APB Methods and Preliminary Research Results

Mark Newton Lowry

David Hovde

Zack Legge

Pacific Economics Group Research, LLC

Ontario Energy Board

29 October 2018

Toronto, ON

Overview

Benchmarking Basics

Benchmarking Methods

Preliminary Empirical Research

- Econometric Models
- Traditional Unit Cost Analysis

Granular Costs Proposed by Staff

- Available data for benchmarking
- New data collection

Benchmarking Basics

Statistical Benchmarking

Statistical <u>Benchmarking</u>	Performance evaluation using data on operations of other utilities
<u>Performance Metrics</u>	Variables that measure company activities (e.g., Unit Cost)
<u>Benchmarks</u>	Comparison value of metric; often reflects performance standard

Statistical methods are used to

- Calculate benchmarks (e.g. average unit cost)
- Draw conclusions about performance from comparisons to benchmarks

Benchmarking Basics (*cont'd*)

Performance Standards

Statistical benchmarks can reflect alternative performance standards

- Peer group average
- Peer group top quartile
- Peer group best practice (frontier)

Frontier standards harder to implement *accurately*

- Data anomalies
- Short run, unsustainable nature of apparent best performances

Cost Drivers

Values of performance metrics (e.g., unit cost) depend on

Utility Performance

e.g., effort and competence

Business conditions (cost "drivers")

>>> Benchmarks ideally reflect ("control for") external business conditions

Cost Drivers (cont'd)

Cost theory sheds light on cost drivers

Relevant drivers depend on *scope* of benchmarking study

Total Cost Benchmarking

Focus on *total* cost of service (O&M + capital)

Total Cost = f (W, Y, Z)

Cost Drivers:

W Prices of all inputs

Y Scale variables (may be multiple)

Z Other business conditions (aka "Z variables")

Cost Drivers (cont'd)

Granular Benchmarking

e.g., *s*tation OM&A expenses, station capex

Included Cost = f ($W^{included}$, Y, Z, X)

Cost Drivers:

$W^{included}$	Prices of *included* inputs
Y	Scale variables
Z	Other business conditions
$X^{excluded}$	Quantities and attributes of *excluded* inputs
	e.g., Substation O&M depends on substation capacity and age

Benchmarking Basics (*cont'd*)

Capital Cost vs. Capex

Capital cost = return on rate base + depreciation

Benchmarking requires standardization of capital data using a "monetary" method (e.g., geometric decay) that subjects gross plant additions to a standard depreciation pattern

Accurate calculation of capital cost requires many years of historical gross plant addition data no matter which benchmarking method is used

Many jurisdictions don't have the capital cost data available in the U.S. and Ontario for these calculations

Capital Cost vs. Capex (cont'd)

Capital *expenditures* ("capex", aka *gross plant additions*) can also be benchmarked

Key issue in rebasing applications

Capex benchmarking doesn't require numerous years of historical data

>>> Capex is focus of benchmarking in Australia, Britain, and continental Europe

Driven by system age and capacity utilization in addition to general operating scale

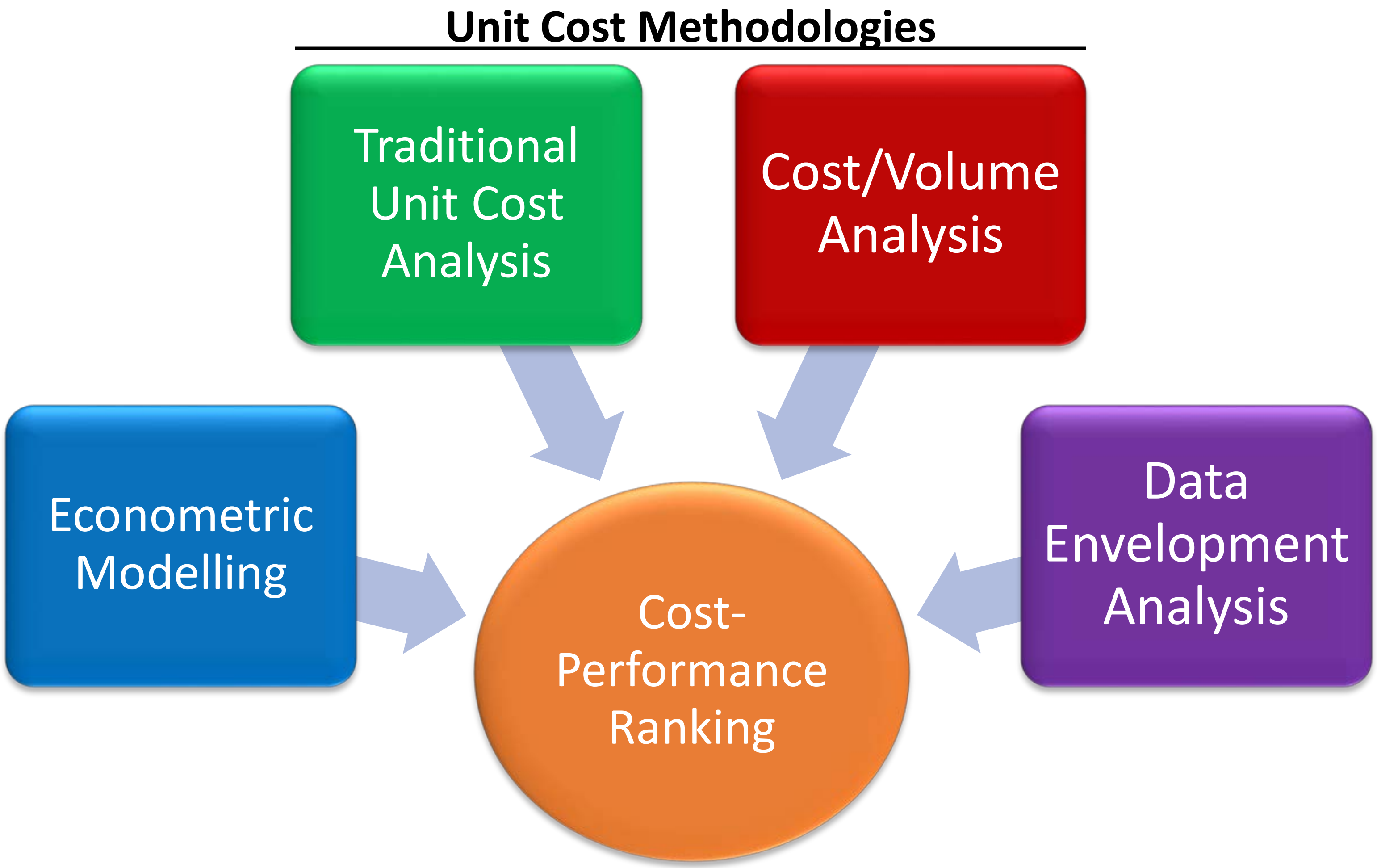
Capex = f(W, Y, Z)

W Construction cost index

Y General operating scale

Z Other cost drivers include system age and capacity utilization

Statistical Benchmarking Methods



Benchmarking Methods

Several well-established approaches to statistical cost benchmarking

Econometric Modelling

Unit Cost Methodologies

- Traditional Unit Cost Analysis
- Cost/Volume Analysis

Each method can be used…

- for total cost or granular benchmarking
- with alternative performance standards

Econometric Cost Modelling

Basic Idea

Formulate cost model

$$Cost = \beta_0 + \beta_1 \, Input\ Price + \beta_2 \, Customers + \beta_3 \, System\ Age + Error\ Term$$

Price, Customers, etc.	cost driver variables
β_0, β_1, β_2, β_3	model parameters

Estimate parameters w/ data on utility operations

Econometric Cost Models

Basic Idea (cont'd)

Econometric benchmark can be calculated using

- Econometric parameter estimates (e.g., b_0, b_1, b_2, b_3)
- Business conditions for subject utility

$$Cost^{Northstar} = b_0 + b_1\,Price_{Labor}{}^{Northstar} + b_2\,Customers^{Northstar} + b_3\,System\ Age^{Northstar}\ldots$$

Historical and forecasted costs can be benchmarked

Econometric Cost Models

Functional Forms

Simple (linear) form:

$$Cost = \beta_0 + \beta_1 Price_{Labor} + \beta_2 Customers$$

When variables are *logged*

$$\ln Cost = \beta_0 + \beta_1 \ln Price_{Labor} + \beta_2 \ln Customers$$

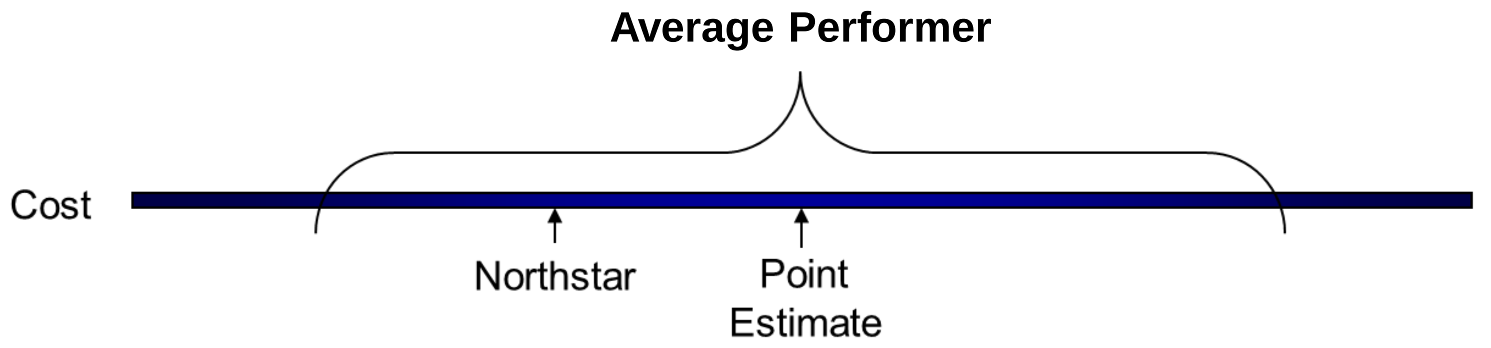
parameters measure cost *elasticities*

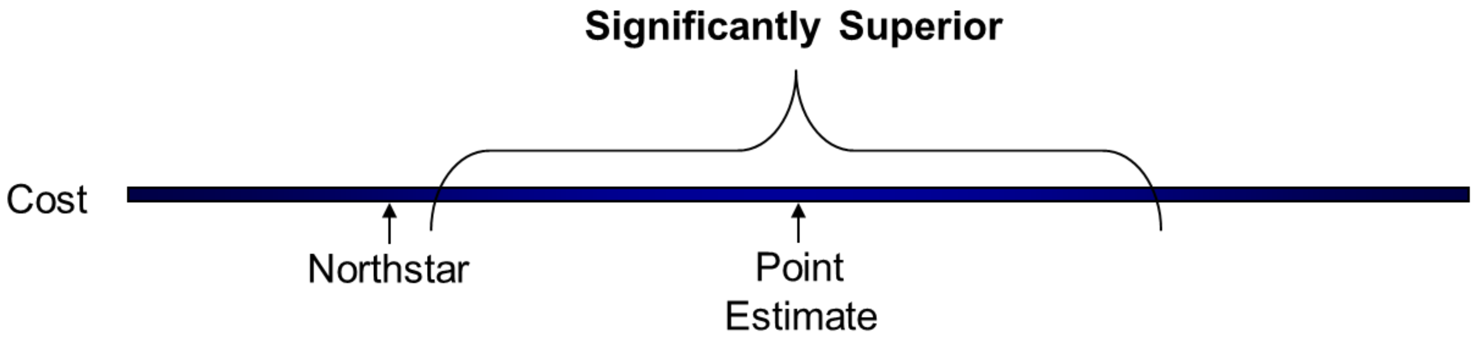
e.g., β_2 = % change cost due to 1% growth customers

Statistical Tests of Efficiency Hypotheses

Confidence interval can be constructed around a cost model's benchmark

If C^{Actual} lies in interval, performance not "significantly" different from benchmark





Econometric Benchmarking (cont'd)

Advantages

Simultaneous consideration of multiple cost drivers

Model specification guided by

- Economic theory
- Statistical significance tests

Each benchmark reflects business conditions facing subject utility

- No need for custom peer groups

Statistical tests of efficiency hypotheses

OEB has much larger data set available than Ofgem, AER, or private vendors (e.g.UMS) for econometric model development

Econometric software readily available, easy to use

Method already used in Ontario

Econometric Benchmarking (*cont'd*)

Disadvantages

Two seemingly reasonable models can produce different scores

>>> Perception by some of "black box" models

Method may lack credibility with utilities, discouraging use in cost management

Knowledge of econometrics needed in producing and interpreting results

Small samples may not support development of sophisticated models

Unit Cost Benchmarking

Benchmarking methods that use unit cost metrics

Unit Cost = Cost/Quantity

>>> Metric controls automatically for differences in operating scale

Performance measured by comparison to peers

$$Performance = Unit\ Cost^{Northstar} / average\ Unit\ Cost^{Peers}$$

Unit Cost Benchmarking (cont'd)

Traditional Unit Cost Analysis

Ratio of cost to a measure of *general operating scale*

Unit Cost = Cost/Scale

Common scale metrics include line miles and customers served

Productivity metrics are "kissing cousins"

Productivity = Output Quantity / Input Quantity

= Input Prices / Unit Cost

>>> Productivity metrics control for differences in output quantities *and input prices*

Unit Cost Benchmarking (cont'd)

Peer Groups

Accurate unit cost analysis sometimes requires custom peer groups

Cost drivers excluded from unit cost metric must be similar to subject utility's

e.g., input prices, forestation, undergrounding, reliability

Econometrics can guide peer group selection if desired

- Are relevant cost drivers excluded from unit cost metric?
- What is their relative importance?

Custom peer groups guided by econometrics used by OEB in IRM3

Unit Cost Benchmarking (cont'd)

Scale Metrics

General operating scale is often multi-dimensional

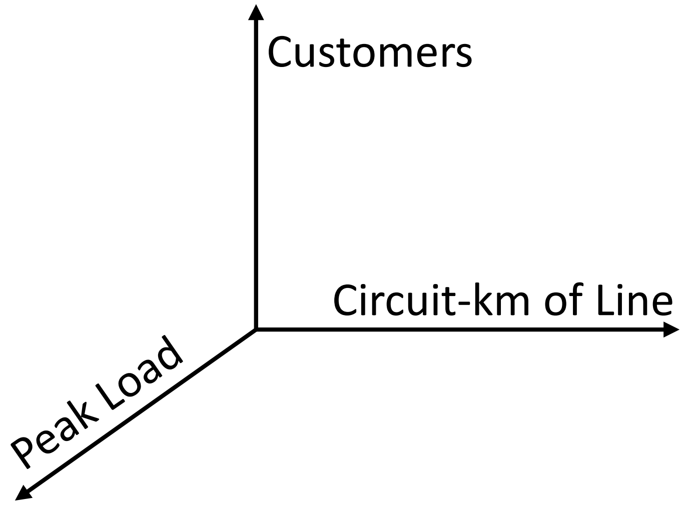
Many unit cost benchmarking studies use simple scale metrics

e.g., Cost / Customer

Unit cost results using different scale variables sometimes differ markedly

Multidimensional scale indexes can be developed

Econometric cost research can help identify scale variables & assign elasticity weights



Unit Cost Benchmarking (cont'd)

Advantages of Traditional Unit Cost Analysis

- Automatically controls for differences in the most important class of cost drivers (scale)
- Computationally easy if scale metrics are simple and custom peer groups aren't needed
- No knowledge of econometrics required
- Used by utilities in some internal benchmarking studies
- More peers available in Ontario than private venders like First Quartile use

Unit Cost Benchmarking (cont'd)

Disadvantages of Traditional Unit Cost Analysis

Doesn't control for other cost drivers

Custom peer groups and/or multidimensional scale indexes sometimes needed for benchmarking accuracy

Private vendors sometimes gather extensive "demographic information" and make normalization adjustments

Custom peer groups may differ for different granular costs

Unit Cost Benchmarking (cont'd)

Cost/Volume Analysis

Some costs can be usefully decomposed into a volume and a cost/volume metric

Cost = Volume of Work x (Cost/Volume)

e.g., pole replacement capex = # poles replaced x (cost/pole replaced)

pole inspection cost = # poles inspected x (cost/pole inspected)

Cost/volume metrics are compared to peer group norms

Custom peer groups sometimes employed

Data may be "normalized" to control for differences in local business conditions

Common applications include capital *expenditures* and vegetation management

Advantages of Cost/Volume Analysis

Cost/volume metrics are worthy of benchmarking

No knowledge of econometrics required

Method used by Australian & British regulators

e.g., average cost/pole used in benchmarking

Method also used in many “internal” utility benchmarking studies

- First Quartile and Navigant Consulting, *Distribution Unit Cost Benchmarking Study Prepared for Hydro One Networks,* 2016
- UMS Group, *Toronto Hydro-Electric System Ltd. Unit Costs Benchmarking Study, 2018*

OEB has asked utilities to file unit cost benchmarking studies

Unit Cost Benchmarking (*cont'd*)

Limitations of Cost/Volume Analysis

Most of the requisite data are not currently gathered in Ontario

Accurate cost/volume analysis sometimes requires detailed data

e.g. UMS substation refurbishment study for Hydro One broke out full station rebuild projects, substation-centric projects, and component-based projects

Australia requests data on 18 different kinds of poles, 15 kinds of service lines, and 40 kinds of transformers

Prudence of cost depends on volumes, not just cost/volume

e.g. # poles replaced

Capex volumes are a key issue in many "custom IR" proceedings

Unit Cost vs. Econometric Benchmarking

Econometric Modelling

- Generally more accurate
- No peer groups or multidimensional scale indexes needed
- Can address capex volumes as well as unit cost
- Currently used in Ontario

Unit Cost

- Easy to understand
- No special training required
- Favored by utilities in internal benchmarking studies
- OEB has experience reviewing these studies

Preliminary Empirical APB Results

Econometric Cost Models

Simple Unit Cost Metrics

Multi-Dimensional
Unit Cost Indexes

Preliminary Empirical APB Research

PEG has done some preliminary benchmarking work using OEB data at various levels of granularity for OM&A expenses

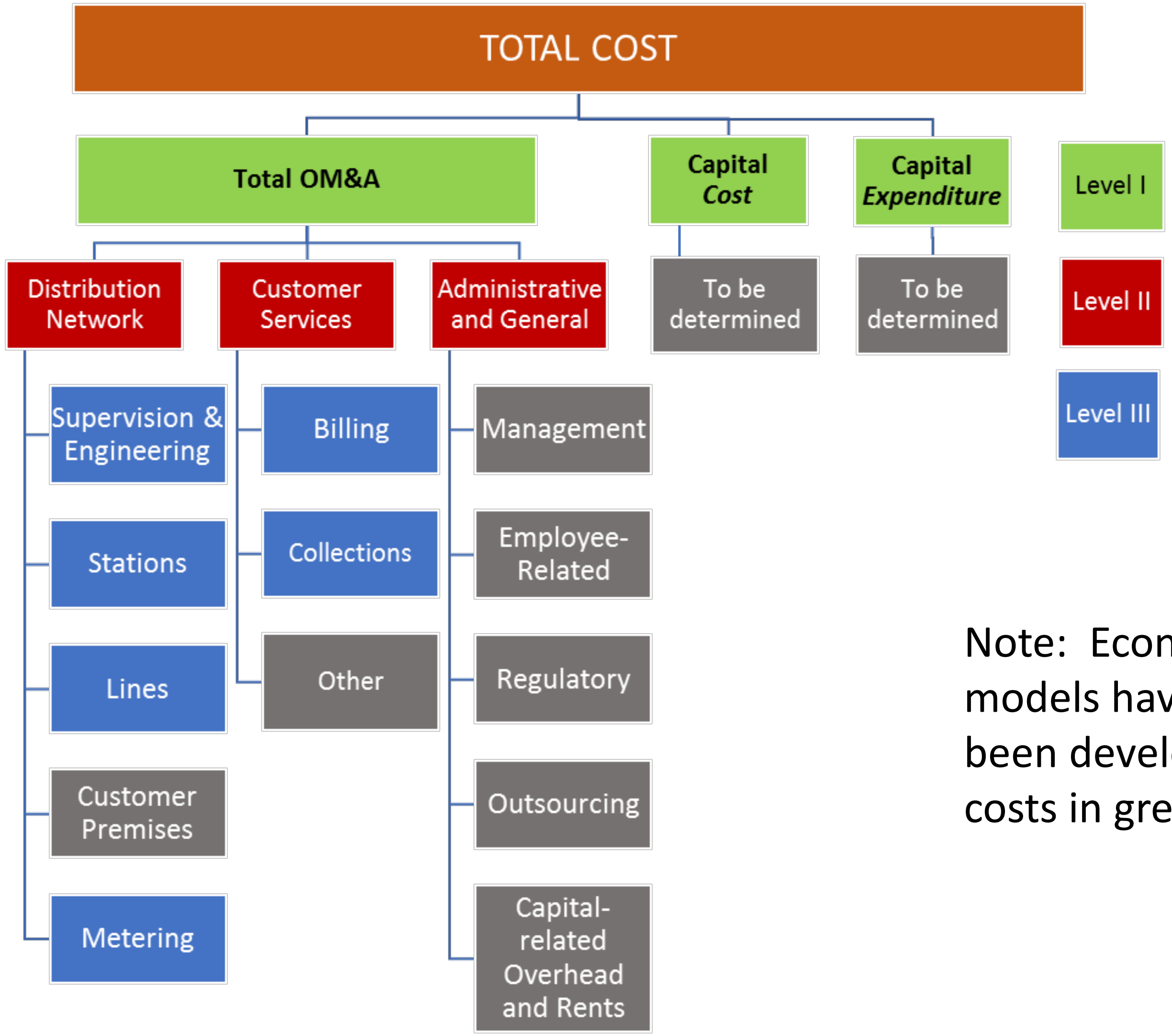
We developed models for

- total OM&A
- major OM&A subcategories reported in rebasings
- more granular OM&A categories

We explored the loss of accuracy at higher levels of OM&A granularity

Preliminary total capital cost and capex models were also developed

Levels of granularity



Note: Econometric models have not been developed for costs in grey boxes.

Comments on Preliminary Econometric Work

We looked at several measures of benchmarking accuracy as granularity increased

- R-squared, an overall measure of how well the model explains cost
- Prevalence of outliers, i.e. extreme evaluations of cost performance. The presence of many extreme outlier harms the credibility of the model.

Accuracy generally fell as granularity increased.

Problem worse with some costs than with others

Econometric models seem helpful in identifying need for custom peer groups and multidimensional scale indexes

Granular Econometric Benchmarking Results

Cost Granularity	R-Squared	Outliers: Number over/under by 40%+	Outliers: Number over/under by 60%+	Outliers: Number over/under by 100%+
Total Capital Cost	0.974	10	4	1
Capital Expenditures	0.915	14	7	3
Total OM&A	0.965	7	4	1
Distribution Network O&M	0.901	18	7	4
Load Dispatching	0.870	40	38	31
Distribution Operation Supervision and Engineering	0.548	31	22	10
Distribution Station Equipment O&M	0.856	13	5	2
Maintenance Poles Towers and Fixtures	0.340	19	11	3
Line O&M	0.800	31	18	6
Vegetation Management	0.571	24	13	7
Metering O&M	0.721	23	10	3
Customer Services	0.943	10	3	0
Collection	0.597	35	25	14
Billing	0.841	17	7	1
Administrative and General	0.880	6	5	1

Level I Granularity

Level II Granularity

Level III Granularity

Pacific Economics Group Research, LLC

Comparing Econometric and Unit Cost Results

Econometric Model: Line O&M

EXPLANATORY VARIABLE	ESTIMATED COEFFICIENT	T-STATISTIC	P Value
Scale Variables:			
Number of customers	0.556	14.262	< 2e-16
Circuit-km of line	0.482	14.381	< 2e-16
Other Business Conditions:			
Percentage change in number of customers over last ten years	-0.617	-2.874	0.004
Percentage of line that is overhead	0.717	12.509	< 2e-16
Time trend	-0.019	-2.711	0.004
Constant	4.233	112.281	< 2e-16

- 0.902 System Rbar-Squared
- 2013-2017 Sample Period
- 325 Observations

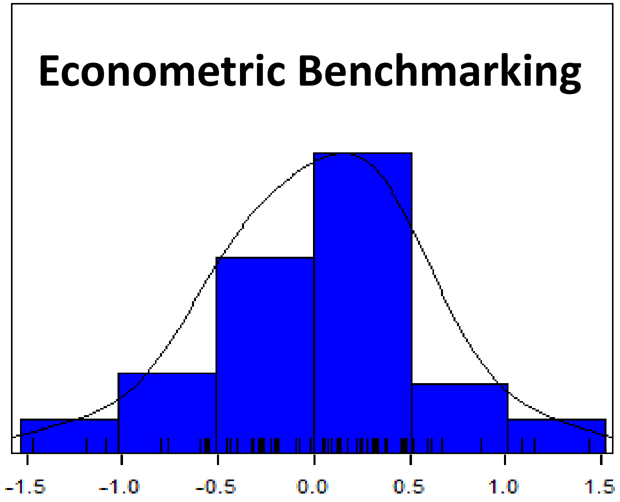
Variable is significant at 95% confidence level

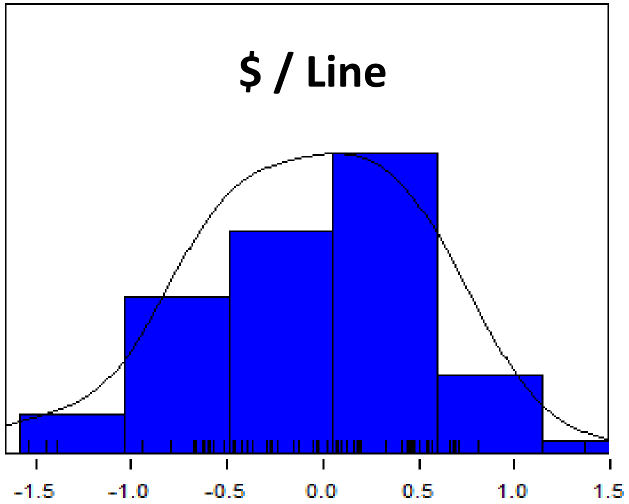
Comparing Results Using 3 Benchmarking Methods: Line O&M Expenses

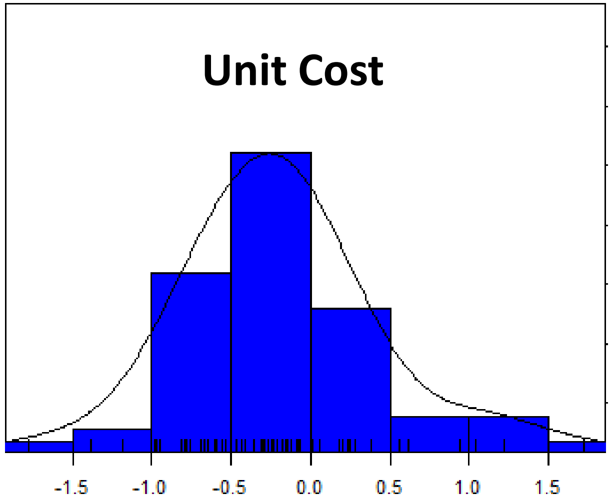
Spearman Rank Correlation Coefficients

	Econometrics	$/Line	Unit Cost
Econometrics	1	0.72	0.76
$/Line	0.72	1	0.70
Unit Cost	0.76	0.70	1

Histogram and Density Plots







Unit Cost as an Analysis Tool

PEG also developed a spreadsheet to demonstrate how unit cost benchmarking might made more accessible to distributors

After selecting a distributor, a summary table is populated with various unit cost metrics:

- Distributor cost for each cost area
- Cost per Customer (or other single measure of scale such as km of line)
- Unit Cost Index (combines multiple scale variables into a single scale index)
- How each of these compare to the average for Ontario LDCs
- A summary measure of performance for easy identification

The following slide gives a partial look for an unnamed distributor

Example: Unit Cost Summary Table

Metric Result	Corresponding Performance
25%+ Below Average	Far Better than Average
0-25% Below Average	Better than Average
0-25% Above Average	High Cost
25%+ Above Average	Very High Cost

			Cost per Customer				Unit Cost Index			
Category	**2016 Cost Level**	**% of Total**	**$/Customer**	**Industry Average**	**Performance***	**Screening Result**	**$/Index**	**Industry Average**	**Performance***	**Screening Result**
Meter Expense (including maintenance)	$1,348,674.74	3.80%	$8.67	$9.93	-13.55%	Better than Average	$12.69	$14.37	-12.49%	Better than Average
Line Operation and Maintenance	$5,328,431.72	15.01%	$34.27	$46.42	-30.35%	Far Better than Average	$46.92	$63.11	-29.65%	Far Better than Average
Maintenance of Poles, Towers and Fixtures	$457,043.89	1.29%	$2.94	$4.83	-49.64%	Far Better than Average		$6.57		
Operation Supervision and Engineering	$1,890,311.92	5.33%	$12.16	$11.26	7.71%	High Cost				
Vegetation Management	$908,822.55	2.56%	$5.84	$15.53	-97.70%	Far Better than Average		$20.85		
Distribution Station Equipment	$735,110.13	2.07%	$4.73	$5.25	-10.43%	Better than Average		$5.25		
Billing Operations	$4,309,297.77	12.14%	$27.71	$56.98	-72.09%	Far Better than Average		$67.60		
General Expenses and Administration	$13,294,116.89	37.46%	$85.49	$116.83	-31.23%	Far Better than Average	$92.93	$126.83	-31.10%	Far Better than Average
Load Dispatching	$1,531,766.01	4.32%	$9.85	$5.05	66.72%	Very High Cost				
Miscellaneous Distribution Expense	$2,560,771.36	7.22%	$16.47	$12.47	27.81%	Very High Cost				
Maintenance Supervision and Engineering	$1,799,061.01	5.07%	$11.57	$4.41	96.51%	Very High Cost				
Other	$5,891,598.38	16.60%	$37.89	$21.93	54.67%	Very High Cost				

Illustrative Results

- The previous slide shows better than average overall distribution network cost performance for this distributor
- It also identifies "other" distribution cost performance as very high.
- It would be reasonable for either management or OEB staff to inquire about the cause of this anomaly.
- Because this "other" category is at odds with the other categories, it may be a sign of insufficient classification of cost. Although the overall cost performance is good, some of the more granular categories look better than expected because not enough cost was explicitly assigned to specific accounts.

Drilling Down into the Data

- It is also possible to “drill down” into more detailed data
- The following slide shows additional detail for station expenses
- Caveat → The ability to drill down into the data does not imply increased accuracy of performance measures. In fact, the more one drills down, the less seriously one should take the comparisons
- Nonetheless, this ability does help in the analysis of the less granular benchmarking results

Unit OM&A Cost Benchmarking

Category	2016 Cost Level	%	Cost per Customer: $/Customer	Industry Average	Performance*	Screening Result
Distribution Station Equipment - Operation Supplies and Expenses	$177,018.14	0.50%	$1.14	$1.36	83.71%	Better than Average
Station Buildings and Fixtures Expense	$407,756.15	1.15%	$2.62	$2.34	112.01%	High Cost
Transformer Station Equipment - Operation Labour	$0.00	0.00%	$0.00	$0.37	0.00%	Better than Average
Transformer Station Equipment - Operation Supplies and Expenses	$0.00	0.00%	$0.00	$0.46	0.00%	Better than Average
Distribution Station Equipment - Operation Labour	$158,372.52	0.45%	$1.02	$1.61	63.20%	Better than Average
Maintenance of Buildings and Fixtures - Distribution Stations	$30,666.72	0.09%	$0.20	$1.22	16.19%	Better than Average
Maintenance of Transformer Station Equipment	$0.00	0.00%	$0.00	$0.52	0.00%	Better than Average
Maintenance of Distribution Station Equipment	$399,719.47	1.13%	$2.57	$2.28	112.96%	High Cost
Station	$1,173,533.00	3.31%	$7.55	$10.16	74.31%	Better than Average
Other Distribution Network	$7,781,910.30	21.93%	$50.05	$33.19	150.80%	Very High Cost
Total: Distribution Network	$16,998,416.20	47.89%	$109.32	$125.09	87.39%	Better than Average

Pacific Economics Group Research, LLC

Additional Benchmarking Data

Research suggests the desirability of gathering some new data for granular benchmarking

These data can either upgrade existing unit cost and econometric research or make such research possible

Useful Data for Granular Cost Benchmarking

Cost Categories ($mm 2016 agg)	Scale Metrics	Other Possible Cost Drivers
Total OM&A Expenses	Customers, Peak Demand, Line Length, Substation Capacity	System Age, Forestation, % Plant Underground, Reliability
Distribution (783)	Customers, Peak Demand, Line Length, Substation Capacity	System Age, Forestation, % Plant Underground, Reliability
Supervision & Engineering (98)	Customers, Peak Demand, Line Length, Substation Capacity	System Age, Forestation, % Plant Underground, Reliability
Station (80)	Customers, Peak Demand, Substation Capacity	System Age, Forestation, % Plant Underground, Reliability
Lines, Line Transformers, and Structures (215)	Customers, Peak Demand, Line Length	System Age, Forestation, % Plant Underground, Reliability
Right of Way (171)	Overhead Line Length	System Age, Forestation, % Plant Underground, Reliability
Customer Premises (58)	Customers	System Age, Forestation, % Plant Underground, Reliability
Metering & Meter Reading (72)	Customers	Meter Types
Other (75)[1]	Customers, Peak Demand, Line Length, Substation Capacity	System Age, Forestation, % Plant Underground, Reliability
Billing and Collecting (264)	Customers	Number of Gas Customers, Unemployment Rate, Number of Languages Spoken, Poverty Rate, Median
Billing (117)[1]	Customers	Number of Gas Customers, Unemployment Rate, Number of Languages Spoken, Poverty Rate, Median
Collecting (79)[1]	Customers	Number of Gas Customers, Unemployment Rate, Number of Languages Spoken, Poverty Rate, Median

Useful Data for Granular Cost Benchmarking (cont'd)

Administrative & General (531)	Customers, Peak Demand, Line Length, Employees, Substation Capacity	Percentage of Assets/Revenues that are Power Distribution, Reliability
Staff (215)	Customers, Peak Demand, Line Length, Employees, Substation Capacity	Forestation, % Plant Underground, Percentage of Assets/Revenues that are Power Distribution, Reliability
Other A&G (316)	Customers, Peak Demand, Line Length, Employees, Substation Capacity	Forestation, % Plant Underground, Percentage of Assets/Revenues that are Power Distribution, Reliability
Total Capital Cost	Substation Capacity, Customers, Peak Demand, Line Length	System Age, % Plant Underground, Reliability
Total Capex (2,160)	Customers, Growth Customers, Peak Demand, Line Length	System Age, % Plant Underground, Reliability
System Access[2]	Customers, Growth Customers, Line Length	% Services Underground, Reliability
System Renewal[2]	Customers, Peak Demand, Line Length	System Age, % Plant Underground, Reliability
System Service[2]	Customers, Peak Demand, Line Length	% Plant Underground, Share of Plant at Full Capacity, Reliability

[1] Supervision and Engineering expenses could be allocated proportionately to the functional categories.

[2] Development of these models would require the collection of new cost data.

Desirable New Data for Benchmarking

System Characteristics

- Non-coincident peak demand of local networks
- MVA of substation capacity
- Share of substation and line capacity approaching full utilization
- Number of line transformers (overhead and pad-mounted)

System Age Variables

- Share of assets near end of service life by asset type
- Asset failures by type of asset
- Asset health index

Detailed Cost and Volume Data for Cost/Volume Analyses

- Vegetation management
- Capex

Desirable New Data for Benchmarking (cont'd)

Other Business Conditions

- Forestation variables
  - Number of vegetation management spans
  - Share of overhead line spans in forested areas
- Line length with standard vehicle access
- Prevalence of pole footing conditions (e.g., soil, rock, or swamp, lacustrine)
- Number of bills processed
- Number of billing-related calls
- Number of customer service and informational calls

OEB Staff's Preliminary Granular Cost Nominations

Introduction

OEB Staff has identified several activities/programs worthy of consideration for benchmarking

We will discuss the current feasibility of benchmarking these costs, required additional data, and solicit comments

This is an opportunity to comment on what we have identified and help us investigate other relevant drivers of cost

Staff's Preliminary List of Activities/Programs

OM&A	Capital
Vegetation management	Line renewal/conversion (U/G and O/H)
Billing	Poles, Towers and Fixtures
Meter Expense	Transformers (including line transformers)
Line operation and maintenance	Distribution station equipment
Operation Supervision and Engineering	Meters
Distribution Station Equipment	Computer hardware
Bad Debt	New services
Collection	System Supervisory Equipment - SCADA
Maintenance Poles, Towers and Fixtures	
Computer software	
System Control/Control Centre Operations	
General Expenses & Administration	

Econometric Model: Distribution Station Equipment O&M

EXPLANATORY VARIABLE	ESTIMATED COEFFICIENT	T-STATISTIC	P Value
Scale Variables:			
Number of customers	0.082	6.968	0.000
Number of substations <= 50kV	1.270	54.701	< 2e-16
Number of substations > 50kV	0.019	9.760	< 2e-16
Business Conditions:			
Percentage change in number of customers over last ten years	-0.227	-2.839	0.005
Time trend	-0.007	-1.938	0.053
Constant	0.259	6.855	0.000

- 0.856 System Rbar-Squared
- 2013-2017 Sample Period
- 315 Observations

Variable is significant at 90% confidence level

Distribution Station O&M

Existing Data

- Accounts 5016, 5017, and 5114: Distribution Station O&M
- Number of customers
- Number of distribution substations
- Area of service territory, km of line

Desirable new data and feedback

- Substation capacity (collection suspended in 2015)
- Forestation
- Reliability
- Substation age
- Does the distributor outsource substation maintenance (e.g., HON does maintenance on jointly owned stations)?

Comments?

Econometric Model: Metering O&M

EXPLANATORY VARIABLE	ESTIMATED COEFFICIENT	T-STATISTIC	P Value
Scale Variables:			
Number of customers	0.360	33.546	< 2e-16
Circuit-km of line	0.158	16.215	< 2e-16
Time trend	-0.013	-3.267	0.001
Constant	1.846	87.157	< 2e-16

- 0.718 System Rbar-Squared
- 2013-2017 Sample Period
- 320 Observations

Variable is significant at 90% confidence level

Pacific Economics Group Research, LLC

Metering O&M

Existing Data

- Accounts 5065 and 5175: Meter O&M expenses
- Number of customers
- Line length, size of service territory
- Net metering customers
- Metering capacity
- Number of reconnections

Desirable new data and feedback

- Number and types of meters
- Are there issues with cost classification between metering and billing?
- Overview of how smart meters are read. Drive by or fully automatic?

Comments?

Econometric Model: Billing

EXPLANATORY VARIABLE	ESTIMATED COEFFICIENT	T-STATISTIC	P Value
Scale Variables:			
Number of customers	0.370	24.134	< 2e-16
Circuit-km of line	0.057	4.215	0.000
Business Conditions:			
Change in number of customers over the sample period	0.448	13.379	< 2e-16
Time trend	-0.001	-0.192	0.848
Constant	2.303	86.745	< 2e-16

- 0.841 System Rbar-Squared
- 2013-2017 Sample Period
- 320 Observations

Variable is significant at the 90% confidence level

Billing O&M

Existing Data

- Number of customers
- Account 5315: customer billing expenses
- Number of reconnections, Number disconnected, Number low income
- Billing Frequency,
- Net metering customers

Desirable new data and feedback

- Are billing operations outsourced
- Are some rates harder to bill than others?
- What other major billing challenges do distributors face?
- What is the impact of smart meters on the collection of billing data?

Comments?

Econometric Model: Administrative and General Expenses

EXPLANATORY VARIABLE	ESTIMATED COEFFICIENT	T-STATISTIC	P Value
Scale Variables:			
Number of customers	0.611	19.666	0.000
Ratcheted peak demand since 2002	0.271	8.692	0.000
Business Conditions:			
Percentage of line that is overhead	0.228	7.160	0.000
Time trend	0.010	2.291	0.023
Constant	4.328	215.265	0.000

- 0.88 System Rbar-Squared
- 2013-2017 Sample Period
- 325 Observations

Variable is significant at 95% confidence level

Administrative and General Expenses O&M

Existing Data

- Accounts 5605-5695
- Number of customers
- Line Length
- Peak Demand
- Number of substations
- Number of employees

Desirable new data and feedback

- Supervision and engineering accounting issues

Comments?

Appendix

Calculating Multidimensional Scale Indexes

e.g., Power Distribution O&M Expenses (Ontario data)

	Estimated Cost Elasticity	Elasticity Share
Customers	0.491	0.52
Deliveries	0.366	0.38
Line Miles	0.094	0.10
Total	0.951	1.00

$\text{Unit Cost}^{Northstar} / \text{Unit Cost}^{Peers}$

$= (\text{Cost}^{Northstar} / \text{Output}^{Northstar}) / (\text{Cost}^{Northstar} / \text{OutputCost}^{Peers}) /$

$= (\text{Cost}^{Northstar} / \text{Cost}^{Peers}) /$

$[0.52(\text{Customers}^{Northstar} / \text{Customers}^{Peers}) +$

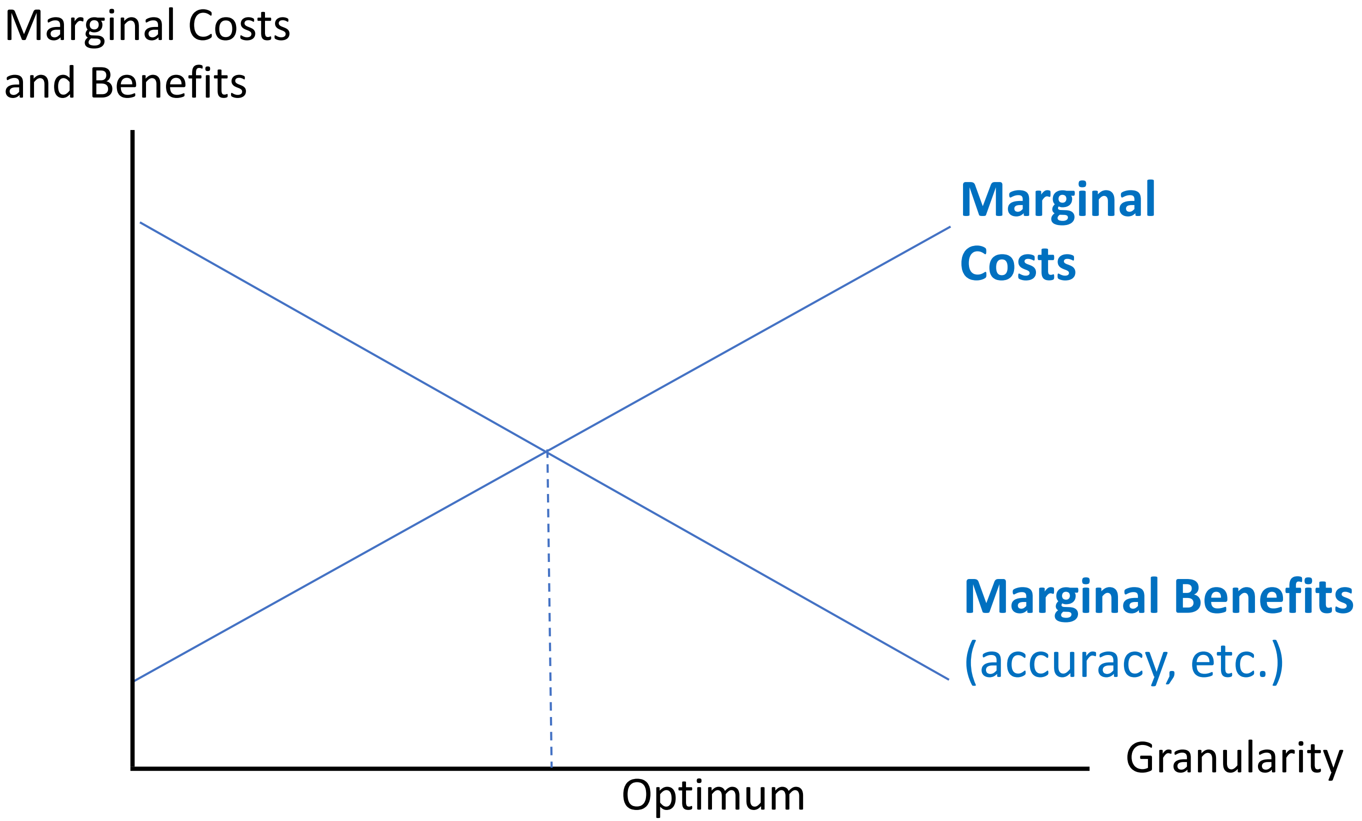
$0.38(\text{Volumes}^{Northstar} / \text{Volumes}^{Peers}) +$

$0.10(\text{Miles}^{Northstar} / \text{Miles}^{Peers})]$

Pacific Economics Group Research, LLC

Optimal Granularity of Benchmarking

Research illustrates tradeoff between benefits and costs of granular benchmarking



Pacific Economics Group Research, LLC