National Grid Gas Pricing Regression Analysis Review

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Contents

Project Objectives

- National Grid requested that the Center for Quantitative Analysis at Bentley University provide
  - An independent high level statistical review of the regression based benchmarking approach employed by Ofgem to set cost allowances for gas distribution networks.
  - A review of the benchmarking methodology proposed by Frontier Economics for the next rate setting process.
  - Possible alternatives or improvements that could strengthen the benchmarking process.

Analysis Scope

- The analysis of the regression methodology used by Ofgem to establish benchmarks is limited to the detail provided in the following documents provided by National Grid and conversations with National Grid staff.
  - Regulatory Finance Training
    - National Grid PowerPoint document dated January 29
  - Gas Distribution Annual Report for 2007-2008
    - Ofgem annual report document dated 27 March 2009
    - Ofgem supplementary appendices dated 27 March 2009
  - Electricity Distribution Price Control Review Final Proposals-Allowed Revenue-Cost Assessment appendix
    - Ofgem appendices dated 7 December 2009
  - Gas Distribution Price Control Review Final Proposals
    - Ofgem decision document dated 3 December 2007
    - Ofgem supplementary appendices dated 3 December 2007
  - RPI-X@20: The future role of benchmarking in regulatory reviews
    - A Frontier Economics report for Ofgem dated May 2010
  - A National Grid communication from Paul Whittaker in reference to the proposed RPI-X@20

Analysis Scope

- The current benchmarking process encompasses three components
  - Data
    - Ofgem collects data across a variety of categories of costs and activities from eight gas distribution networks (GDNs), representing four separate ownership groups. Historic data is collected through Regulatory Reporting Packs and future data through the Business Plan Questionnaire. Additional meetings and discussions are conducted to clarify and standardize, to the extent possible, this data across GDNs.
  - Regression analysis
    - Regression analysis is used to relate certain cost categories with associated cost drivers across GDNs. The assumption is that the resulting linear relationship between the driver and the cost category should account for differences in costs across GDNs. Regression analysis is performed at an aggregated level (top down) and a disaggregated level (bottom up).
  - Benchmarking analysis
    - For each regression analysis, a benchmark line is established by a third quartile (or top quartile) line which is projected parallel to the regression line so that two GDNs fall below the line and six above. The benchmark line is used to set efficient cost expectations. This is done for the disaggregated and aggregated regression models. Finally, an adjustment is made to link the third quartile line in the top down case to the total represented by combining the bottom up third quartile results.

Analysis Scope

- The recommendation for the future rate setting process proposed by Frontier Economics
  - The recommended process includes benchmarking future plans for operating and capital expenditures supported by a top-down historic cost benchmarking similar to the current benchmarking process.

Data Considerations

- Number and independence of observations
  - There are only eight GDNs that can be included in any benchmarking analysis
    - The statistical power associated with the small sample size can be expected to be low, causing the regression analysis to lack robustness, and drawing into question any conclusions regarding the 'efficient' line.
    - Small sample sizes can also have a negative impact on the stability of resulting regression analyses due to the potential influence and degree of leverage that individual GDNs can have in such a small sample.
  - The observations of the eight GDNs do not represent independent observations as typically assumed by linear regression
    - Multiple GDNs operate under the same corporate umbrella (London, West Midlands, East England and Northwest owned by National Grid and South of England and Scotland owned by Scotia Gas Networks) which suggests that the costs and/or drivers for these GDNs could be correlated
    - Ofgem (Gas Price Control Review Final Proposals) suggests that meaningful comparisons between GDNs could not be made until National Grid sold four of the GDNs. Yet the current analysis takes no apparent account of the fact that four of the DGNs are still owned by National Grid.

Data Considerations

- Descriptive statistics
  - There are no descriptive statistics (e.g. means, medians, variation, histograms) provided for individual variables
  - There are no scatter plots of the cost categories versus the various unique cost drivers to assess the underlying relationships making it difficult to determine which transformations (e.g. logarithms or others) may be most appropriate.
- Cost bases and cost drivers
  - Consistency issues
    - Ofgem attempts to ensure that the data collected in the Business Plan Questionnaire is consistent across all GDNs however, consistency of data and standardization of interpretation across GDNs appears to be an ongoing issue.
      - The issue regarding the consistency and standardization of data definitions is alluded to in several of the reports reviewed. This would indicate that this issue is known to Ofgem (see for example, Gas Distribution Annual Report 2007-2008, Appendix 4, paragraph 1.10).
    - Mixing operating and capital expenditures may be difficult to accommodate in the same analysis.
      - The longer time frames often associated with capital expenditures makes it difficult to compare across GDNs on a consistent basis. Longer time frames also make capital costs more susceptible to change and fluctuation and hence less stable.

Data Considerations

- Accuracy issues
  - Although it is difficult to assess data accuracy from the reports reviewed, there are enough suggestions of significant data revisions (see for example, Gas Distribution Annual Report 2007-2008 Appendix 4 1.10 or Gas Distribution Price Control Review Final Proposals, Appendix 5, 1.16) to suggest that accuracy of the core data is likely to be an issue.
    - The lack of consistency and standardization of data definitions noted above will have a compounding impact on any inherent inaccuracy in the data used in the analyses.
  - Ofgem does attempt to adjust for issues not common to all GDNs (e.g. regional pay differences) but it is unclear whether the adjustments Ofgem makes are sufficient given the range of coverage of the GDNs.
  - In most cases the cost pools being analyzed represent multiple components of cost requiring the use of a proxy cost driver constructed from multiple variables.
    - The appropriateness of such proxies cannot be assessed from the material reviewed.
    - The use of proxy cost drivers could negatively impact the robustness of the analysis.

Regression Considerations

- Top down and bottom up regression analysis
  - The choice between a top down or bottom up regression analysis is driven by the trade off between simplicity and accuracy.
    - A top down approach uses a single cost pool and cost driver (which may represent a composite scale variable (CSV)) which is conceptually simpler than the bottom up approach which requires several cost pools and cost drivers.
    - A single cost pool masks the underlying complexity and variety of the underlying component costs and makes it difficult to determine a single cost driver or CSV that can explain changes in the cost pool. This is particularly evident, for example, in attempting to combine operating costs and capital expenditures in the same cost pool.
    - Bottom up regression analysis breaks the single cost pool down into smaller more homogeneous cost pools (e.g. work management activities, emergency services, repairs, maintenance and other indirect costs) in the expectation that more appropriate cost drivers can be identified for each component cost pool thus improving the accuracy of each of the bottom up regression analyses.
      - Bottom up analyses must be combined in some way to establish cost expectations for rate setting purposes . There is no rationale provided for the specific methodology utilized by Ofgem to link the bottom up and top down analyses.
      - The cost pools utilized in the bottom up regression analyses represent combinations of a variety of component costs and may be too highly aggregated to identify appropriate cost drivers

Regression Considerations

- Data transformations
  - The appropriateness of transformations (typically logarithms) to cost pool data are difficult to assess
    - Ideally, such transformations should be performed to enhance the linear relationship between the cost pool and the associated cost driver or because there is a known functional relationship (e.g. costs are known to be a specific nonlinear function of the cost driver) between the cost pool and the cost driver .
    - It would be useful to see scatter plots of untransformed cost pool data to assess whether logarithmic transformations are in fact the best transformations to use for this purpose.
  - Combinations and weightings of cost drivers into CSVs are difficult to assess.
    - It would be useful to see scatter plots of untransformed cost driver data to assess the reasonableness of variables combined into CSVs
      - Colinearity of individual components of a CSV should be a consideration in the determination of appropriate weights used to create CSVs. If drivers are correlated then the weights used by Ofgem may not be the 'true' weights which could negatively impact the robustness of the CSVs. This issue is highlighted in the Frontier Economics report (RPI-X@20, Section 4.3)
      - This could suggest that multiple models should be considered, each using a different single driver, and then the results from the ensemble models could be compared and possibly aggregated

Regression Considerations

- Accuracy and appropriateness of CSVs are critical to the resulting benchmarking
  - Different weightings of cost drivers could effectively change the rankings of firms in the benchmarking if it reverses their ranking on the driver
    - If the cost pools and drivers of two GDNs are such that one is above the 3rd quarter line and the other below, it is conceivable that by changing the definition of the CSV, you could reverse the ranking of the two GDNs on the new CSV making the inefficient one efficient and vice versa (see Appendix)
  - It is difficult to evaluate appropriateness and robustness of the CSVs
    - Ofgem recognizes the problem (e.g. see Gas Distribution Annual Report for 2007-2008, Appendix 4, paragraph 1.7)
    - Difficult to assess how accurately the CSVs drive cost (either directly or by proxy) or whether they are only associated with the cost and hence may not be robust predictors
    - Hard to assess the potential errors introduced by combining drivers into CSVs
  - The documents reviewed did not indicate what other potential cost drivers had been evaluated and how they compared with the CSVs actually used in the analyses

Regression Considerations

- Evaluation of regression analyses
  - There is no evaluation of the sensitivity of the results to specific GDNs (leverage and influence)
    - See for example the repair regression actual costs of 2006-2007 and the location of South of England. It would appear that this one GDN could have a significant impact on the final regression line and hence the benchmark
    - The same could be observed for East of England and the South of England in the top down opex regression
  - There is no longitudinal (year on year) evaluation of the stability of the results of the regression with respect to coefficients, error, rankings or fit characteristics.
  - It is interesting to note that Ofgem was unable to create a regression reflecting other indirect cost (Gas Distribution Price Control Review Final Proposals Document, Supplementary Appendices, Appendix 5, paragraph 1.16)
    - This could reflect issues previously identified such as the inability to find a feasible driver for a highly aggregated cost pool and/or the inability to establish consistent standardized data definitions of costs and drivers across GDNs

Regression Considerations

- There is no assessment of the error inherent in the regression estimates which impacts the determination of the regression line and hence the determination of the third quartile line
  - The standard errors associated with the regression slope and intercept as well as the overall mean square error of the regression are not provided
  - Other sources of error that would impact the robustness of the results include measurement errors, differences in definitions of cost and cost drivers and cost drivers not included in the analysis.
- Other inherent assumptions in the analyses that could not be evaluated from the documents reviewed include
  - Whether the cost driver relationships with cost pools remains the same over the time of the rate setting
  - That the only difference between the position of a GDN and the average line/benchmark line is due to inefficiency
    - RPI-x@20 highlights this issue in Section 2.2.3
    - Examples of other issues confounding the measurement of inefficiency appear on page 9
  - While there may be a conceptual justification for the use of logarithms ,there is no evaluation of their rationale based on the actual data
    - There is no discussion of the implication of the use of logarithms and weightings for CSVs on the interpretation of the relationship between actual costs and specific cost drivers (reality check)

Benchmarking Considerations

- Efficiencies may follow a law of diminishing returns
  - There is no assessment of each GDN's ability to reduce costs at constant rate into the future in the current benchmarking methodology
  - May not be reasonable to expect a constant rate of decrease in costs over time (See for example the comments in RPI-X@20 Section 2.3)
- Identification of top quartile line
  - Doesn't reflect variability in the regression line results due to uncertainty in the regression parameters, accuracy of the cost pools or robustness of the CSVs
    - Doesn't reflect the greater degree of accuracy of regression results near the point of averages of the independent and dependent variable and the lower accuracy at the extremes of the independent and dependent variables in a regression analysis
- Process for linking bottom up results with top down results is not clearly defined
  - A fundamental issue in comparing the top down and bottom up approach is that the 3rd quartile (sum of component costs) > sum (third quartile of each component cost)
    - Since there are multiple ways to get two sums to be 'equal', there are multiple ways that a top down analysis could be linked to a bottom up analysis.
    - There is no rationale provided for the specific approach used by Ofgem and no indication of what other methods have been evaluated.

Benchmarking Considerations

- Projections are fixed for multiyear period
  - Projecting costs at fixed rates over several years appears to contradict the primary premise for a new approach provided by Frontier Economics in RPI-X@20, i.e. that activities and underlying cost structures will be changing too rapidly in the near term to continue the current approach.

Future Benchmarking Considerations

- RPI-X@20 recommendations
  - Proposed future benchmarking methodology focuses on the benchmarking of strategic plans supported by historic cost benchmarking using a top down approach for both
    - The proposal is at a conceptual level and lacks specificity regarding how a strategic plan will be converted to a framework allowing for objective benchmarking comparison
    - Proposed cost drivers are speculative and will be dependent upon available data
    - There is no clear indication of how the linkage between benchmarking of past costs and benchmarking of future plans will be evaluated
    - The appropriate measurement and incorporation of capital costs is acknowledged to be an issue.
    - Use of historic benchmarking as a point of reference rather than a funding criteria could overcome many points of contention and limitations inherent in the current methodology
  - The proposed approach, although in principle broader in scope than the present approach, will likely suffer from all the issues currently observed in the current benchmarking process.
    - There are no recommendations regarding how limitations evident in the current regression benchmarking methodology will be overcome in the proposed methodology
      - Issues with appropriate, consistent and standardized data, a top down approach, cost driver definition and the application of regression are not resolved in discussion of the proposed methodology
  - The proposed methodology is discussed at too high a level to evaluate the likelihood of success
    - Operationalization will define the validity and ultimate success of any new methodology

Recommendations

- Key issues along with recommendations for alternatives to address them are indicated in the table below

Issue	Recommendations
Data consistency and accuracy	*Identify and exclude any differences in costs not attributable to efficiency through* • continuing to refine data definitions and data collection methods. • using scatter plots of costs versus drivers to identify actual relationships and to identify inconsistent patterns. • using descriptive statistics on all variables and resolving all outliers or inconsistent values.

Recommendations

- Key issues along with recommendations for alternatives to address them are indicated in the table below

Issue	Recommendations
Cost bases and cost drivers	*Identify optimal weightings and incorporate collinearity considerations into the development of any CSVs through* • performing bottom-up activity based cost analysis by breaking cost bases down to elemental cost components and identifying optimal cost drivers for each • identifying any remaining network specific features • evaluating the appropriateness of transformations at the elemental cost component level based on optimizing the linear relationships between costs and drivers • using multiple feasible single drivers to evaluate the validity and robustness of the results • considering multiple approaches for the top-down analysis

Recommendations

- Key issues along with recommendations for alternatives to address them are indicated in the table below

Issue	Recommendations
Regression analysis	*In order to address issues associated with the small sample size, it is critical to assess the robustness of each regression through* • analyzing high leverage and high influence values in each regression • assessing each regression year on year and possibly through panel data analysis to compare results • using results and residual analysis to help identify inconsistencies that are due to factors other than efficiency gaps • evaluating the standard errors of the parameter estimates and the error of the regression and incorporating these measures into the establishment of the benchmarking target • using multiple models with different drivers to evaluate the robustness of the drivers and evaluating the best way to incorporate differences in the resulting rankings

Recommendations

- Key issues along with recommendations for alternatives to address them are indicated in the table below

Issue	Recommendations
Benchmarking	*Assess the appropriate efficiency targets through* • evaluating multiple ways of linking top down and bottom up cost analyses and using the different results along with sensitivity analysis to determine the most appropriate and robust way to link the two • working with the GDNs to evaluate the realistic opportunity for efficiency improvement • building uncertainty into efficiency targets to accommodate any ongoing issues with data accuracy and consistency and driver appropriateness – issues that were documented in GDPCR1

Recommendations

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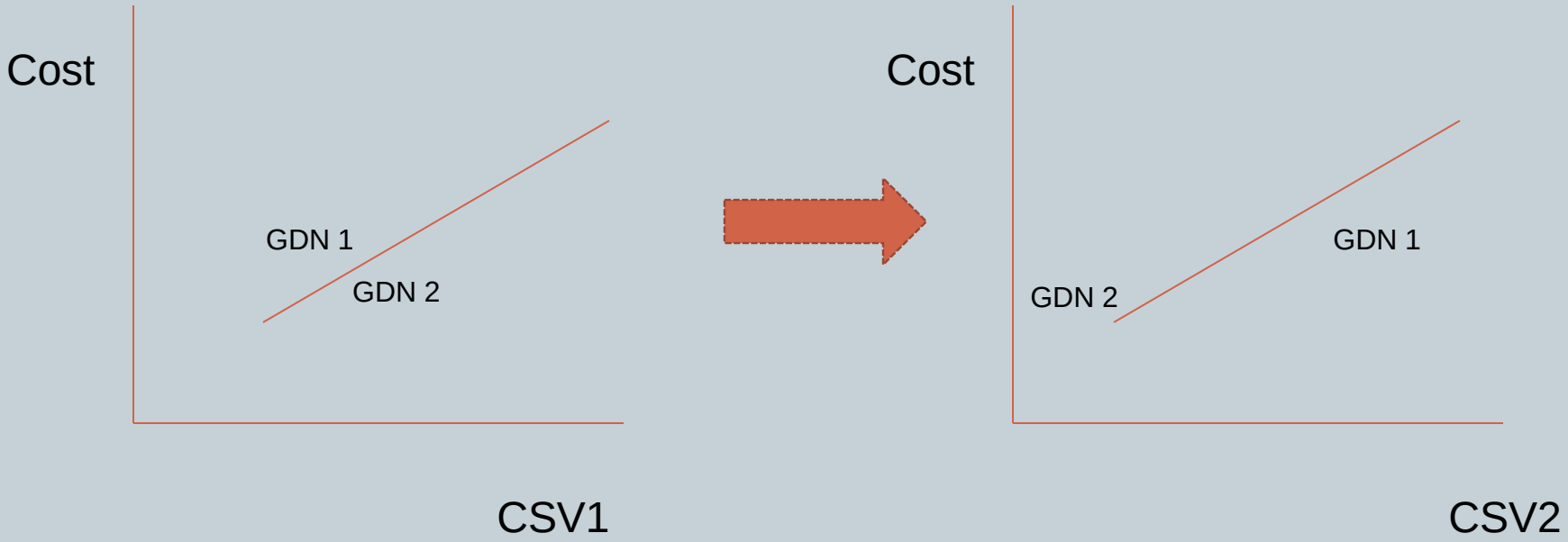
Issue	Recommendations
Proposed benchmarking	*Optimize the proposed use of future years' totex costs and activities for benchmarking through* • requiring GDNs' plans to demonstrate a robust link between past and future costs and activities • evaluating multiple time horizons over which to measure capital expenditures • using the abundance of already collected business plans and cost data to test and optimize the collection of consistent, robust data and to test proposed benchmarking methodologies • using existing and simulated data to anticipate, identify and address any issues or potential weaknesses with the proposed methodology

Appendix

Importance of CSV



Cost remains constant for each GDN but GDN 1 is deemed inefficient according to CSV1 and efficient according to CSV2