Index Research for Ontario Gas IRMs

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Introduction

The OEB is developing incentive regulation plans for gas utilities

- Enbridge Gas Distribution
- NRG
- Union Gas

Rate escalation mechanisms will be based on input price & productivity research

PEG will take lead on indexing work

This presentation describes work plan

Plan of Presentation

Introduction to X Factor Design

Calculating the Input Price Differential

Calculating the Productivity Differential

Choosing a Stretch Factor

Introduction to X Factor Design

In North America, design of price cap indexes commonly based on price & productivity research

If GDP-IPI is the price cap index inflation measure, X factor commonly has 3 terms

- Input Price Differential
  = trend Input Prices^{Economy} – trend Input Prices^{Industry}
- Productivity Differential
  = trend TFP^{Industry} – trend TFP^{Economy}
- Stretch Factor

Introduction to X Factor Design (*cont'd*)

Divisia index logic (see Appendix) is rationale for differentials

GDP-IPI is an *output* price index for Canada's economy (*i.e.* analogous to a power distribution *rate* index)

Thus, it reflects input price & productivity trends of economy

X calibration warranted only if input price & productivity trends of economy differ from the gas utility industry's

Introduction to X Factor Design (*cont'd*)

Input price and productivity trends of the economy and the gas utility industry can differ, for several reasons

Industry is much more capital intensive than economy

- Fewer opportunities for labour-saving technical progress
- Characteristically brisk growth in labour compensation has less impact

Demand growth in industry may be unusually brisk or slow

Calculating the Input Price Differential

Introduction

Goal is to compute the input price differential (IPD)

$$IPD = \text{trend Input Prices}^{\text{Canadian Economy}} - \text{trend Input Prices}^{\text{Ontario Gas Utilities}}$$

Three basic steps:

1. Compute trend Input Prices$^{\text{Canadian Economy}}$
2. Compute trend Input Prices$^{\text{Ontario Gas Utilities}}$
3. Compare the trends

Step 1 - Measuring Economy's Input Price Growth

GDPIPI, as an *output* price index, doesn't measure economy's *input* price inflation

Index logic helps us to deduce input price trend simply

If

trend *Output* Prices^{Economy}
= trend *Input* Prices^{Economy} – trend TFP^{Economy}

then

trend *Input* Prices^{Economy}
= trend *Output* Prices^{Economy} + trend TFP^{Economy}
= trend GDPIPI + trend TFP^{Economy}

STEP 2: Measuring Input Price Trend of Ontario Utilities

Trend Input Prices
= weighted average of trends in input price *subindexes*
(*e.g.* capital, labour, materials & services)

Weights: Utility (total) *cost* shares

Tornqvist functional form:

$$\ln (W_t/W_{t-1}) = \text{Sum}_j \ (1/2) \ (sc_{j,t} + sc_{j,t}) \ \ln(W_{j,t}/W_{j,t-1})$$

W_t = summary input price index
$W_{j,t}$ = input price *sub*index for input j
$sc_{j,t}$ = cost share of input j

Utility Cost Data

Utility cost data used to calculate cost shares

Labour OM&A salaries & wages
OM&A pension and other benefit expenses

Materials & Services Non-gas OM&A expenses
- OM&A labour expenses

Capital Standardized calculations based heavily on plant additions data are preferred due to inconsistencies in plant vintage and depreciation reporting

Utility Cost Data (cont'd)

Capital Key issues in capital cost specification:

- Asset valuation: replacement or book?
- Depreciation: straight line or geometric decay?

Capital cost must decompose into consistent price & quantity indexes

Capital Cost = Capital Price Index
x Capital Quantity Index

Capital quantity index measures trend in the real [inflation adjusted] value of utility plant

Input Price Subindexes

Input price subindexes (mostly) drawn from Stats Canada data

Labour:

- Average weekly earnings, Ontario workers
- Alternative: Cost/Employee, Ontario LDCs

Materials & Services:

- GDP-IPI
- Alternative: Industrial Producer Price Indexes

Capital: Capital price index

Table 1

CAPITAL SERVICE PRICE INDEX CALCULATIONS[0]

	Rate of Return						Capital Gains			Real Rate	Depreciation	Real RoR Smoothing	Capital Service Price Indexes			
Year	Long Bond		ROE for all Canadian Companies		Weighted Average Cost of Capital		Construction Cost		Capital Gain (%)	of Return	Rate	Real RoR (Smoothed)	Unsmoothed	Unsmoothed Growth Rate	Real Rate Smoothed	Smoothed Growth Rate
	Yield[1]	Growth Rate	Calculation[2]	Growth Rate	Calculation	Growth Rate	Index[3]	Growth Rate								
	[A]		[B]		[C] = ([A]+[B])/2		[D]		[E]	[F]=[C]-[E]	[G]	[H]=3 Year MA of [F]	[K]=[F]x[D(-1)]+[G]x[D]		[L]=[D]*[G]+[D(-1)]*[H]	
1988	10.22%		12.70%		11.46%		91.9	5.9%	6.1%	5.3%	3.18%		7.55			
1989	9.92%	-3.0%	11.51%	-9.8%	10.71%	-6.7%	95.5	3.8%	3.9%	6.8%	3.18%		9.28	20.7%		
1990	10.85%	9.0%	7.59%	-41.6%	9.22%	-15.0%	98.5	3.1%	3.1%	6.1%	3.18%	6.1%	8.94	-3.8%	8.93	
1991	9.76%	-10.6%	3.87%	-67.5%	6.81%	-30.3%	97.7	-0.8%	-0.8%	7.6%	3.18%	6.8%	10.62	17.2%	9.09	1.7%
1992	8.77%	-10.7%	1.68%	-83.2%	5.23%	-26.5%	100.0	2.3%	2.4%	2.9%	3.18%	5.5%	5.99	-57.3%	9.86	8.1%
1993	7.85%	-11.1%	3.82%	81.9%	5.83%	11.0%	102.5	2.5%	2.5%	3.3%	3.18%	4.6%	6.59	9.7%	8.79	-11.5%
1994	8.63%	9.5%	6.69%	56.2%	7.66%	27.3%	108.2	5.4%	5.6%	2.1%	3.18%	2.8%	5.59	-16.4%	8.17	-7.3%
1995	8.28%	-4.1%	9.78%	37.9%	9.03%	16.4%	116.7	7.6%	7.9%	1.2%	3.18%	2.2%	4.98	-11.6%	6.71	-19.7%
1996	7.50%	-9.9%	10.35%	5.7%	8.92%	-1.2%	116.6	-0.1%	-0.1%	9.0%	3.18%	4.1%	14.22	104.9%	6.28	-6.6%
1997	6.42%	-15.5%	10.94%	5.6%	8.68%	-2.8%	118.0	1.2%	1.2%	7.5%	3.18%	5.9%	12.48	-13.1%	8.53	30.6%
1998	5.47%	-16.0%	8.77%	-22.1%	7.12%	-19.8%	122.8	4.0%	4.1%	3.1%	3.18%	6.5%	7.51	-50.8%	11.59	30.7%
1999	5.69%	3.9%	9.93%	12.4%	7.81%	9.3%	126.1	2.7%	2.7%	5.1%	3.18%	5.2%	10.30	31.7%	10.42	-10.7%
2000	5.89%	3.5%	10.94%	9.7%	8.42%	7.5%	128.7	2.0%	2.1%	6.4%	3.18%	4.8%	12.11	16.1%	10.20	-2.1%
2001	5.78%	-1.9%	7.44%	-38.6%	6.61%	-24.2%	129.6	0.7%	0.7%	5.9%	3.18%	5.8%	11.73	-3.2%	11.58	12.7%
2002	5.66%	-2.1%	5.70%	-26.5%	5.68%	-15.1%	130.5	0.7%	0.7%	5.0%	3.18%	5.8%	10.61	-10.0%	11.60	0.2%
2003	5.28%	-6.9%	9.64%	52.5%	7.46%	27.3%	130.6	0.1%	0.1%	7.4%	3.18%	6.1%	13.79	26.2%	12.11	4.2%
2004	5.08%	-3.9%	11.40%	16.7%	8.24%	9.9%	131.1	0.4%	0.4%	7.9%	3.18%	6.7%	14.43	4.5%	12.98	6.9%
Average Annual Growth Rate																
1994-2004		**-5.3%**		**5.3%**		**0.7%**		**1.9%**				**8.9%**		**9.5%**		**4.6%**
1990-2004		**-5.4%**		**2.9%**		**-0.8%**		**2.0%**				**0.7%**		**3.4%**		**2.7%**

All growth rates are logarithmic

[0]Assumes replacement valuation of assets and geometric decay

[1]Source: Statistics Canada, Average Yields for 30-Year Bonds, Government of Canada

[2]Source: Statistics Canada, Tables 187-0001, 187-0002: Return on Equity: Canadian Companies, All Industries

[3]Source: Statistics Canada, Electric Distribution Utility Construction Cost Index

Table 2

Gas Distribution Industry IPI

	Capital (Unsmoothed)			Labor			Materials and Services			IPI - Ontario Gas Utilities	
Year	Index[1]	Growth Rate	Weight[o]	Index[2]	Growth Rate	Weight[o]	Index[3]	Growth Rate	Weight[o]	Level	Growth Rate
1990	8.9		59.0%	*542.52*		20.0%	88.5		21.0%	1.000	
1991	10.6	17.2%	59.0%	576.13	6.0%	20.0%	91.5	3.3%	21.0%	1.128	12.1%
1992	6.0	-57.3%	59.0%	598.80	3.9%	20.0%	93.0	1.6%	21.0%	0.814	-32.7%
1993	6.6	9.7%	59.0%	612.33	2.2%	20.0%	94.9	2.0%	21.0%	0.869	6.6%
1994	5.6	-16.4%	59.0%	628.16	2.6%	20.0%	96.3	1.5%	21.0%	0.795	-8.9%
1995	5.0	-11.6%	59.0%	634.17	1.0%	20.0%	97.4	1.1%	21.0%	0.745	-6.4%
1996	14.2	104.9%	59.0%	649.55	2.4%	20.0%	98.5	1.1%	21.0%	1.394	62.6%
1997	12.5	-13.1%	59.0%	663.73	2.2%	20.0%	100.0	1.5%	21.0%	1.300	-7.0%
1998	7.5	-50.8%	59.0%	672.67	1.3%	20.0%	101.3	1.3%	21.0%	0.969	-29.4%
1999	10.3	31.7%	59.0%	683.70	1.6%	20.0%	102.6	1.3%	21.0%	1.175	19.3%
2000	12.1	16.1%	59.0%	700.12	2.4%	20.0%	105.0	2.3%	21.0%	1.305	10.5%
2001	11.7	-3.2%	59.0%	712.88	1.8%	20.0%	106.8	1.7%	21.0%	1.290	-1.2%
2002	10.6	-10.0%	59.0%	726.21	1.9%	20.0%	109.3	2.3%	21.0%	1.226	-5.0%
2003	13.8	26.2%	59.0%	734.78	1.2%	20.0%	110.8	1.4%	21.0%	1.439	16.0%
2004	14.4	4.5%	59.0%	748.10	1.8%	20.0%	112.5	1.5%	21.0%	1.488	3.3%
Average Annual Growth Rate											
1994-2004		**9.5%**			**1.7%**			**1.6%**			**6.3%**
1990-2004		**3.4%**			**2.3%**			**1.7%**			**2.8%**

[o]Source: Cost shares based on recent PEG research on cost trends of U.S. gas LDCs, as reported in testimony for Sempra Energy to the California Public Utilities Commission (Docket U904-G)

[1]Source: PEG calculation. See Table 1 for details

[2]Source: Statistics Canada; Average Weekly Earnings, Total Economy of Ontario

[3]Source: Statistics Canada; GDPPI, Final Domestic Demand

Table 3

Gas Distribution Industry IPI

	Capital (Real Rate Smoothed)			Labor			Materials and Services			IPI - Ontario Gas Utilities	
Year	Index[o]	Growth Rate	Weight[1]	Index[2]	Growth Rate	Weight[o]	Index[3]	Growth Rate	Weight[o]	Level	Growth Rate
1990	8.9		59.0%	*542.52*		20.0%	88.5		21.0%	1.000	
1991	9.1	1.7%	59.0%	576.13	6.0%	20.0%	91.5	3.3%	21.0%	1.030	2.9%
1992	9.9	8.1%	59.0%	598.80	3.9%	20.0%	93.0	1.6%	21.0%	1.092	5.9%
1993	8.8	-11.5%	59.0%	612.33	2.2%	20.0%	94.9	2.0%	21.0%	1.030	-5.9%
1994	8.2	-7.3%	59.0%	628.16	2.6%	20.0%	96.3	1.5%	21.0%	0.994	-3.5%
1995	6.7	-19.7%	59.0%	634.17	1.0%	20.0%	97.4	1.1%	21.0%	0.889	-11.2%
1996	6.3	-6.6%	59.0%	649.55	2.4%	20.0%	98.5	1.1%	21.0%	0.861	-3.2%
1997	8.5	30.6%	59.0%	663.73	2.2%	20.0%	100.0	1.5%	21.0%	1.039	18.8%
1998	11.6	30.7%	59.0%	672.67	1.3%	20.0%	101.3	1.3%	21.0%	1.253	18.7%
1999	10.4	-10.7%	59.0%	683.70	1.6%	20.0%	102.6	1.3%	21.0%	1.183	-5.7%
2000	10.2	-2.1%	59.0%	700.12	2.4%	20.0%	105.0	2.3%	21.0%	1.180	-0.3%
2001	11.6	12.7%	59.0%	712.88	1.8%	20.0%	106.8	1.7%	21.0%	1.281	8.2%
2002	11.6	0.2%	59.0%	726.21	1.9%	20.0%	109.3	2.3%	21.0%	1.293	1.0%
2003	12.1	4.2%	59.0%	734.78	1.2%	20.0%	110.8	1.4%	21.0%	1.333	3.0%
2004	13.0	6.9%	59.0%	748.10	1.8%	20.0%	112.5	1.5%	21.0%	1.398	4.8%
Average Annual Growth Rate											
1994-2004		**4.6%**			**1.7%**			**1.6%**			**3.4%**
1990-2004		**2.7%**			**2.3%**			**1.7%**			**2.4%**

[o]Source: Cost shares based on recent PEG research on cost trends of U.S. gas LDCs, as reported in testimony for Sempra Energy to the California Public Utilities Commission (Docket U904-G)

[1]Source: PEG calculation. See Table 1 for details.

[2]Source: Statistics Canada, Average Weekly Earnings, Total Economy of Ontario

[3]Source: Statistics Canada, GDPPI, Final Domestic Demand

STEP 3 - Comparing the Input Price Trends

Issues are encountered in drawing conclusions about input price differential from index data

Sample Period

- Same for both input price indexes?
- Same as that used to compute productivity differential?
- Longest possible with available data?
- Chosen to capture long-term trends?

Statistical tests are sometimes used to test input price differential hypotheses

Table 4

INPUT PRICE DIFFERENTIALS

IPI for the Canadian Economy					IPI for Gas Distribution (Growth Rate)		Input Price Differential (Economy - Industry)	
GDP-PI[1]		MFP[2]		Implied IPI	Not	Real Rate	Not	Real Rate
Level	Growth Rate	Level	Growth Rate	Growth Rate	Smoothed[3]	Smoothed[4]	Smoothed	Smoothed
	[A]		[B]	[C]=[A]+[B]	[D]	[E]	[C]-[D]	[C]-[E]
88.4		97.7						
91.4	3.3%	95.0	-2.8%	0.5%	12.1%	2.9%	-11.5%	-2.4%
93.0	1.7%	95.9	0.9%	2.7%	-32.7%	5.9%	35.4%	-3.2%
94.9	2.0%	96.3	0.4%	2.4%	6.6%	-5.9%	-4.1%	8.4%
96.3	1.5%	99.0	2.8%	4.2%	-8.9%	-3.5%	13.1%	7.7%
97.4	1.1%	99.5	0.5%	1.6%	-6.4%	-11.2%	8.1%	12.8%
98.5	1.1%	98.7	-0.8%	0.3%	62.6%	-3.2%	-62.3%	3.5%
100.0	1.5%	100.0	1.3%	2.8%	-7.0%	18.8%	9.8%	-16.0%
101.3	1.3%	101.1	1.1%	2.4%	-29.4%	18.7%	31.8%	-16.3%
102.6	1.3%	103.5	2.3%	3.6%	19.3%	-5.7%	-15.6%	9.3%
105.0	2.3%	106.1	2.5%	4.8%	10.5%	-0.3%	-5.7%	5.1%
106.8	1.7%	106.7	0.6%	2.3%	-1.2%	8.2%	3.4%	-5.9%
109.3	2.3%	108.9	2.0%	4.4%	-5.0%	1.0%	9.4%	3.4%
110.8	1.4%	109.0	0.1%	1.5%	16.0%	3.0%	-14.5%	-1.6%
112.7	1.7%	109.5	0.5%	2.2%	3.3%	4.8%	-1.2%	-2.6%
.994-2004	**1.57%**		**1.01%**	**2.58%**	**6.27%**	**3.41%**	**-3.69%**	**-0.83%**
.990-2004	**1.73%**		**0.81%**	**2.55%**	**2.84%**	**2.39%**	**-0.29%**	**0.16%**

tatistics Canada; GDP-PI

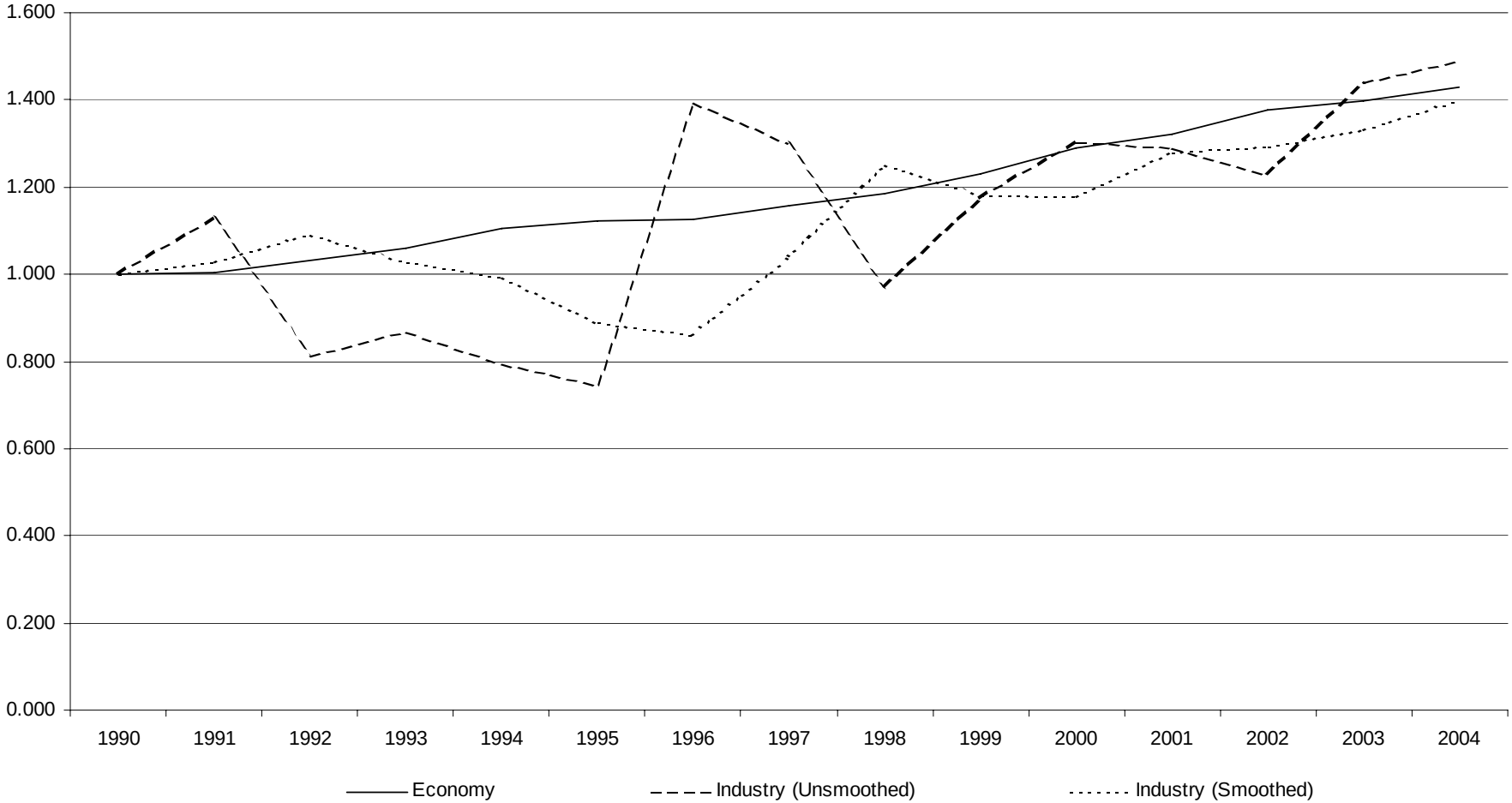
tatistics Canada; Table 383-0016: Multifactor productivity of aggregate business sector

ee Table 2 for details

ee Table 3 for details

Figure 1

IPI FOR ONTARIO LDCs AND CANADIAN ECONOMY



Productivity Differential

Introduction

Total Factor Productivity (TFP) trend of utility industry may differs from that of the economy due *e.g.* to industry's capital intensiveness

Need productivity differential (PD) to close this gap

$$PD = \text{trend } TFP^{\text{Industry}} - \text{trend } TFP^{\text{Canadian Economy}}$$

Two basic steps:

1. Compute trend $TFP^{\text{Gas Utilities}}$
2. Compare to trend in $TFP^{\text{Canadian Economy}}$

STEP 1 - Calculating Productivity Trend of Industry

TFP Basics

The TFP growth of each utility in the sample is measured using the formula

growth TFP = growth Output Quantities - growth Input Quantities

Productivity trends of regional (*e.g.* Ontario) aggregates are cost-weighted averages of trends for individual utilities

>>> TFP research requires development of output and input quantity indexes for individual utilities

Input Quantity Indexes

Input Quantity indexes can be calculated directly or indirectly

Trend Input Quantities
= weighted average of trends in input quantity *subindexes*
(*e.g.* capital, labour, materials & services)
= trend Total Cost – trend Input Price Index

We will use the *indirect* method that involves Input Price Index

IPI constructed from

- *Cost* shares of the utilities
- Input price subindexes (mostly) from government sources

IPI form: Tornqvist

Output Quantity Indexes

Output quantity indexes constructed from data on utility output trends

Trend Output Quantities
= weighted average of trends in output quantity *subindexes*
(*e.g.* customers, delivery volumes)

Output quantity data obtained from utilities

Output Quantity Indexes (cont'd)

Weights: *cost elasticity* shares based on econometric (total) cost research using U.S. (and perhaps also Ontario) cost & output data

Cost elasticity = % change cost due to % change output

Index form:

$$\ln (Y_t/Y_{t-1}) = \text{Sum}_i \; se_i \; \ln(Y_{i,t}/Y_{i,t-1})$$

Y_t = summary output quantity index
$Y_{i,t}$ = output quantity *sub*index for output i
se_i = cost elasticity share of output subindex i

Sampled Companies

Project will consider TFP trends of 40+ gas utilities

- 2-3 Ontario utilities
- 39 U.S. utilities in PEG sample

Rationale

Regional or national data customarily used in X factor calibration

- Stronger performance incentives
- Less TFP volatility

Reliance on U.S. data will be even more important in *2nd generation* IRMs due to incentive issue

How to Use U.S. Research Results

U.S. TFP trends can be used in several ways to calibrate X

1. "Reality check" for Ontario results

   e.g. if Ontario and U.S. trends are similar, use Ontario trends

2. Combine results for Ontario & U.S. utilities to calculate TFP trend of *North American* aggregate

3. Combine results for Ontario & selected U.S. utilities to calculate TFP trend of *peer groups* selected on basis of similar productivity drivers (*e.g.* output growth and average use trends)

Sample Period

TFP is volatile from year to year

Want to capture *recent long-run* productivity trends

U.S. utilities in PEG sample: 10+ years ending in *2004*

Ontario utilities: Hopefully, 10+ years ending in *2005*

Update of U.S. sample to 2005 is possible but may not be cost-effective

STEP 2: Compare to TFP Trend of Economy

TFP Trends of North American Economies

Federal governments of U.S. & Canada report "MFP" trends for private business sector

"MFP" considers productivity of labour and capital but not of intermediate inputs

Best available approximation of TFP

Source	*Activity*	*Estimated Trend*
BLS	U.S. economy	1.3%
Stats Canada	Canadian economy	1.1%

Measuring Long Run Productivity Trends

Two ways to measure long run TFP trend

Traditional PEG Method

Choose sample period of 10+ years that best reflects recent long run TFP trend

e.g. Minimal shift in short run demand drivers like weather

Econometric Estimate of TFP Trend

Using TFP indexes, estimate parameters of

$$\ln TFP_t = a_0 + a_1 T_t$$

Average Use Adjustment

Financial impact of trends in average use will be handled by separate fixed factor

$$\text{Average Use Factor} = \text{trend } Y_t^R - \text{trend } Y_t^E$$

Y_t^R = *Revenue* weighted output quantity index
Y_t^E = *Cost elasticity* weighted output quantity index

Need detailed volume data (*e.g.* $\mathbf{V}^{\text{residential}}$, $\mathbf{V}^{\text{commercial}}$, V^{other}) to compute

Factor will be negative (lowering X, as we expect) if *cost* impact of output trends exceeds *revenue* impact

Choosing a Stretch Factor

Stretch factors commonly added to X factors to ensure that customers share IR benefits

Basis:

- Industry average stretch = 0.49
- PEG's incentive power research suggests 1% + productivity acceleration for typical utility if regulatory lag moves from 1 to 6 years

Appendix

Divisia Index Logic

In an industry where

trend Revenue = trend Cost

since, additionally, there exist Divisia indexes such that

trend Revenue = trend Output Prices + trend Output Quantities
trend Cost = trend Input Prices + trend Input Quantities

it follows that

trend Output Prices
= trend Cost – trend Output Quantities
= trend Input Prices
- (trend Output Quantities – trend Input Quantities)
= trend Input Prices – trend TFP

If, additionally, GDPIPI is the inflation factor,

growth Output Prices^{Industry}

= growth GDPIPI + (growth Input Prices^{Industry} - growth GDPIPI)
- growth TFP^{Industry}

= growth GDPIPI
+ (growth Input Prices^{Industry} - growth Output Prices^{Economy})
- growth TFP^{Industry}

= growth GDPIPI
+ [growth Input Prices^{Industry}
- (growth Input Prices^{Economy} - growth TFP^{Economy})]
- growth TFP^{Industry}

= growth GDPPI - (growth Input Prices^{Economy} – growth Input Prices^{Industry})
- (growth TFP^{Industry} - growth TFP^{Economy})

Board-Approved IPI for Ontario Power Distributors

Input Category	Approved Subindex
Labor	$$/Employee, Ontario distributors
Other O&M	Industrial Producer Price Index
Capital	Custom Index based on …
	Utility construction cost index Bank of Canada long bond yields

Controversy encountered in capital subindex specification

Sources of Productivity Growth

trend in TFP = trend Input Prices – trend Unit Cost

Theoretical & empirical work has identified sources of TFP growth

Short Run Effects

- Capacity utilization
- Volume/customer
- Reduced "X-Inefficiency"

Long Run Effects

- Technological change
- Scale Economies
- Scope Economies

Capital Price Index

Here capital price index corresponding to replacement valuation & geometric decay

Widely used in cost research

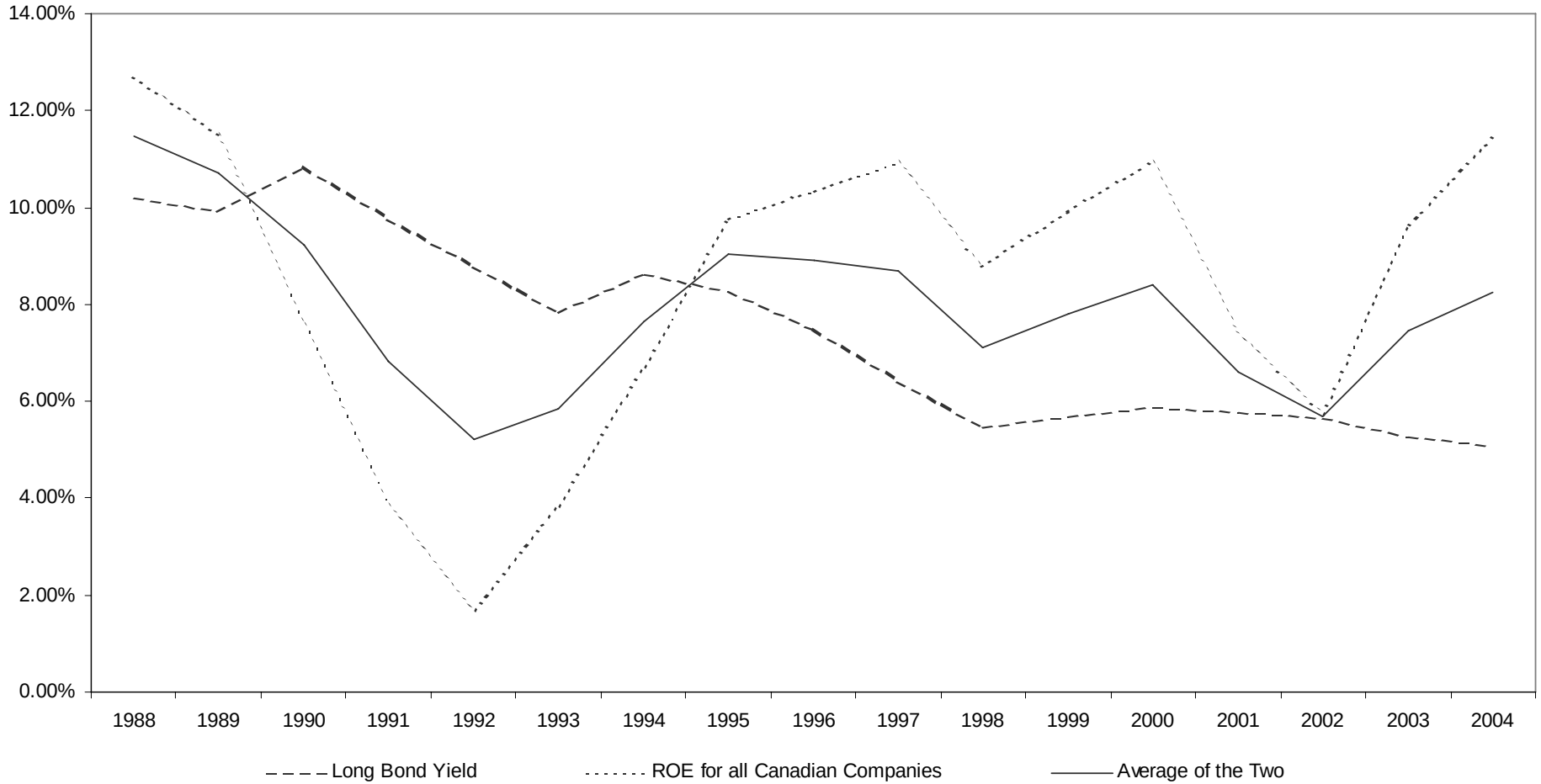
$$Price^{Capital} = d\ WKA_{t-1} + r_t\ WKA_{t-1} - (WKA_t - WKA_{t-1})$$
$$= d\ WKA_{t-1} + r_t - \frac{WKA_t - WKA_{t-1}}{WKA_{t-1}}$$

WKA_t = Stats Canada power distribution construction cost index
r_t = 50/50 weighting of Canada ROEs, long bond yields
d = (constant) depreciation rate reflects average service life

Smoothing: 3-year moving average of *real* rate of return

Figure 2

Rates of Return in Canadian Capital Markets



Capital Quantity Index

Capital *quantity* index measures trend in the real (inflation-adjusted) value of utility plant

1. Real quantity measured in a "benchmark" year using data on utility net plant value
2. Growth in quantity after benchmark year is measured by perpetual inventory equation

$$Quantity^{Total}_{t} = (1\text{-}d) \times Quantity^{Total}_{t-1} + Quantity^{Added}_{t}$$

where

$$Quantity^{Added}_{t} = Gross\ Plant\ Additions_{t} / WKA_{t}$$

Capital Quantity Index

Accuracy is greater the more distant is the benchmark year due to "rough and ready" character of benchmark year adjustment

Companies	*Benchmark Year*
PEG's gas utility sample	1983
PEG's electric utility sample	1964
Ontario Gas Utilities	???

Output Quantity Indexes (cont'd)

Appropriate output index weights depend on research application

How does output growth affect *revenue*?

- Output quantity index has *revenue share* weights
- Sensitive to rate design and average use trends

How does output growth affect *cost*?

- Output quantity index has *cost elasticity* weights
- Cost elasticity = % change cost due to % change output
- Less sensitive to average use trends

Output Quantity Indexes (cont'd)

Divisia logic suggests that *revenue* shares are appropriate when designing a price cap index since we care about how output growth affects revenue

PCI must

- compensate *utility* (w/ lower X) for *declining* average use
- reward *customer* (w/ higher X) for *increasing* average use

Table 1
X FACTORS APPROVED IN INDEXING PLANS FOR GAS AND ELECTRIC UTILITIES

Industry	Company	Term	Jurisdiction	Acknowledged Productivity Trend	Inflation Measure (P)	Stretch Factor	X-Factor	Comments
Bundled power service	Pacificorp	1994-1996	California	1.4%	Industry specific	NA	1.4%	Company specific productivity
Bundled power service	Central Maine Power (I)	1995-1999	Maine	NA	GDPPI	NA	0.9% (average)	
Gas distribution	Southern California Gas	1997-2002	California	0.50%	Industry specific	0.80% (Average)	2.30% (Average)	Special 1% factor added to X to reflect declining rate base
Power distribution	Southern California Edison	1997-2002	California	NA	CPI	0.58% (Average)	1.48% (Average)	0.90% productivity trend estimated by Edison and Commission staff but not formally acknowledged by CPUC
Gas distribution	Boston Gas (I)	1997-2003	Massachusetts	0.40%	GDPPI	0.50%	0.50%	
Gas distribution	San Diego Gas and Electric	1999-2002	California	0.68%	Industry specific	0.55% (Average)	1.23% (Average)	
Power distribution	San Diego Gas and Electric	1999-2002	California	0.92%	Industry specific	0.55% (Average)	1.47% (Average)	
Gas distribution	Consumers Gas	2000-2002	Ontario	0.63%	CPI	0.50%	1.10%	O&M Productivity
Power distribution	All Ontario distributors	2000-2003	Ontario	0.86%	Industry specific	0.25%	1.5%	Productivity trend referenced is the 10 year average growth rate X factor is based on 5 and 10 year weighted average
Gas distribution	Union Gas	2001-2003	Ontario	0.9%	GDPPI	0.5%	2.5%	
Power distribution	Central Maine Power (II)	2001-2007	Maine	NA	GDPPI	NA	2.57% (Average)	
Gas distribution	Berkshire Gas	2002-2011	Massachusetts	0.40%	GDPPI	1.0%	1.0%	Adopted the productivity study used by Boston Gas I
Gas distribution	Boston Gas (II)	2004- 2013	Massachusetts	0.58%	GDPPI	0.30%	0.41%	
Power distribution	All Dutch distributors	2004-2006	Netherlands	1.5%	CPI	NA	NA	X factor assigned by regulator is not determined on comparable basis to the rest in the sample
Power distribution	All New Zealand distributors	2004-2009	New Zealand	2.1%	CPI	0% (Average)	1%	
Gas distribution	Bay State Gas	2006-2015	Massachusetts	0.58%	GDPPI	0.4%	0.51%	Adopted the productivity study used by Boston Gas II
Power distribution	Nstar	2006-2012	Massachusetts	NA	GDPPI	NA	0.63% (Average)	

X Factor Precedents

Table 1 (cont)
X FACTORS APPROVED IN INDEXING PLANS FOR GAS AND ELECTRIC UTILITIES

Industry	Company	Term	Jurisdiction	Acknowledged Productivity Trend	Inflation Measure (P)	Stretch Factor	X-Factor	Comments
All utilities	Sample Average			0.88%		0.49%	1.28%	
All, industry specific P	Sample Average						1.58%	
All, macroeconomic P	Sample Average						1.27%	
Power distribution	Sample Average			1.35%			1.44%	
Power distribution, industry specific P	Sample Average						1.49%	
Power distribution, macroeconomic P	Sample Average						1.42%	
Gas distribution	Sample Average			0.58%			1.19%	
Gas distribution, industry specific P	Sample Average						1.77%	
Gas distribution, macroeconomic P	Sample Average						1.00%	

X Factor Precedents (cont'd)

Data on utility rate trends contain *implicit* X factors

IMPLICIT X FACTOR IN GAS DISTRIBUTION RATES, 1991-2005

Year	PPI Natural Gas Distribution - Transportation Only[1]			GDP-PI[2]			Implied X Factor[3]
	Level	Level (1991=100)	Growth Rate	Level	Level (1991=100)	Growth Rate	
1991	96.8	100.0		84.5	100.0		
1992	99.5	102.8	2.8%	86.4	102.3	2.3%	-0.5%
1993	101.5	104.9	2.0%	88.4	104.7	2.3%	0.3%
1994	101.2	104.5	-0.3%	90.3	106.9	2.1%	2.4%
1995	106.9	110.4	5.5%	92.1	109.1	2.0%	-3.5%
1996	105.7	109.2	-1.1%	93.9	111.1	1.9%	3.0%
1997	109.4	113.0	3.4%	95.4	113.0	1.6%	-1.8%
1998	103.6	107.0	-5.4%	96.5	114.2	1.1%	6.6%
1999	102.3	105.7	-1.3%	97.9	115.9	1.4%	2.7%
2000	103.9	107.3	1.6%	100.0	118.4	2.2%	0.6%
2001	103.4	106.8	-0.5%	102.4	121.3	2.4%	2.9%
2002	105.5	109.0	2.0%	104.2	123.4	1.7%	-0.3%
2003	108.2	111.8	2.5%	106.3	125.9	2.0%	-0.5%
2004	113.3	117.0	4.6%	109.1	129.2	2.6%	-2.0%
2005	116.1	119.9	2.4%	112.2	132.8	2.8%	0.3%
Formula			**[B]**			**[A]**	**[A] - [B]**
Average 91-05			**1.3%**			**2.0%**	**0.7%**
Average 91-00			**0.8%**			**1.9%**	**1.1%**
Average 00-05			**2.2%**			**2.3%**	**0.1%**

[1]Source: PPI Natural Gas Distribution - Transportation Only: Bureau of Labor Statistics; http://www.bls.gov

[2]Source: GDP-PI: Bureau of Economic Analysis; http://www.bea.gov

[3]Note: Assumes GDPPI - X Index Formula

Trends in Average Gas Use for Residential & Commerical Gas Customers by State[1]

	region	1997-2005 Non-Normalized	1997-2005 Normalized[2]	1997-2002 Non-Normalized	1997-2002 Normalized[2]	2002-2005 Non-Normalized	2002-2005 Normalized[2]
National Aggregate		**-1.77%**	**-1.58%**	**-1.90%**	**-1.50%**	**-1.55%**	**-1.74%**
North East Aggregate		**-0.99%**	**-1.01%**	**-1.37%**	**-0.43%**	**-0.37%**	**-2.00%**
Connecticut	NE	-1.53%	-1.33%	-1.68%	-0.35%	-1.26%	-2.97%
D.C.	NE	-0.59%	-0.98%	-1.95%	-1.32%	1.68%	-0.42%
Maine	NE	3.20%	3.70%	7.32%	8.31%	-3.67%	-3.98%
Maryland	NE	0.93%	0.53%	0.67%	1.30%	1.35%	-0.75%
Massachusetts[3]	NE	-4.82%	-4.94%	-6.04%	-5.10%	-1.79%	-4.55%
New Hampshire	NE	0.64%	1.02%	-0.81%	0.37%	3.05%	2.09%
New Jersey	NE	-1.82%	-1.79%	-3.40%	-2.46%	0.81%	-0.68%
New York	NE	-0.69%	-0.75%	-0.05%	0.87%	-1.77%	-3.44%
Pennsylvania	NE	-1.32%	-1.25%	-2.47%	-1.48%	0.59%	-0.87%
Rhode Island	NE	-0.86%	-0.93%	-1.69%	-0.45%	0.53%	-1.73%
Vermont	NE	-3.05%	-2.51%	-4.88%	-3.76%	0.00%	-0.42%
Southeast Aggregate		**-0.55%**	**-0.87%**	**-1.00%**	**-0.96%**	**0.19%**	**-0.74%**
Delaware	SE	-0.46%	-0.81%	-1.14%	-0.16%	0.66%	-1.90%
Florida	SE	2.45%	0.85%	4.59%	2.76%	-1.12%	-2.33%
Georgia	SE	-1.00%	-1.46%	-1.68%	-2.12%	0.14%	-0.38%
North Carolina	SE	-0.66%	-0.52%	-1.98%	-1.09%	1.53%	0.44%
South Carolina	SE	-0.84%	-0.90%	-1.24%	-0.72%	-0.17%	-1.20%
Virginia[3]	SE	-2.06%	-1.52%	-3.28%	-2.26%	0.97%	0.34%
West Virginia	SE	-1.41%	-1.03%	-2.14%	-0.94%	-0.19%	-1.18%
North Central Aggregate		**-2.23%**	**-1.72%**	**-2.44%**	**-1.59%**	**-1.88%**	**-1.94%**
Illinois	NC	-1.93%	-1.24%	-1.98%	-1.06%	-1.84%	-1.54%
Indiana	NC	-1.76%	-1.13%	-2.78%	-1.55%	-0.06%	-0.44%
Iowa	NC	-3.09%	-2.44%	-3.34%	-2.47%	-2.67%	-2.40%
Kansas	NC	-2.68%	-2.17%	-0.96%	-0.61%	-5.55%	-4.75%
Michigan	NC	-2.28%	-1.95%	-2.70%	-1.89%	-1.60%	-2.04%
Minnesota	NC	-2.07%	-1.44%	-0.85%	-0.36%	-4.11%	-3.24%
Missouri	NC	-2.62%	-1.78%	-2.98%	-2.21%	-2.02%	-1.06%
Nebraska	NC	-4.02%	-3.39%	-4.16%	-3.84%	-3.79%	-2.64%
North Dakota	NC	-2.84%	-2.31%	-1.07%	-0.91%	-5.79%	-4.63%
Ohio	NC	-2.06%	-1.86%	-3.16%	-2.05%	-0.23%	-1.55%
South Dakota	NC	-2.54%	-1.77%	-2.87%	-2.34%	-2.00%	-0.83%
Wisconsin	NC	-2.60%	-2.15%	-2.31%	-1.58%	-3.08%	-3.10%

Trends in Average Gas Use for Residential & Commerical Gas Customers by State[1]

South Central Aggregate		**-1.94%**	**-1.28%**	**-1.86%**	**-1.37%**	**-2.08%**	**-1.14%**
Alabama	SC	-2.28%	-1.71%	-2.95%	-2.26%	-1.16%	-0.79%
Arkansas	SC	-1.48%	-0.82%	-0.32%	-0.39%	-3.40%	-1.53%
Kentucky	SC	-2.47%	-1.91%	-3.10%	-1.97%	-1.43%	-1.80%
Louisiana	SC	-1.70%	-0.57%	-0.94%	-0.56%	-2.97%	-0.57%
Mississippi[3]	SC	-1.86%	-1.20%	-1.44%	-1.01%	-2.91%	-1.68%
Oklahoma	SC	-1.93%	-1.32%	-1.54%	-1.74%	-2.59%	-0.62%
Tennessee	SC	-2.14%	-1.58%	-2.33%	-1.46%	-1.83%	-1.77%
Texas[3]	SC	-3.33%	-1.78%	-1.92%	-1.03%	-6.84%	-3.67%
Northwest Aggregate		**-2.19%**	**-2.15%**	**-1.53%**	**-1.93%**	**-3.29%**	**-2.53%**
Idaho	NW	-1.60%	-1.78%	-0.26%	-0.66%	-3.84%	-3.64%
Montana	NW	-2.48%	-2.41%	-0.97%	-1.48%	-4.99%	-3.95%
Oregon	NW	-1.73%	-1.86%	-1.26%	-1.54%	-2.51%	-2.40%
Washington	NW	-2.23%	-2.11%	-1.95%	-2.42%	-2.70%	-1.60%
Wyoming	NW	-2.86%	-2.48%	-1.64%	-1.91%	-4.90%	-3.42%
Southwest Aggregate		**-1.65%**	**-1.92%**	**-1.41%**	**-2.61%**	**-2.04%**	**-0.76%**
Arizona	SW	-2.92%	-2.05%	-2.89%	-2.28%	-2.99%	-1.66%
California	SW	-1.11%	-1.87%	-0.94%	-2.98%	-1.39%	-0.02%
Colorado	SW	-3.07%	-2.30%	-2.23%	-1.79%	-4.48%	-3.16%
Nevada	SW	-2.19%	-1.60%	-3.13%	-2.25%	-0.63%	-0.50%
New Mexico	SW	-3.35%	-2.72%	-3.33%	-2.89%	-3.39%	-2.42%
Utah	SW	-2.59%	-2.63%	-2.24%	-3.13%	-3.19%	-1.80%

1 Source of volume data: Energy Information Administration Form EIA-857, "Monthly Report of Natural Gas Purchases and Deliveries to Consumers"

2 Data are normalized using the estimated regression equation grcvn = -0.011+0.607*ghdd where grcvn is the annual change in residential and commercial gas volumes by state and ghdd is the annual change in heating degree days by state. The t-statistics on the regression coefficients are -4.718 and 22.981, respectively. Heating degree days data for this equation is from NOAA (National Oceanic and Atmospheric Administration) Historical Climatology Series 5-1.

3 Data is missing for 2005; period ends in 2004

*** Residental Volume and Customer Data in addition to Commercial Customer data was entered from 2003-05, while Commercial Volume was entedred from 2000-05**

Impact of Volume/Customer & Cast Iron Replacement on Productivity Trends of 39 U.S. Gas LDCs,1994-2004

	Input Quantities		Output Quantities		Output Quantity Index Weights: 80% Customers/20% Deliveries					Output Quantity Index Weights: 20% Customers/ 80% Deliveries				
	All	O&M	80/20	20/80	TFP	PFP-Labour	PFP-M&S	PFP-Capital	PFP-OM	TFP	PFP-Labour	PFP-M&S	PFP-Capital	PFP-OM
All	0.76%	-0.76%	1.53%	0.44%	0.77%	5.90%	-1.43%	-0.10%	2.31%	-0.33%	4.80%	-2.52%	-1.20%	1.22%
Significant Cast Iron Reduction (3%)	0.57%	-1.44%	0.93%	-0.26%	0.36%	5.89%	-1.14%	-0.90%	2.41%	-0.82%	4.71%	-2.32%	-2.09%	1.23%
Some Reduction (0-3%)	1.04%	-0.21%	1.77%	0.64%	0.73%	4.89%	-2.18%	0.12%	1.98%	-0.40%	3.76%	-3.31%	-1.01%	0.85%
No reduction	0.72%	-0.39%	2.19%	1.29%	1.47%	7.21%	-0.92%	0.89%	2.58%	0.57%	6.31%	-1.82%	-0.01%	1.68%
Some + None (<3%)	0.90%	-0.29%	1.95%	0.92%	1.05%	5.90%	-1.63%	0.45%	2.24%	0.02%	4.87%	-2.66%	-0.58%	1.21%
Significant - All (Nominal)	-0.20%	-0.68%	-0.60%	-0.69%	-0.41%	0.00%	0.29%	-0.80%	0.10%	-0.50%	-0.10%	0.20%	-0.89%	0.01%
Significant - All (w/slow-growth adjustment)					-0.33%	0.08%	0.37%	-0.72%	0.18%	-0.40%	0.00%	0.29%	-0.80%	0.10%