Use of econometric models for cost assessment at PR19

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PR14 models’ emphasis on within-sample goodness of fit led to unstable predictions of cost for AMP6

PR14 model issues

Overfitted, misspecified Translog models:

— Variable sign, magnitude and significance often inconsistent with narratives and across models

— Interaction terms difficult to interpret

— Company efficiency differences explained away

Panel estimation techniques:

— Unstable random effects models

Omitted variables:

— Asset-level economies of scale poorly captured

— Urbanisation, sparsity and drainage not included

Other issues:

— Lack of diversity in model variables

— Load inconsistently measured across industry

Our modelling approach

Use of engineering narratives:

— Variables chosen based on causal engineering narratives, and only then tested econometrically

— Focus on engineering and economic interpretation reduces the risk of spurious relationships

Statistical tests of robustness and stability:

— Multicollinearity assessed through VIF scores and RESET tests

Qualitative diversity assessment:

— Assess narrative and variable diversity formally

— Use multiple models when supporting statistical and engineering evidence is equally strong

Drainage, treatment economies of scale and urbanisation are key narratives selected through the engineering-based approach

Variable (service areas)	Engineering narrative	Econometric evidence
Drainage / urban runoff (network & treatment)	Runoff varies by 50% between regions, and raises network asset size requirements and treatment volumes in combined networks	Positive coefficient with right magnitude when included in models; stable across different specifications
Economies of scale (treatment)	Large WwTWs have unit costs six times lower than small ones, with size largely driven by exogenous population distribution	Load at small WwTWs has positive, significant coefficient
Urbanisation (network & treatment)	Operational and maintenance costs are higher in urban areas due to slower traffic speeds, space constraints and hard surfaces	Positive, and largely significant coefficient when included in new network, treatment and botex models

Price control risks are reduced by *model suite* selection frameworks which reflect narrative diversity

1. Identify candidate approaches to dividing totex between cost lines
2. For each cost line, assess models against report criteria *individually*
3. For each cost line, *collectively* assess models, keeping only top performer(s)
4. Assess totex splits, accounting for model quality and contribution to overall diversity

Cost assessment carries considerable risk for firms and consumers

— Econometric models are subject to projection biases, with no ‘perfect model’

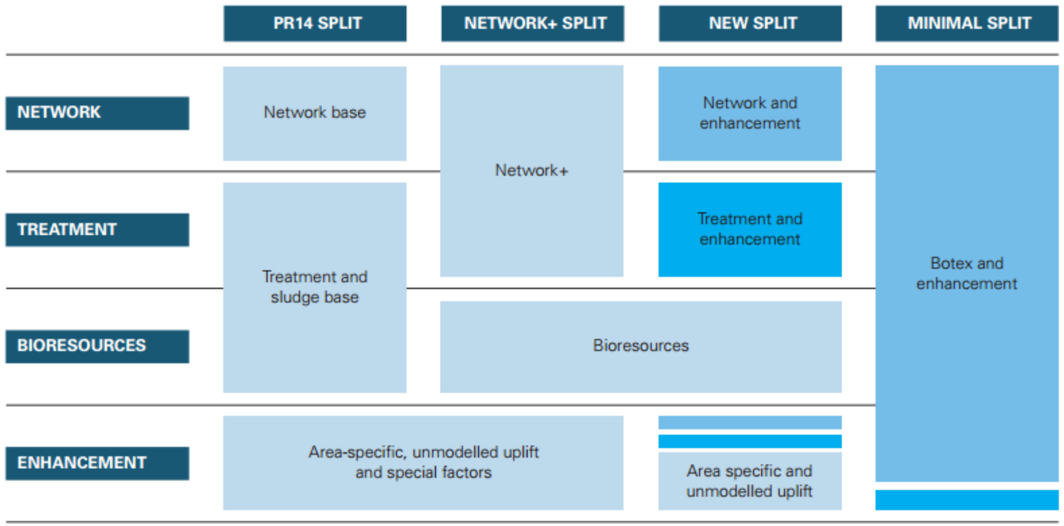
— Arbitrary choices between equally valid models have large impacts on individual firms and their customers

Diverse sets of models reduce these risks

— Projection biases within subservice areas are ‘smoothed out’

— More engineering narratives covered, and trade-offs between bottom-up and top-down models captured

— Model diversity is assessed qualitatively; quantitative approaches were tested but found to be unsuccessful



Measurement error is a major source of risk in model outputs that can be accounted for in model selection

Measurement error in drivers can be large, but is reported inconsistently:

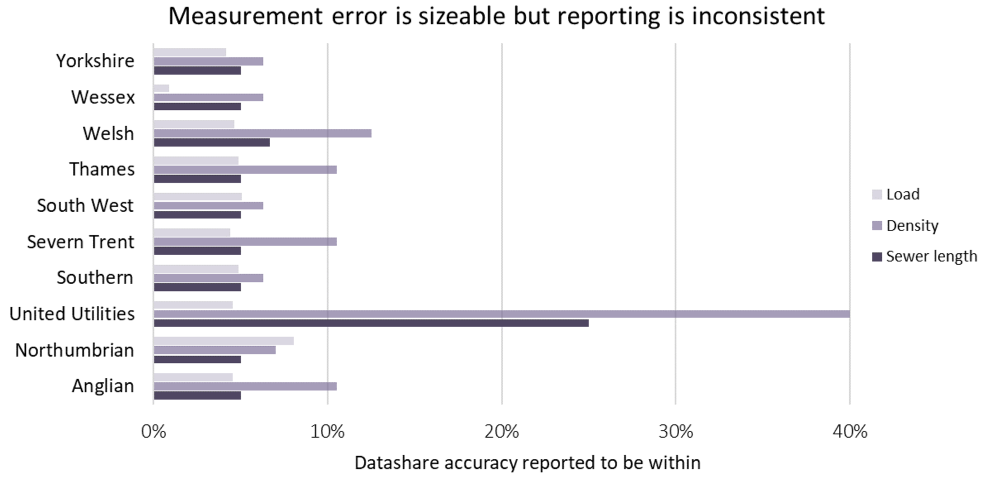
- Key scale variables such as load and sewer length are affected by persistent errors in measurement
- The scale of differences across the industry does not seem credible

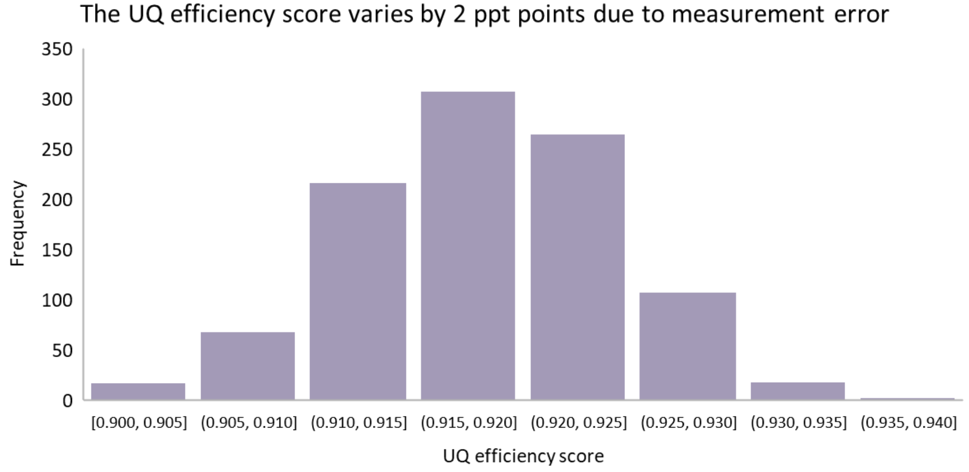
Monte Carlo analysis shows that measurement error affects the level and range of efficiency scores:

- Measurement error attenuates model coefficients and alters driver forecasts
- This biases company allowances and efficiency scores

Taking this into account can improve price control robustness:

- Variables and models could be chosen by using the effects of measurement error on results as a selection criterion
- The true extent of measurement error is likely to be greater due to differences in cost allocation practices





Source: *Vivid Economics analysis of 2017 industry datashare*

Notes: *Confidence bands based on company reporting; UQ scores based on PR14 Split set out in 2018 Cost assessment models report*

An efficiency challenge can be based on wider range of sources on reasonable levels of variation

An efficiency challenge adjusts modelled allowances to allow companies to recover only efficient cost

— This will involve the use of model evidence on the size of efficiency differences across the industry

Unexplained variation in cost assessment models is made up of efficiency differences and modelling noise

— This cannot be decomposed effectively using statistical methods due to the issues of small sample size and identifiability

— The level of unexplained variation is not robust to modelling choices:

- Overfitted PR14 wastewater base cost models had little unexplained variation and implied a very small efficiency challenge of 4%
- The overall challenge of 10% was based on poorly fitted enhancement models which made the most active companies appear efficient in each activity area

Models	Full UQ	Base only UQ
PR14 waste	0.896	0.956
PR14 water	0.935	0.941

Modelling evidence can be used in setting an efficiency challenge when grounded in an explicit view of reasonable levels of efficiency variation

— This level can be informed by past price controls, evidence from other regulated sectors and the international water industry

— Model diagnostics and robustness to measurement error help to identify how much of unexplained variation is 'true efficiency' and how much is noise or bias

***Source:** PR14 scores based on Ofwat PR14 efficiency scores spreadsheet*

***Notes:** Stochastic Frontier Analysis can decompose errors into noise and efficiency, but produces unreliable results in wastewater cost modelling*

Recommendations for PR19

- Engineering narrative-driven approach to variable selection
- Formal suite selection criteria to reflect diversity and modelling trade-offs
- Robustness testing including effects of measurement error
- Efficiency challenge based on explicit view of variation levels

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