Electricity Policy Research Group

UNIVERSITY OF CAMBRIDGE

Does Environment Matter? An Analysis of US Electricity Distribution Utilities

Paul Nillesen
PwC

Michael Pollitt
University of Cambridge

Marco Wiltjer
PwC

Important notice

- *This presentation contains analyses based on public information available from the US Federal Energy Regulatory Commission (FERC).*
- *PricewaterhouseCoopers LLP (PwC) and/or its affiliated firms have not performed an audit, verification or independent validation of the aforementioned data and thus does not undertake any responsibility or liability and does not give and must not be interpreted as to be giving any (explicit or implicit) assurance for the accuracy or the completeness of the data.*
- *This presentation does not constitute investment and/or legal advice and is for academic discussion purposes only.*
- *The company referred to in this presentation – First Energy – was chosen for presentational purposes only. PricewaterhouseCoopers and the University of Cambridge have not undertaken this study for First Energy nor has there been any contact with the management of First Energy.*

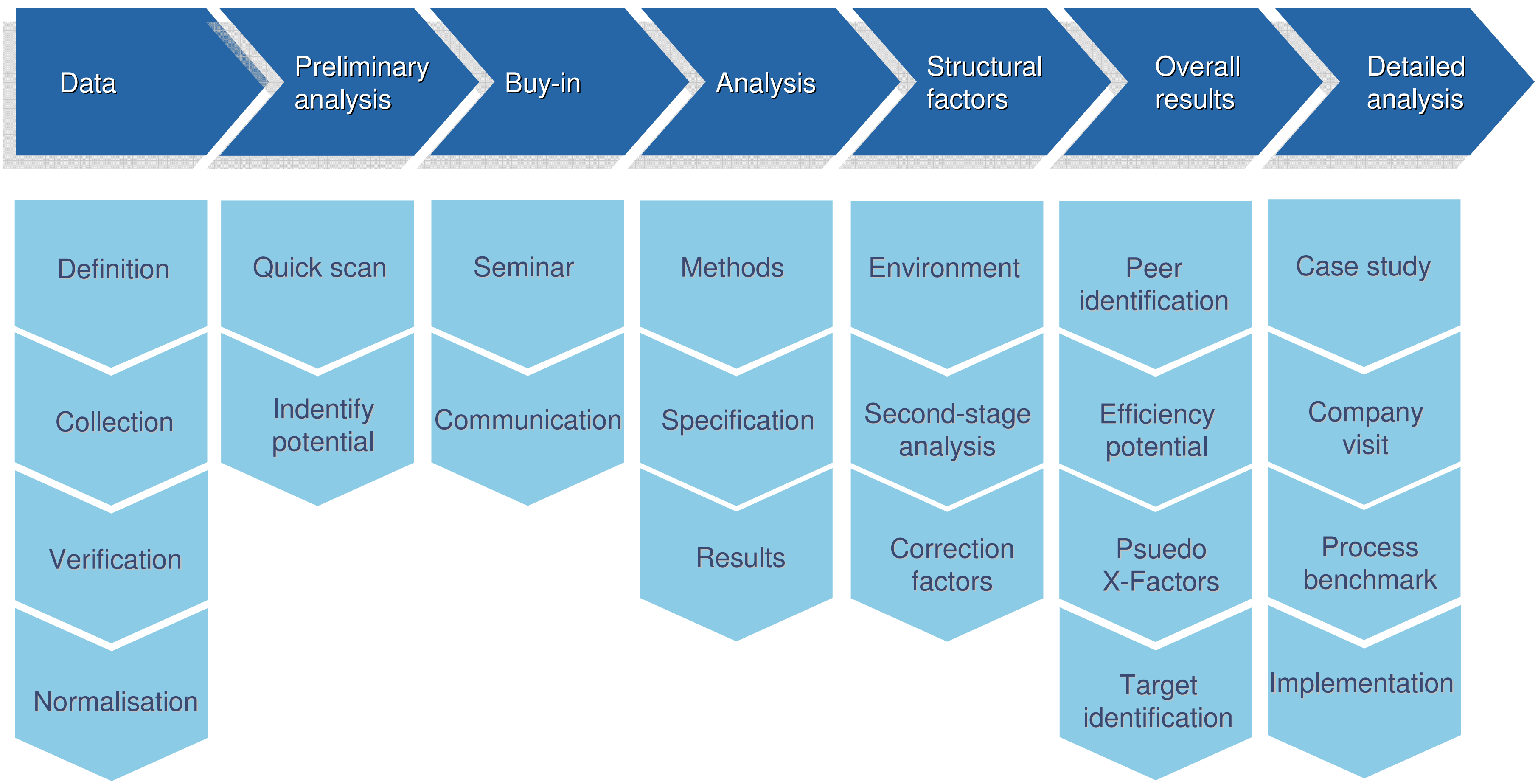
Background

- MP, Paul Nillesen, Marco Wiltjer, and PwC
- Draws on benchmarking applied by Ofgem
- Benchmarking by regulator sets X factors for companies to achieve
- Benchmarking for companies sets internal targets for business units
- Similar specification of production to that used by regulators
- We report DEA, but also undertook COLS

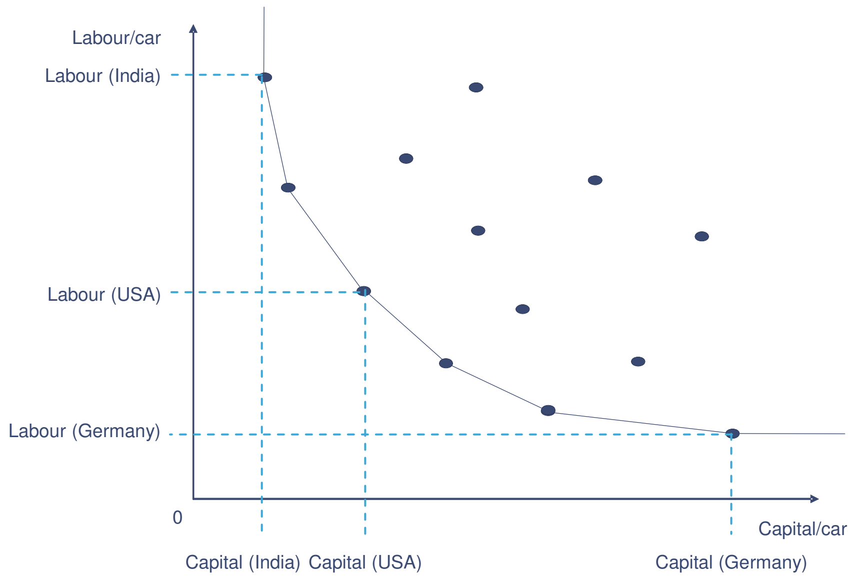
Outline

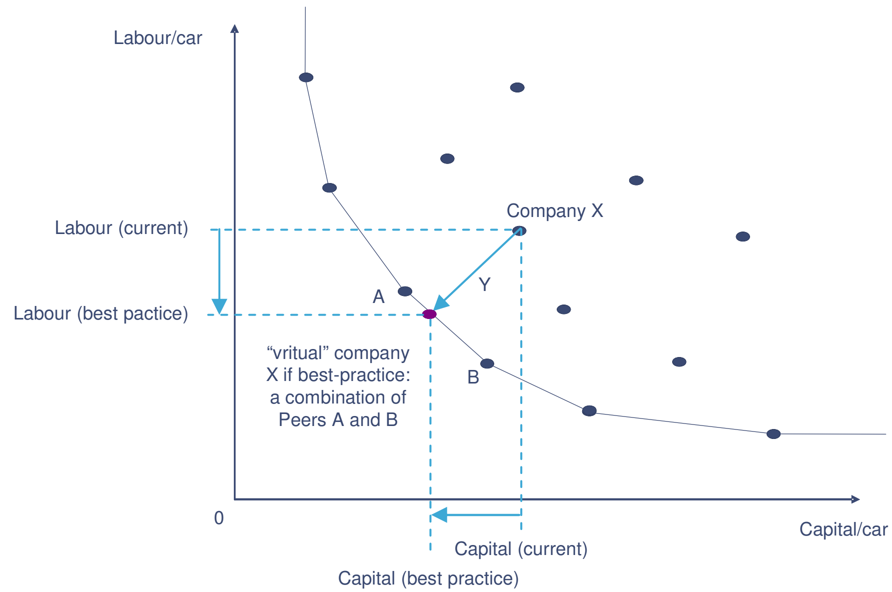
- Data Envelopment Analysis (DEA)
- Environmental effects
- Data issues
- Basic DEA results: US and NE
- Tobit environmental analysis: US and NE
- Adjusted results
- Implications

The benchmarking process



Data envelopment analysis (DEA): in theory





Imagine constructing an automobile in three different countries. To produce a car requires labour and capital (e.g. factory and robots). In India a car can be constructed using relatively little capital and lots of labour. On the other hand, in Germany a car is built using a lot of capital and very little labour (as labour is more expensive than in India). Each dot on the figure above represents the amount of labour and capital required to build a car.

The combinations closest to the origin are using the least amount of inputs to produce a car (output). Therefore, enveloping those combinations that use the least inputs per unit of output gives a production frontier along which one car is produced.

The companies to the right of this envelope are using more labour and capital to produce one car and are therefore inefficient.

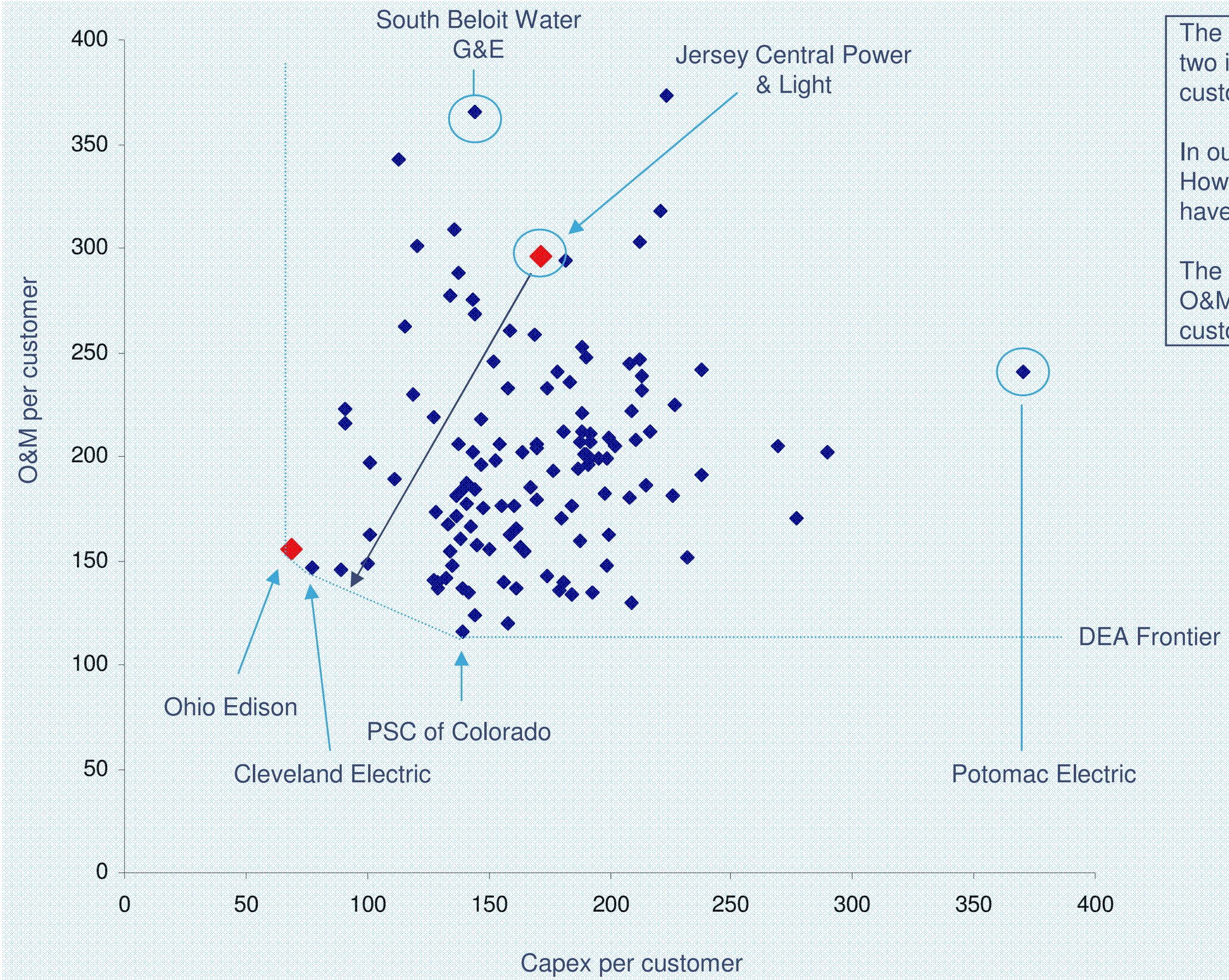
Company X uses relatively more capital and labour to produce one unit of output (e.g. a car). Company X can decrease its labour and capital input to the best-practice level and still produce one car.

The virtual company is a linear combination of best-practice frontier companies A and B (peer companies). Distance Y relative to the distance to the origin is the relative efficiency score of company X.

Note: All companies on the frontier are technically best-practice. However, from an allocation perspective this is not necessarily the case. Allocative efficiency results from optimising the labour-capital ratio on the basis of their relative costs. In India it is allocatively efficient to choose more labour than capital.

The sum of allocative and technical efficieny is economic efficiency. As prices for labour and capital are difficult to calculate, DEA analysis usuallu focuses on technical efficiency.

Data envelopment analysis (DEA): in practice



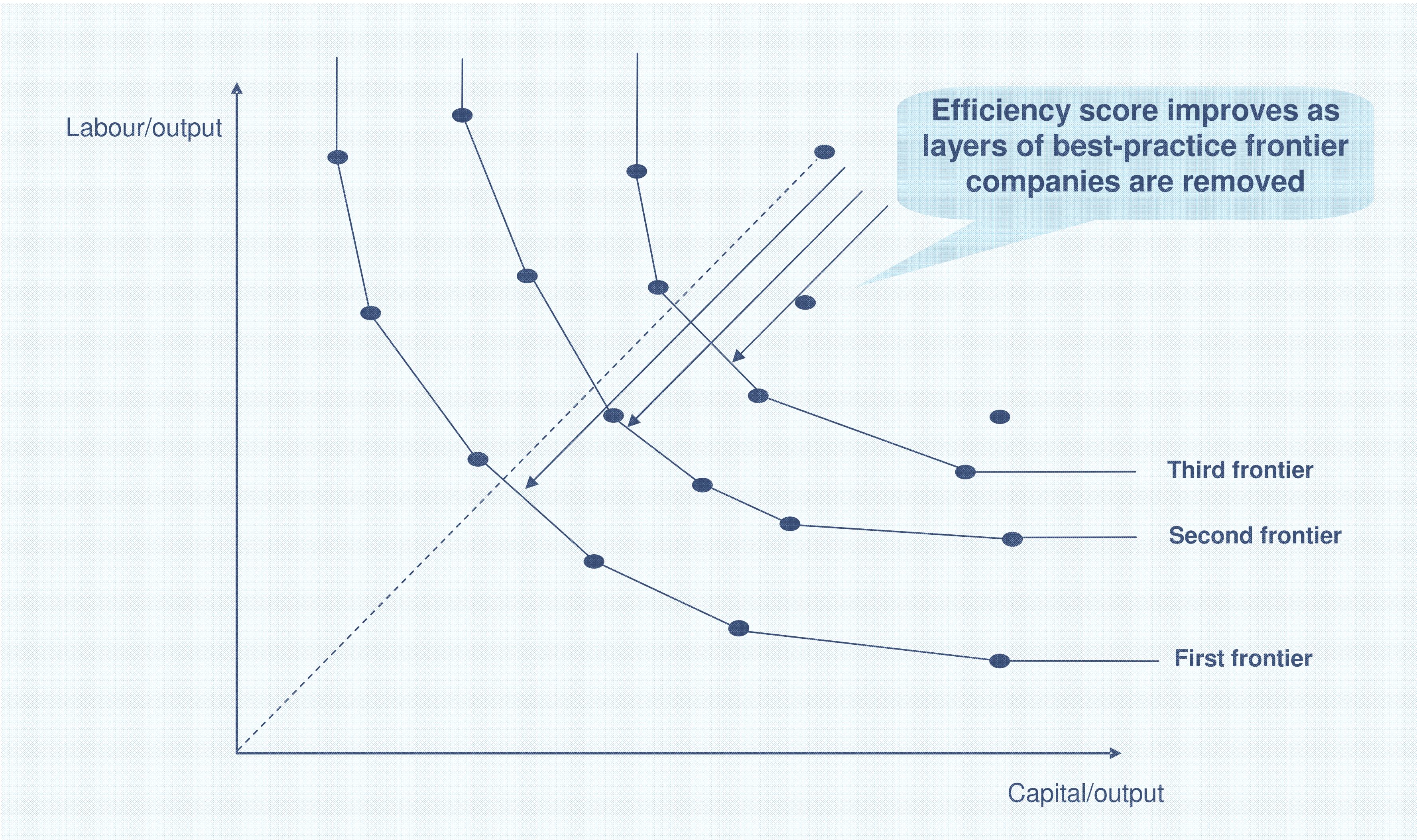
The figure on the left shows a DEA-style plot using two inputs: O&M and capex and one output: customers.

In our analysis we use Totex (O&M and capex). However, in order to visualise how DEA works we have split Totex out.

The scatters represent different combinations of O&M and capex to “produce” or serve one customer.

Jersey is far from the frontier. Ohio is part of the frontier. In terms of efficiency score, this means that Ohio is efficient but Jersey is not.

Sensitivity Analysis: Peer company stripping



How to handle ‘environmental factors’

- The Separation Approach: within DEA model directly (e.g. as fixed factors)
  - (see Banker and Morey, 1986)
- The Inclusion Approach: within DEA like inputs and outputs
  - (see Yaiswarng and Klein, 1994)
- Multistage Approaches (see Pastor, 2002), for example:
  - Two stage analysis (estimate DEA, then Tobit regression of raw scores)
  - Three stage analysis (DEA, SFA of slacks against environment, DEA of adjusted data)

Data

- Basic Source: FERC Form 1 and Platts
  - 123 US firms in 2003
  - 40 NE firms in 2003

- Outputs: Units distributed, customer numbers and network length

- Input: Total costs = O+M costs + Capital costs

- Issues:
  - Adjusting for retail competition
  - Adjusting for DSM
  - Adjusting for pensions and benefits

Focus firms: Output Data First Energy

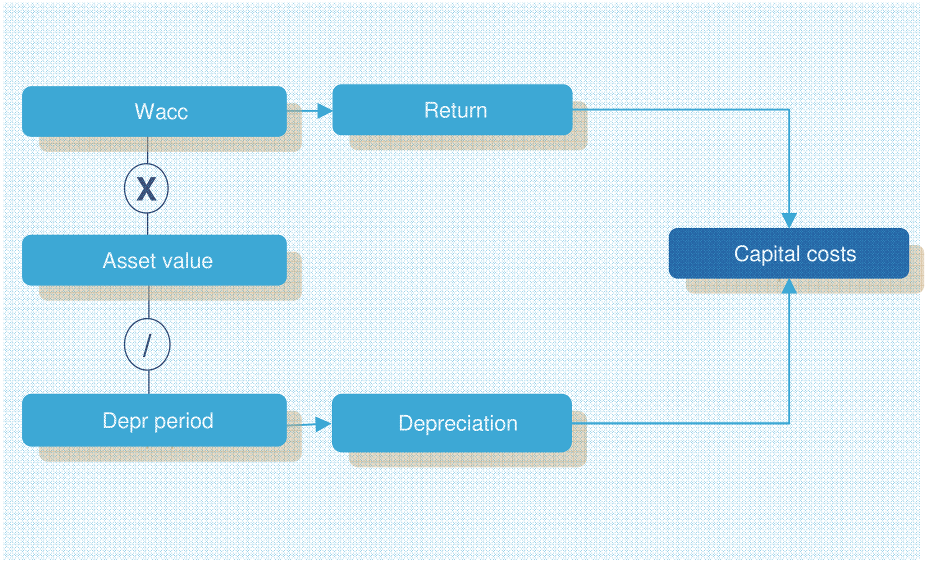
	Units Distributed 2003 TWh	**Customer Numbers 2003**	**Network Length 2003 miles**
Jersey Central Power & Light	**20.770**	**1,044,024**	**17,764**
Metropolitan Edison	12.982	512,290	14,434
Ohio Edison	**32.313**	**1,315,861**	**27,750**
Pennsylvania Electric	13.356	583,136	20,258
Pennsylvania Power	4.252	155,361	5,232
Toledo Edison	12.523	427,729	696
Average US	***18.054***	***729,784***	***19,261***

Environmental factors

Variable	Calculation	*A priori* expectation
Wage	Deviation from average wage. State-based in electricity sector. Source: Bureau of Labor Statistics 2003	*A priori* there is no clear causal relationship between wage levels and efficiency. A company can be a price-taker and thus not directly control wages. This might reduce its efficiency levels if wage levels are substantially higher than average. However, it could extract more production from its labour force or switch to more capital intensive production. Paying higher wages can also be an explicit strategy to reward higher productivity. Walmart pays above-average wages to reduce labour turnover.
Climate	Deviation from 2003 Normal Heating Degree Day. State-based. Source: National Oceanic and Atmospheric Admin	*A priori* we expect that companies operating in more temperate conditions to have higher efficiency levels, than companies operating in more extreme temperature conditions. Simultaneously, colder regions may experience higher demand in winter for electricity thereby increasing the load factor of the network. A similar argument can be made for air-conditioning in summer months for hotter regions. Perhaps more significant for the efficiency of a network is the variation in temperature (storms etc). We have not collected data for this.
Age of assets	Deviation from average age of distribution assets. Cumulative depreciation divided by annual depreciation in 2003	*A priori* the causality between age of assets and efficiency is not clear. Older assets result in lower capital costs. At the same time there is a potential trade-off with operating costs that may be higher for older assets. In our preliminary analysis we found no trade-off in efficiency between operating expenditure and capital expenditure. We therefore expect that in our results there is a negative relation between age of assets and operating efficiency.
Vertical integration	Deviation from average degree of vertical integration. Percentage own production to total power required	*A priori* we expect companies with some degree of vertical integration to be more efficient than those companies that purchase all their power.
Customer Mix	Deviation from average customer mix. Percentage industrial units delivered to total	*A priori* we expect that companies with a higher proportion of kWh's delivered to industrial consumers will be more efficient than those companies delivering power to predominantly residential consumers.

Capital costs (I)

- Capital and labour are two major inputs into the production process
- Labour input is estimated using O&M expenses
- Capital input is estimated by adding
  - Depreciation
  - Reasonable rate of return on invested capital



Capital costs (II): Wacc

- We estimate a nominal post-tax Wacc for a US electricity distribution business at 6 percent
- The main inputs for this Wacc are:
  - Asset beta of 0.4 – based on an international survey of regulated utilities by PwC
  - Risk-free rate of 4.4% - based on current yield of 10-year T-Bill
  - Tax rate at 25% - based on PwC Corporate Finance calculations
  - Market risk premium of 4.5% - based on PwC Corporate Finance calculations
- The nominal Wacc is used to calculate capex

Asset beta 0.4
Tax rate 25%
D/E 1.5

Cost of equity	
Risk free interest rate	4,4%
Market risk premium	4,5%
Beta equity	0,85
Company specific risk	
Cost of equity	8,2%

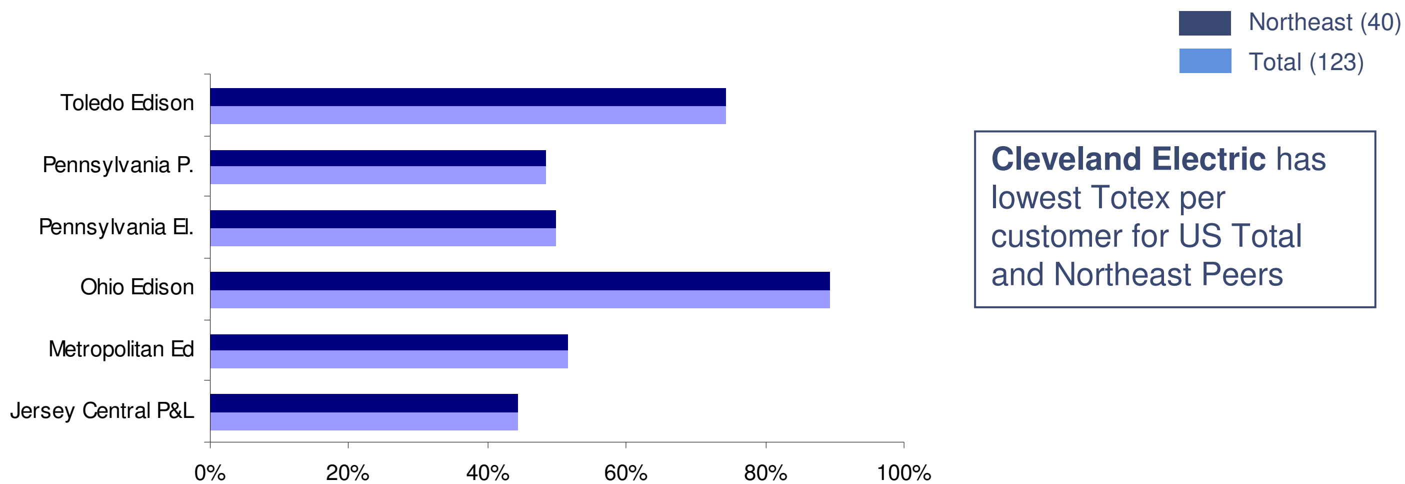
Cost of debt	
Risk free interest rate	4,4%
Company specific risk	1,5%
Tax effect (1-T)	75%
Cost of debt	4,4%

Target financial structure	
Equity	40%
Debt	60%
	100%

WACC	
Weighted equity	3,3%
Weighted debt	2,7%
WACC	**5,95%**

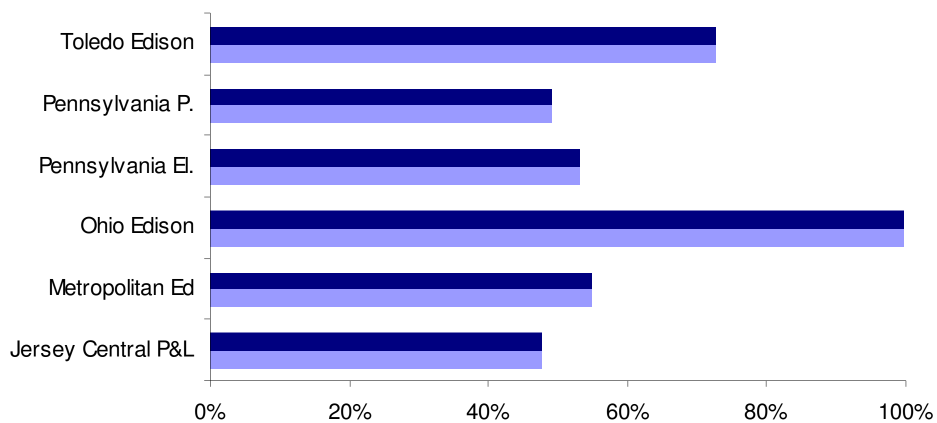
Single Factors: Totex per customer

Base Case



Cleveland Electric has lowest Totex per customer for US Total and Northeast Peers

Adjusted



Cleveland Electric has lowest Totex per customer for US Total and Northeast Peers

Totex DEA analysis 2003 adjusted

Total Sample

Jersey	48%
Metropolitan	58%
Ohio Edison	100%
Penn El	57%
Penn P	55%
Toledo E	81%

Best-practice Peers

Cleveland Electric
Commonwealth El
Ohio Edison
KGE
Kingsport
Westar
Wheeling Power

Northeast Sample

Jersey	48%
Metropolitan	63%
Ohio Edison	100%
Penn El	64%
Penn P	64%
Toledo E	87%

Best-practice Peers

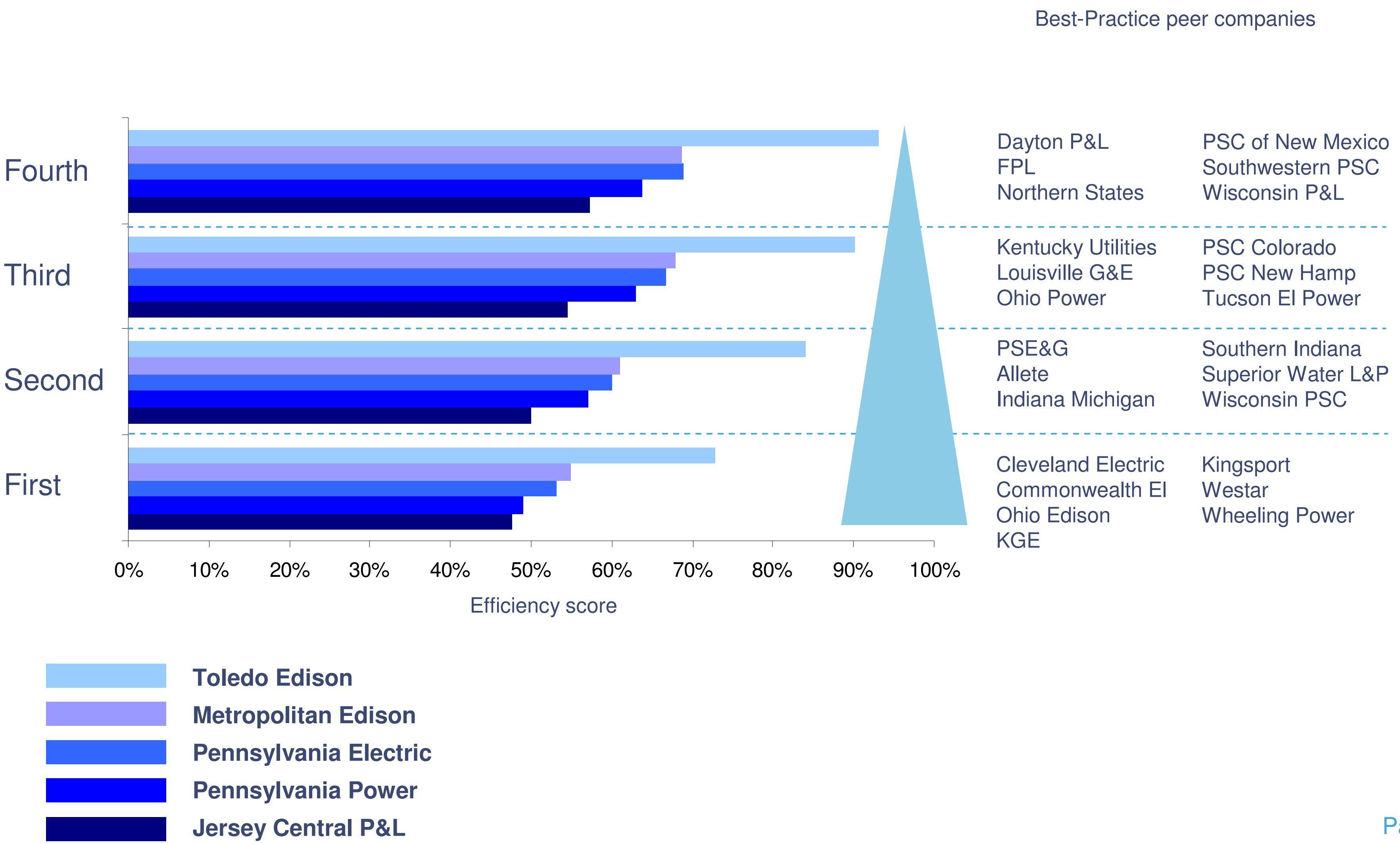
Cleveland Electric
Commonwealth El
Ohio Edison

Sensitivity Analysis: Effects of removing the best-practice firms

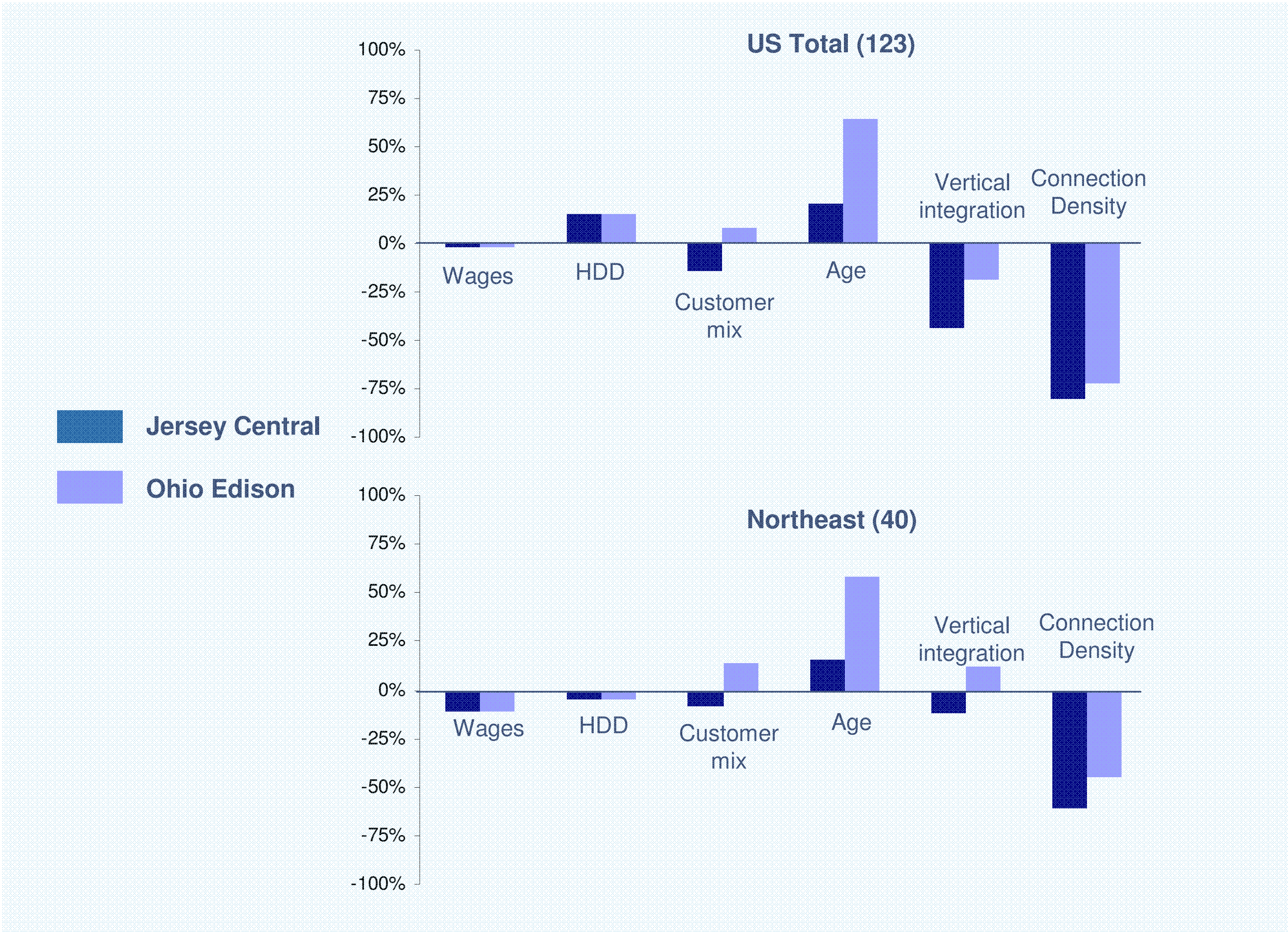
	Totex Best Case	*First tier Peers*	Removing First tier Peers	*Second tier Peers*
US Total	Jersey 48% Metropolitan 58% Ohio Edison 100% Penn El 57% Penn P 55% Toledo E 81%	Cleveland Electric Commonwealth El Ohio Edison KGE Kingsport Westar Wheeling Power	Jersey 50% Metropolitan 61% Ohio Edison --- Penn El 60% Penn P 57% Toledo E 84%	*PSE&G* *Allete* *Indiana Michigan* *Southern Indiana* *Superior Water L&P* *Wisconsin PSC*
Northeast	Jersey 48% Metropolitan 63% Ohio Edison 100% Penn El 64% Penn P 64% Toledo E 87%	*Cleveland Electric* *Commonwealth El* *Ohio Edison*	Jersey 50% Metropolitan 69% Ohio Edison --- Penn El 70% Penn P 67% Toledo E 100%	*Cambridge Electric* *Conn Valley Electric* *Monongahela Power* *Potomac Edison* *PSE&G* *Toledo Edison*

Note: Removing 3 best-practice companies from Northeast analysis, results in 8 percent of the sample being removed.

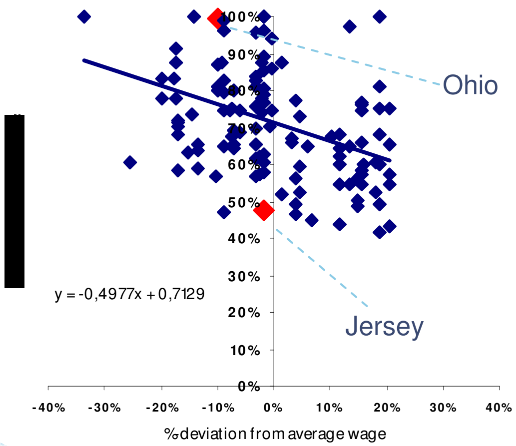
Sensitivity Analysis: Removing layers of best-practice companies does not improve scores substantially for **US Total**



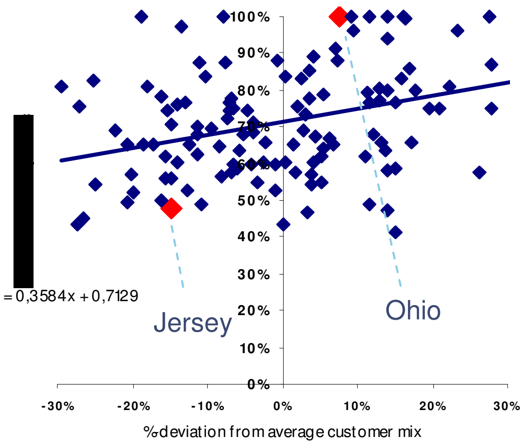
Deviation from average environment for dataset



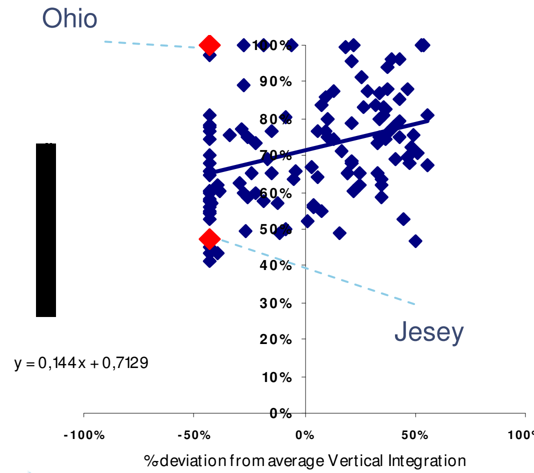
US Total: Environmental factors against efficiency scores



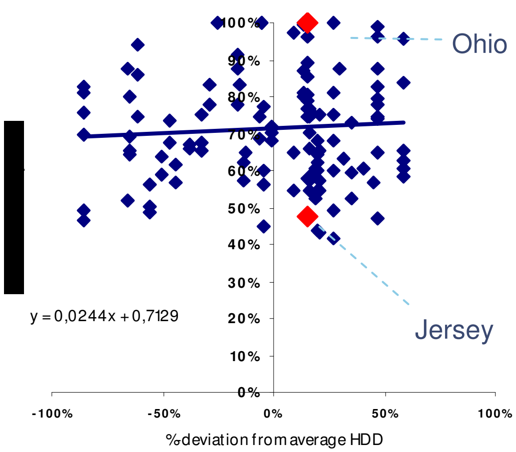
▶ **Wage: statistically significant**



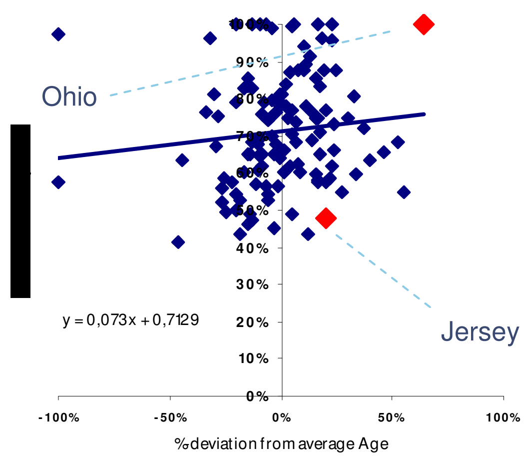
▶ **Cust mix: statistically significant**



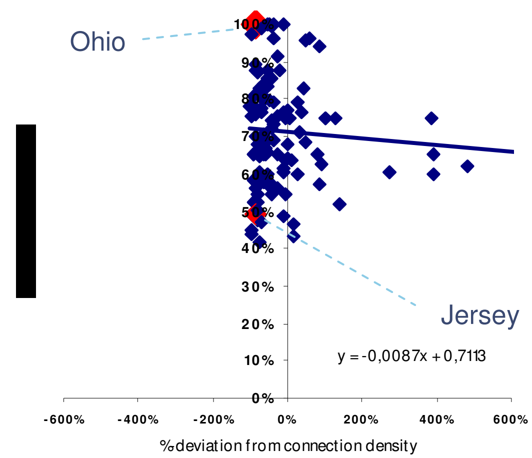
▶ **Vert Int: not statistically significant**



▶ **HDD: not statistically significant**



▶ **Age: not statistically significant**



▶ **Con. Dens.: statistically significant**

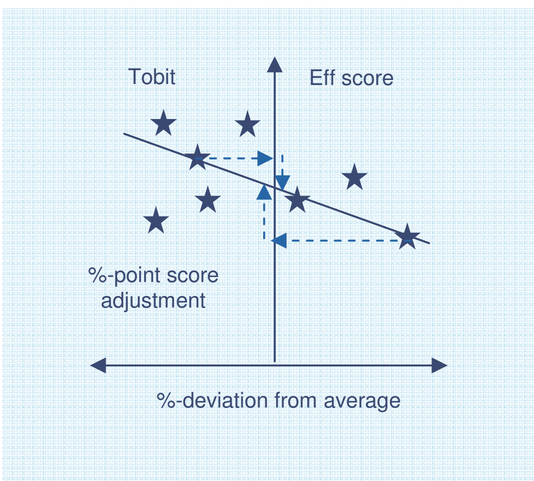
Note: Statistical significance tested using Tobit regression, coefficients reported here are OLS-based, but do not differ substantially from Tobit coefficients.

US Total: Tobit analysis

Tobit Regression

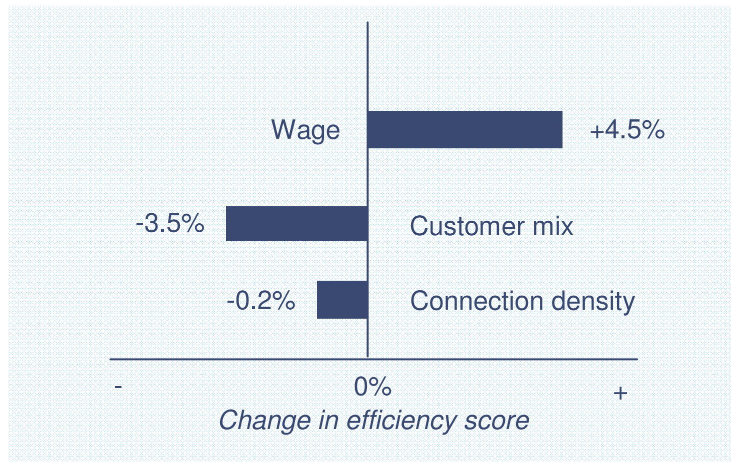
Tobit regression is an extension of OLS regression, except in the sample (efficiency scores) are truncated at 0% and 100%.

The adjustments reported here normalise for environmental conditions. That is, all companies are normalised to average conditions.



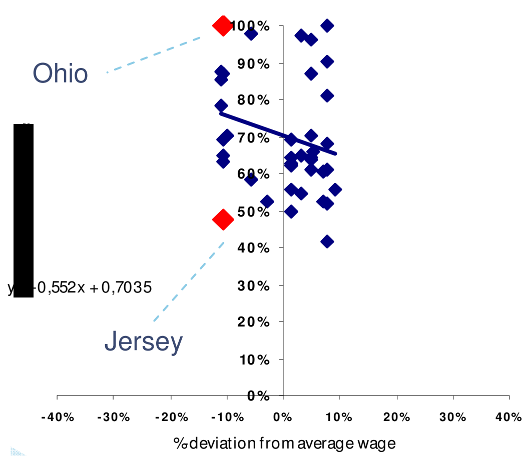
Note: Slope changes for negative score corrections

Adjustment in score if environmental factor deviates by 10%-point from average

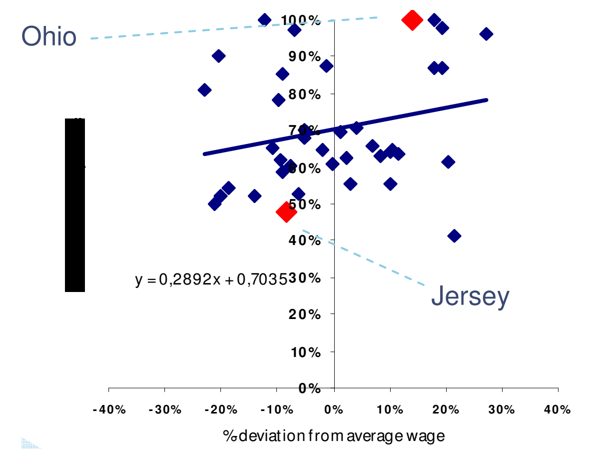


	Original	Normalised for environment
Jersey	48%	51%
Metropolitan	58%	55%
Ohio Edison	100%	95%
Penn El	57%	65%
Penn P	55%	59%
Toledo E	81%	74%

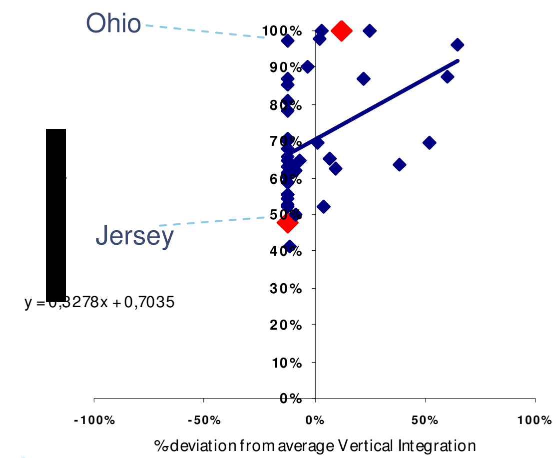
Northeast: Environmental factors against efficiency scores



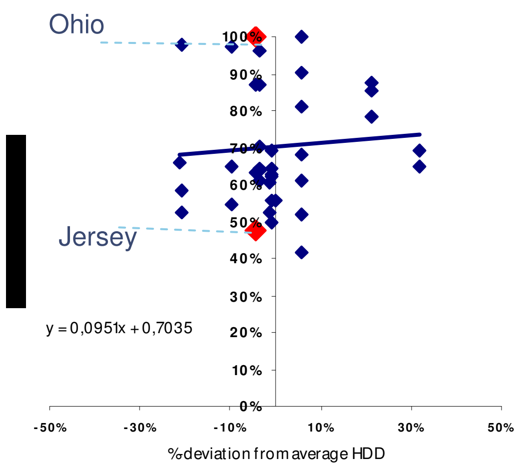
Wage: not statistically significant



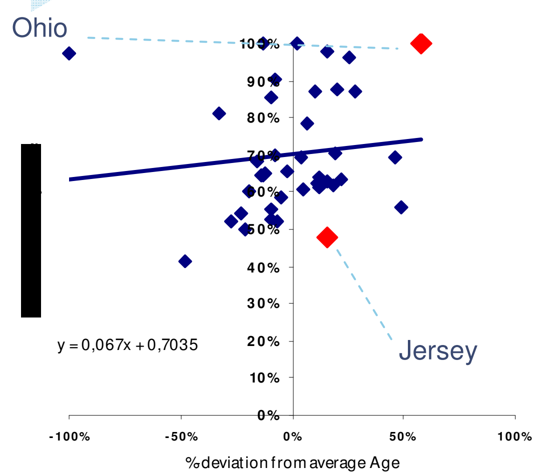
Cust mix: not statistically significant



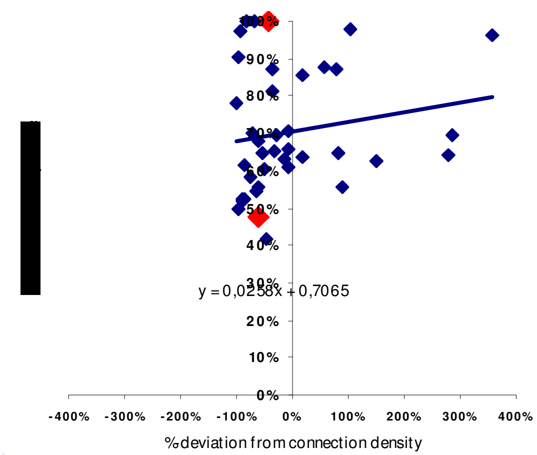
Vert Int: statistically significant



HDD: not statistically significant



Age: not statistically significant



Con. Dens.: not statistically significant

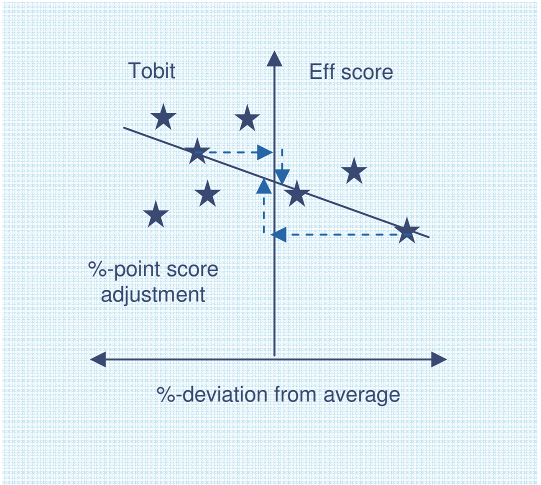
Note: Statistical significance tested using Tobit regression, coefficients reported here are OLS-based, but do not differ substantially from Tobit coefficients.

Northeast: Tobit analysis

Tobit Regression

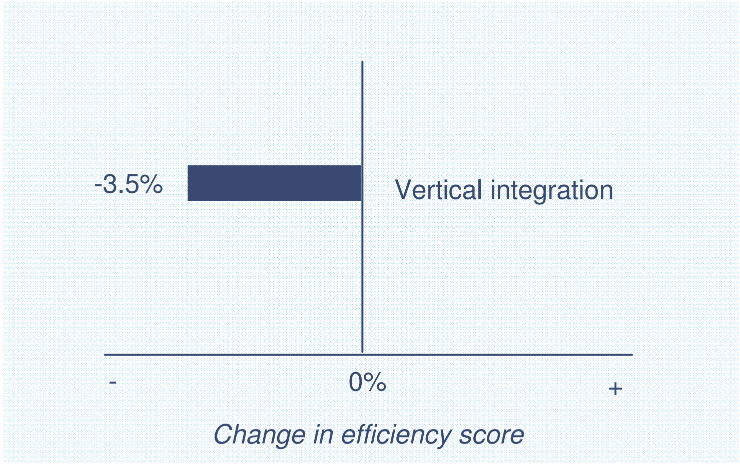
Tobit regression is an extension of OLS regression, except in the sample (efficiency scores) are truncated at 0% and 100%.

The adjustments reported here normalise for environmental conditions. That is, all companies are normalised to average conditions.



Note: Slope changes for negative score corrections

Adjustment in score if environmental factor deviates by +10%-point from average



Original

Jersey	48%
Metropolitan	63%
Ohio Edison	100%
Penn El	64%
Penn P	64%
Toledo E	87%

Normalised for environment

Jersey	52%
Metropolitan	67%
Ohio Edison	96%
Penn El	68%
Penn P	50%
Toledo E	79%

Overview DEA results

US Total

Original		Normalised for environment	
Jersey	48%	Jersey	51%
Metropolitan	58%	Metropolitan	55%
Ohio Edison	100%	Ohio Edison	95%
Penn El	57%	Penn El	65%
Penn P	55%	Penn P	59%
Toledo E	81%	Toledo E	74%

Northeast

Original		Normalised for environment	
Jersey	48%	Jersey	52%
Metropolitan	63%	Metropolitan	67%
Ohio Edison	100%	Ohio Edison	96%
Penn El	64%	Penn El	68%
Penn P	64%	Penn P	50%
Toledo E	87%	Toledo E	79%

Correcting for environmental factors in the Northest can have substantial effects

Scores and rankings DEA: First Energy

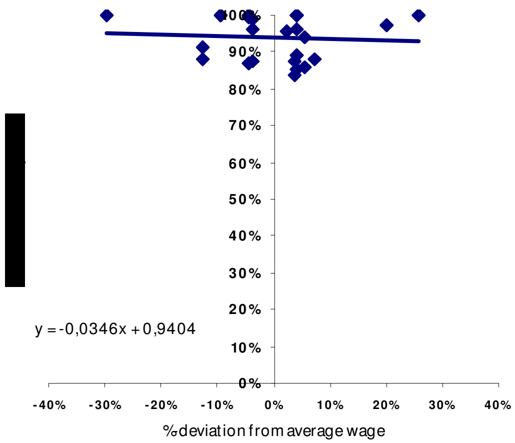
	TOTEX northeast				TOTEX us total			
	DEA		Corrected		DEA		Corrected	
Jersey Central Power & Light Co.	48%	39	52%	36	48%	117	51%	118
Metropolitan Edison Co.	63%	25	67%	20	58%	98	55%	113
Ohio Edison Co.	100%	1	96%	4	100%	1	95%	5
Pennsylvania Electric Co.	64%	23	68%	19	57%	101	65%	88
Pennsylvania Power Co.	64%	24	50%	39	55%	106	59%	99
Toledo Edison Co.	87%	9	79%	11	81%	33	74%	47
Number of companies	40		40		123		123	
Customer weighted average	68%		69%		68%		71%	
Simple average	70%		70%		71%		71%	
Median	65%		67%		58%		62%	
Maximum	100%		100%		100%		100%	
Minimum	42%		46%		42%		37%	

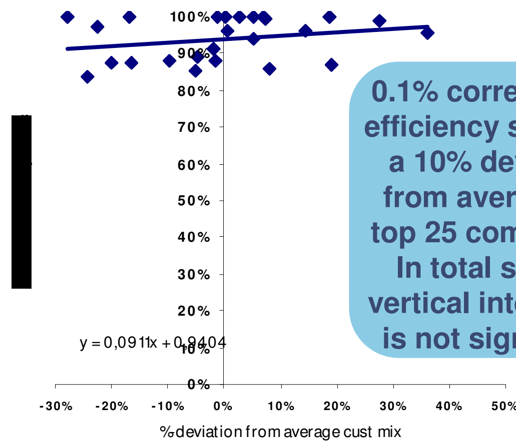
DEA Score Correlations for 40 NE Firms

	NE	*NE Corrected*	*US*	*US Corrected*
NE	1.00			
NE Corrected	0.90	1.00		
US	0.94	0.87	1.00	
US Corrected	0.91	0.82	0.94	1.00

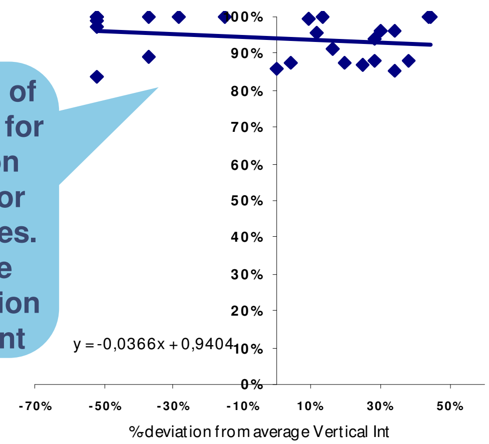
This implies that if US Total Corrected is the 'True Score' then using a NE Corrected score is worse than using an uncorrected US score.

Vertical Integration plays a minor role for US top 25 performers…





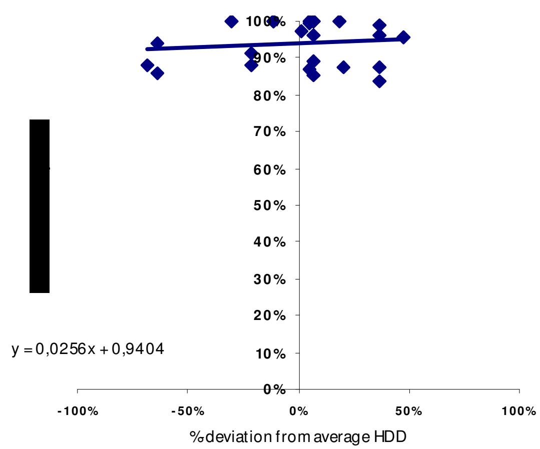
0.1% correction of efficiency score for a 10% deviation from average for top 25 companies. In total sample vertical integration is not significant

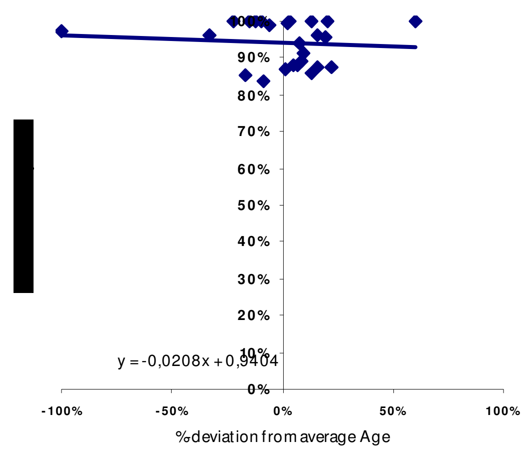


Wage: not statistically significant

Cust mix: not statistically significant

Vert Int: statistically significant





HDD: not statistically significant

Age: not statistically significant

Note: Statistical significance tested using Tobit regression, coefficients reported here are OLS-based, but do not differ substantially from Tobit coefficients.

Conclusions

- Substantial efficiency gains possible for focus firms
- Substantial efficiency gains possible in whole sample
- Simply restricting the peer group is not best way of handling environment
- Top 25 firms show virtually no environmental effects

- Implication for business:
- Some justification for regional peer group on environmental grounds
- Double correction of regional peer group and environmental adjustment dubious
- However allowing managers to claim environment important is dubious

- Implication for regulators:
- Need to look outside state for comparators
- Need to model environmental effects carefully