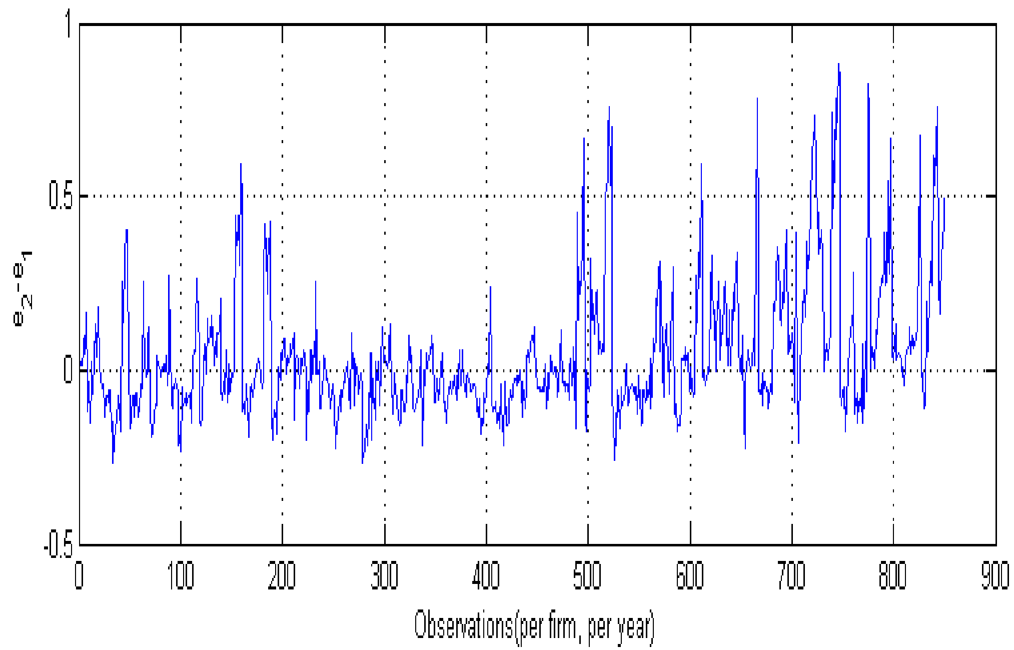
$$C_1 = Opex + Cost\ of\ \ Losses\ +\ Cost\ of\ Energy\ Not\ Supplied$$

- The “total number of customers”, “number of substations” and “length of network” are used as outputs
- The parameters used in the model are obtained by maximum likelihood estimation procedure
- All variables are divided by their sample median prior to estimation

Results - Efficiency variation

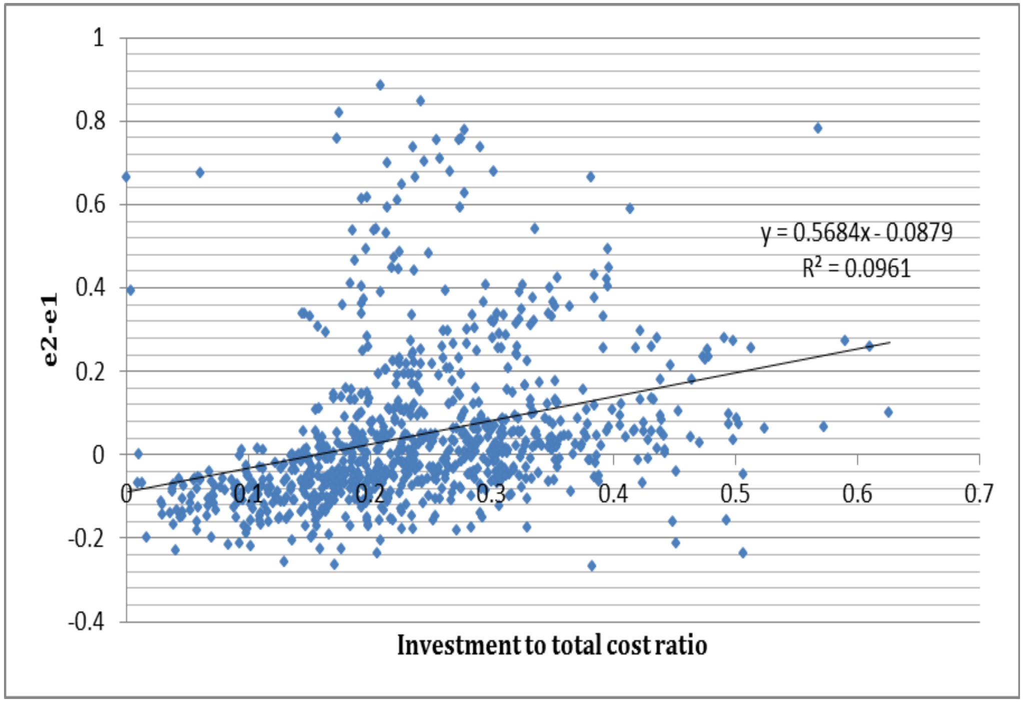
- Investment has impacted efficiency and in a relatively wide range

- On average, investments led to 4.8% efficiency gain



Results - Efficiency gain and loss

- Efficiency loss is prevalent among the companies with lower investment to total cost ratios
- Middle size share of investment created more efficiency gain
- Again high share of investments created less efficiency gain



Dynamic Efficiency and Incentive Regulation:

Analysis of Norwegian DNOs

Rahmat Poudineh
Tooraj Jamasb

Dynamic efficiency

- The measure of efficiency obtained in benchmarking is only appropriate for the short run
- Because, it captures the firm's performance in a snapshot towards its long run equilibrium
- The factors affecting short run behaviour of firm may not adjust instantaneously when the firm invests (e.g., in new technologies or R&D)
- Under this condition, investment may create a virtual inefficiency which persists over time

Results

Variable	Simple random effect		Correlated random effect	
	Mean	SD	Mean	SD
β_0	0.34205	(0.053887)	0.23665	(0.051422)
β_1	0.28762	(0.046698)	0.11701	(0.104343)
β_2	0.36065	(0.029827)	0.21606	(0.093205)
β_3	0.24970	(0.036858)	0.11259	(0.056200)
β_4	0.09727	(0.038841)	0.03807	(0.070256)
β_5	-0.06312	(0.100805)	-0.28806	(0.182883)
β_6	-0.06084	(0.053950)	-0.21201	(0.071650)
β_7	-0.02394	(0.072697)	0.01034	(0.125549)
β_8	-0.00349	(0.030478)	-0.01356	(0.046992)
β_9	0.04121	(0.052897)	0.20701	(0.090193)
ξ_1	0.00007	(0.000210)	0.03050	(0.003544)
ξ_2	0.00000	(0.000000)	-0.00002	(0.000006)
σ_v	0.03418	(0.003877)	0.03899	(0.003730)
δ	0.26944	(0.057608)	0.46890	(0.106928)
ρ	0.76600	(0.038328)	0.69766	(0.064994)
σ_u	0.24952	(0.027429)	0.28747	(0.036909)
σ_ω	0.12275	(0.010901)	0.11816	(0.009491)
Long run TE	0.75832		0.82424	
Log likelihood	1071.00		1163.80	
Posterior probability	0.00000		0.00000	

Conclusions

- 76% of ratio of inefficiency is transmitted to the subsequent periods
- This arises because of technological difference among firms or cyclical investments
- This effect of sluggish adjustment of output is problematic for companies revenue under ex-post regulatory treatment of investment
- Thus, inclusion of capital cost in benchmarking model might result in unintended outcome for investment and innovation behaviour of distribution companies

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Determinates of Investments:

Analysis of Norwegian DNOs

Rahmat Poudineh
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Methodology

- Due to the uncertainty around the response of the firm to different incentive instruments we adopt a Bayesian Model Averaging (BMA) technique

- BMA is a powerful tool to examine the extent to which any given factor improves the explanatory power of the estimated models when it is included

- It takes into account the uncertainties around model selection and estimation

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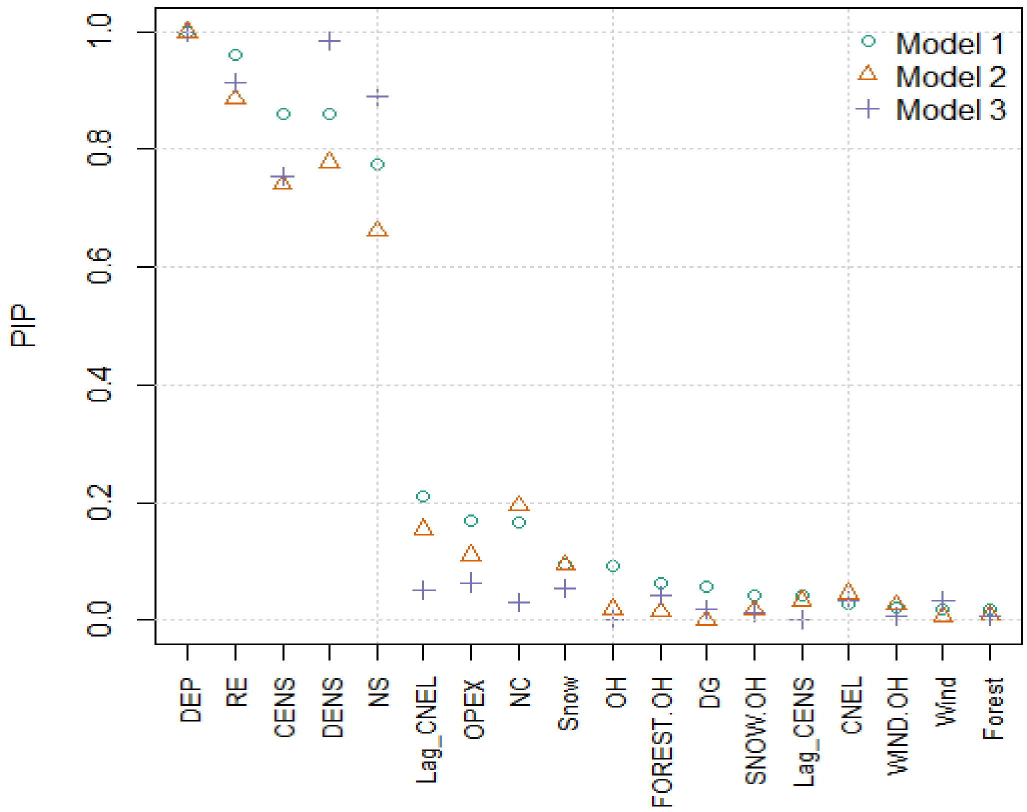
Group	Variable	Name	Min	Max	Mean
Dependent	Investment*	IN	74	337124	22003
Group 1: Demand factors	Energy density (MWh/KM)	$DENS$	137	2234	546
	Number of stations (#)	NS	29	14405	993
	Number of customers(#)	NC	243	535443	19869
	Number of leisure home (#)	RE	68	27307	2279
	Distributed generation (MW)	DG	0	96	10
Group 2: Quality factors	Cost of energy not supplied*	$CENS$	12	58527	2928
	Cost of network energy loss*	$CNEL$	278	394127	14949
Group 3: Environmental factors	Share of overhead lines (%)	OH	0.13	0.97	0.67
	Snow condition (millimetres)	$snow$	53	1194	367
	Wind and distance to coast (ratio)	$wind$	0	0.16	0.015
	Forest productivity (fraction)	$forest$	0	0.55	0.16
Group 4: Other factors	Depreciation*	DEP	631	281978	16606
	Operational expenditure*	$OPEX$	878	854646	45136

Posterior inclusion probability



Conclusions

- Depreciations, number of leisure homes, number of transformers, energy density, and cost of energy not supplied are main drivers of investments

- No evidence of environmental factors driving investments
- No investment effect from distributed generation sources

- Cost of network energy loss also had no impact on investments
- Possibly, because of different treatment of cost of network energy loss and quality of service