Ofwat Research Paper Number 1

# COMPARING THE COST OF WATER DELIVERED

## Initial research into the impact of operating conditions on company costs

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March 1993

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## Abstract

The paper examines the scope for using econometric modelling techniques and company level data to identify (a) the broad impact of operating conditions on the costs of companies delivering water in England and Wales, and (b) differences in company costs that may not be attributable to variations in operating conditions. The problems of deriving a relevant and robust measure of total costs in the water industry are reviewed, and the paper considers the relative costs and benefits of analyses carried out at different levels of detail. Standard regression techniques are used to investigate hypothesised relationships between costs and a range of measures of operating conditions. A number of measures are found to have significant effects. They include measures relating to the size of works, the level of treatment, the type of source, and the amount of pumping required.

**CONTENTS**

# 1 Summary and Conclusions

1.1 Statistical modelling can permit a comparison of costs that takes account of variations in companies' operating conditions. Initial modelling of water service costs has been carried out at the company level. The main conclusions so far are that:

* given the limited number of companies, and the range of potential explanatory factors, statistical modelling carried out at this level is an imperfect tool, and results will need careful interpretation in the light of other measures of company performance;

* although modelling total costs is the theoretically preferred option, more work is required to define an appropriate measure of total costs;

* in the interim, modelling operating expenditure can yield useful results;

* modelling data obtained from below the company level (eg on the basis of sub-areas or individual works) would have costs as well as benefits;

* the balance of advantage for the water service points at present to carrying out comparisons at the company level (perhaps incorporating an analysis of costs by activities);

* it is possible to identify the impact of a range of "explanatory factors";

* a significant proportion of the variation in unit operating expenditure appears to be related to such factors, but some does not;

* further investigation of certain explanatory factors is needed in order to explain some anomalous results;

* the modelling of the costs of individual activities (ie resources/ treatment and distribution separately) may improve the quality of the analysis, but is unlikely to result in a radical improvement.

1.2 A new regulatory accounting guideline (RAG 4) will become operative with the 1992/93 accounts. This will permit the separate examination of the main activities carried out by water companies (principally, resources/treatment and distribution). Retrospective information for 1991/92 is currently being reviewed to asses the validity of such an approach. It is too early either to draw final conclusions about the most appropriate way to model water service costs, or to make firm judgements on the relative performance of companies.

## 2 Comparing Costs

Principles

2.1 For most customers, water is provided by a monopoly supplier. Unregulated monopolists could charge prices in excess of costs, and would not be subject to the full pressures to cut costs that are experienced in competitive (or contestable) markets. Cost comparisons can, however, help a regulator to replicate some of the positive effects of market forces[1]. Price limits can be set to reflect the costs incurred by efficient companies[2].

2.2 In the water industry, costs are influenced by operating conditions, and, to a large extent, the output produced is not directly measured. Both factors complicate the comparison of cost levels. Furthermore, the industry is far from being in a steady state. Large investment programmes in very long-lived assets reflect the quality improvements expected of the industry, but affect companies to a different degree. Inefficiencies in achieving such improvements would probably not be identified if attention was confined to summary output measures and total company costs.

2.3 One result is that a range of measures will need to be examined when price limits are reset in 1994-95. Statistical modelling, which attempts to correct costs for differences in operating conditions, will be just one component.

Explanatory Factors

2.4 As a first step towards taking proper account of the impact of operating conditions, Ofwat has explored with industry experts the range of "explanatory factors" which might be expected a to result in cost variations[3]. It was intended that this would inform model selection and testing. For the water service, potential explanatory factors identified included:

- resource characteristics;
- population/economic growth;
- density of connections;
- turnover of occupation;
- the "quality gap" between raw and treated water;

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1 Comparisons of cost are more relevant than comparisons of productivity, since they take account of price efficiency in factor markets as well as technical efficiency.

2 The use of yardsticks in the context of price control type regulation of monopolies was introduced in the UK by Littlechild (1986). A formal presentation of the theory had been given by Shleifer (1985).

3 These discussions took place within the Comparative Performance Technical Group.

- topography;
- impact of regional factor markets;
- asset condition;
- customer mix;
- standards of service.

2.5 Quantitative measures are needed in each of these areas. Measures should be relevant, robust, readily available, and auditable. The measures used in this paper represent a compromise between these objectives.

2.6 "Explanatory factors" should represent features of geography, geology, and economic circumstance beyond managerial control. However, in an industry with very long lived assets, there are a range of factors which, whilst subject to managerial influence, are largely pre-determined. (Such factors will include the size distribution of works, and the treatment methods used.)

2.7 In principle, one could attempt to determine separately long-run and short run efficient levels of cost. In practice, this is unlikely to be helpful. First, the most practicable measures of the impact of geography and geology relate to configurations of assets (eg pumping head or treatment method required). Second, the time scales involved, and the changes in quality and technology, make a statistical attempt to determine long-run optimal cost of little value. Third, results may be biased by the omission of "short-run" explanatory factors.

2.8 The large number of potential explanatory factors relative to the number of observations (ie companies) makes difficult both the identification of explanatory factors and their precise quantification. On the other hand, it could be bad for incentives if current responses to difficult operating environments were taken to be the best possible.

2.9 One way to reduce the difficulties posed by the presence of explanatory factors could be to eliminate directly the "subjective" elements of spending associated with the relevant factors. Thus the costs of "materials and consumables" might be regarded as being determined by the degree of treatment required. However, there are a number of difficulties with this approach. First, the impact of operating conditions is unlikely to be neatly confined to certain elements of spending. Second, it would probably be unwise for the regulator to make an a priori assumption of efficiency in any area. Third, exclusive attention to the results of comparisons based on costs adjusted in this way would be bad for incentives.

2.10 Nevertheless, it may be that the approach is on balance appropriate for some areas of spending, such as rates and abstraction charges. And it might not be possible to achieve the required level of consistency in the estimation of pumping head. The RAG 4 analysis of costs is designed to facilitate the identification of those subjective elements that are most likely to be determined to a significant degree by operating conditions. Comparative work to be carried out using RAG 4 cost data will explore these issues.

Water Delivered

2.11 The major output produced by water undertakers is the water they deliver to customers[4]. Since the objective of regulation is to contribute to the incentives on companies to produce efficiently, the relevant measure of output is water delivered to customers. Since around two-thirds of total water delivered is delivered unmeasured, the total must be estimated. Results thus need to be tested for sensitivity to the assumptions employed.

Costs

2.12 Efficiency requires the minimisation of costs in total. It does not follow however, that it is appropriate for cost comparisons to focus exclusively on the total cost as charged to customers:

(a) To do this would be to create a circular procedure, since total cost to customers is itself largely determined by the regulator in setting price limits.

(b) Profit levels reflect judgements made at initial K setting on required revenue streams, rather than the economic cost of the assets employed.

(c) Similar assets constructed before and after privatisation may earn different rates of return.

2.13 An alternative approach to total costs, which would construct a total cost figure on the basis of the cost of capital applied to (net) current cost asset values, faces other difficulties:

(a) The use of the "modern equivalent asset (MEA)" principle for valuing some assets results in optimality being to a degree "built-in" to costs, and in a way that may be a source of inconsistency across companies.

b) To the extent that assets are valued on a like-for-like rather than a true MEA basis modelling total costs will identify apparent "efficiency savings" which it would in fact not be efficient to try to achieve (since they are defined with respect to a notional cost figure).

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4 Formally, explanatory factors and volume could be regarded as describing multiple dimensions of output, with efficiency being assessed relative to a multi-dimension cost function.

(c) Calculating total cost involves making an assumption about the cost of capital. It will be difficult to justify a priori any particular assumption for comparative purposes in an industry in which effective costs of capital have changed over time (it is very unlikely that asset values will have been "adjusted" so as to counteract this effect).

(d) The sheer size of the capital charge in the water industry threatens to swamp potentially interesting variations in operating expenditure.

2.14 A further option exists. It is possible to define alternative measures of total cost, for instance by using the market values of companies in the derivation of the capital charge, as outlined in "Assessing Capital Values at the Periodic Review" (issued November 1992). Work in this area continues, but it is not yet possible to undertake comparative cost modelling on this basis. And it seems unlikely that the difficulties inherent in the total cost approach can be completely overcome.

2.15 For all these reasons, initial studies have sought to model operating expenditure and operating costs[5] rather than total costs. Asset values have been included as an explanatory factor in an attempt to take account of inter-dependencies between operating costs and capital costs. It is recognised that this is an imperfect solution.

2.16 The main theoretical danger of incorporating asset values as an explanatory factor (ie on the right hand side in a regression equation) is that they could be correlated with the error term (particularly since the latter will include operating inefficiency) leading to biased and inconsistent parameter estimates. However, in so far as the MEA principle is applied, capital inefficiency should be eliminated and the danger of correlation reduced. And in so far as the problem remains, its significance will depend on how important capital/operating trade-offs actually are in practice. This should be a matter for empirical investigation; this initial study has failed to find any evidence for a relationship between asset values and operating expenditure[6]. Finally, given the change in regime in the water industry, and the long lived nature of assets, it may be most appropriate to represent the main problem facing managers (at least in the short term) as one of minimising operating expenditure, given the asset base.

2.17 It may be worth in future trying to identify explicitly techniques associated with "high" operating expenditure, although the small number of observations available at the company level, and the range of existing explanatory factors, must cast doubt on whether useful results can be obtained.

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5 Operating costs equal operating expenditure plus current cost depreciation and the infrastructure renewals charge (the equivalent of depreciation on very long lived assets).

6 In investigating this it is important to examine interaction terms to take account of the impact of explanatory factors on capital intensity.

## 3 Data

Sources

3.1 The 1992 July Return[7] collected systematic information on water service explanatory factors for the first time. Data for the first year was confined to measures that were thought to be both major drivers of cost and relatively easy to define. Information was reported on source type, works size (by size bands), treatment methods, pumping head and an index of peak demand. Additional information was available from elsewhere in the July Return on length of mains, number of connections (and hence density of connections), incidence of mains bursts, and water delivered to various categories of customer.

3.2 All data is obtained from the 1992 July Return and Regulatory Accounts, and relates to the report year 1991-92. Illustrative results have been included to aid interpretation and for the information of companies. They should be treated with caution at this stage.

Measurement of Output

3.3 The water delivered totals reported by companies in the 1992 July Return showed that there was considerable variation in the key assumptions - ie those made about:

**(a)** per capita consumption for unmeasured household properties;

**(b)** per property consumption for unmeasured non-household properties;

**(c)** supply pipe leakage.

3.4 Two companies also made adjustments for alleged meter under registration.

3.5 A number of companies have subsequently revised their 1991-92 water delivered totals in the light of the report on companies' estimates of water delivered for 1990-91 issued by Ofwat to the industry in June 1992. However, the variation in the key assumptions was not reduced. To some extent, this may simply reflect the variety of methods used by companies to estimate the volume of water delivered[8].

3.6 There may be sound reasons why the assumptions made by companies in estimating water delivered differ. (For instance, there is evidence that

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7 The "July Return" is annual report provided to Ofwat by the companies. It provides data and a written commentary on various aspects of company output.

8 Some further minor amendments have been made in the "Principal Statements" (which report revenue data) for 1993-94. These amendments have not been incorporated at this stage.

household per capita consumption varies with occupancy.) And, given the limited nature of the available evidence, a variety of judgements may be equally credible, even where the underlying facts are the same (this may be the case with supply pipe leakage). However, the assumptions made by some companies appear to lack a sound basis.

3.7 In principle, it would be possible to model costs against the various categories of customer, thus avoiding the need to make the key assumptions outlined above. In practice, given the range of other factors influencing costs in the water industry, this approach is unlikely to yield meaningful results.

3.8 In the report 'The Cost of Water Delivered to Customers 1991-92' (published November 1992), Ofwat presented alternative water delivered estimates, constructed on the basis of a common methodology and standardised assumptions. These may provide a sounder basis for cross-company comparisons. Modelling has employed both estimates, and provides some evidence on their relative accuracy.

3.9 Other dimensions of output - levels of service and quality of water - have not been incorporated into this exercise. To do so would have made the model excessively complex (and there are some doubts about relevance - see section 4). It should be possible to examine the cost efficiency of companies as indicated by modelling relative both to their performance on levels of service, and to compliance on quality in order to establish whether such factors do account for differences in cost efficiency.

## 4 Investigation of Explanatory Factors

4.1 Modelling was carried out using both the estimates of water delivered reported by companies and the alternative estimates constructed by Ofwat. And the relationship of water delivered to both operating expenditure and operating costs (ie operating expenditure plus current cost depreciation and the infrastructure renewals charge) was explored. The conclusions that follow are generalisations that result from exploring a large number of formulations. Particular models are discussed in section 5.

4.2 In general, the use in combination of the alternative estimates of water delivered and operating expenditure appeared to produce more convincing models; in such models a higher proportion of the variation in the dependent variable was explained, and the signs, scale and significance of explanatory factors seemed more plausible. In the rest of this paper, the models cited are of this form, unless otherwise stated.

4.3 The apparent superiority of models based on the alternative estimates of water delivered is perhaps not surprising (see section 3).

4.4 The variability of current cost depreciation and the infrastructure renewals charge (which result in the increased variation of operating costs when compared with operating expenditure) is currently under investigation by WGAR[9]. It is at present not clear to what extent the variability reflects accounting inconsistencies (particularly over the treatment of fully depreciated assets) rather than true cost differences. For this reason, cost comparisons incorporating current cost depreciation and the infrastructure renewals charge should be treated with particular caution.

4.5 The underlying relationship between water delivered (as reported) and operating expenditure is illustrated in Appendix 1. It can be seen that, whilst there is clearly a close relationship between water delivered and opex, average opex varies considerably, and with little obvious relationship to the total volume of water delivered. The analysis has examined a variety of explanatory factors which could contribute to an understanding of the reasons for this variation.

Functional Form / Economies of Scale

4.6 A variety of functional forms were examined at different stages of the analysis. Regressing operating expenditure against water delivered (alternative estimates) with different combinations of explanatory factors generally produced results in which the coefficient on water delivered was not significantly different from unity, with the log form preferred. This implies an absence of scale economies at the level of the total appointed business, and suggests that the selection of a simple relationship between average

9 Working Group on Accounting Issues for Regulation - one of the Director's Ofwat-industry working groups.

(unit) costs and explanatory factors may be appropriate. The decision between average cost and log average cost was a fine one; for present purposes the former has been adopted on the basis of the absence of any obvious rationale for a non-linear relationship. The main conclusions would not have been affected by the alternative choice, and (with the exception of a very small number of companies) the predicted cost figures would be very similar.

Resources and Treatment Categories

4.7 Data had been collected on the proportions of distribution input derived from river abstraction, impounding reservoirs, and boreholes (ie sources of groundwater). Treatment was categorised as simple disinfection, plus three levels of complexity for each of surface and ground water.

4.8 The base group selected was surface water subject only to simple physical treatment. It was found that more complex treatment of surface water, and any treatment of ground water beyond simple disinfection, was associated with higher opex. However, there was no significant[10] difference between the additional costs imposed by different complexities of treatment, or between the types of raw water. This may reflect the inherent limitations of modelling on the basis of 32 observations. On the other hand, it may be that increasing complexity of treatment tends to be counteracted by scale economies or associated with more modern assets which impose lower operating expenditure requirements.

4.9 Operating expenditure was found to fall as the average size of borehole sources (weighted by the proportion of water derived from such sources) increased. This was as expected.

4.10 A surprising result, which came through very clearly, was that ground water and simple disinfection were associated with relatively high opex. The term capturing the interaction between these was particularly significant. One possibility is that such sources tend to be small, and that this was not being adequately captured by the average size of boreholes; this will be investigated further once refined data has been obtained in the 1993 July Return. (No other interaction terms were found to be significant.)

Works Size

4.11 Information had been collected on the basis of 5 size bands. (Data could not be conveniently collected in a continuous way, nor could such data be easily incorporated into comparisons carried out at the company level.) These bands were of a width that increased with size, reflecting the results of previous studies, and the received wisdom.

4.12 Increasing works size (unlike company size) was associated with reduced opex. But only one cut-off (at 25 Ml/d) was significant. It is not clear

10 In all cases, significance is determined at the conventional 95% level.

whether this reflects a genuine step in the cost function, inter-dependencies between treatment and distribution costs, or simply the limitations of working with data that is banded rather than continuous.

Density

4.13 Density (measured as connections per length of main) was not found to be significant once the other main explanatory factors had been included. Density is correlated with these other factors taken as a group. Thus companies found to have difficult operating environments on the basis of these other factors also tend also to have low densities of connection. Whether this correlation is accidental or causal requires further investigation.

Pumping

4.14 The average pumping head for the water service as a whole was measured, and was found to be positively associated with opex (as expected).

Large Supplies

4.15 Two proxy measures for large supplies were used - the average volume delivered to measured non-household properties, and the proportion of water delivered to this category. They are highly correlated, and when considered in turn, each was found to be significant, the latter more so (and hence only this measure was used).

Capital

4.16 The impact of capital on operating expenditure was investigated using gross and net asset values expressed relative to length of main, and the ratio of gross to net asset values. The former was intended to take account of a major explanatory factor for capital (ie the size of the distribution system), the latter to assess the impact of vintage. No significant relationships were found.

4.17 This approach is clearly rather crude; however, the restricted number of observations, and the large number of other explanatory factors, severely limits the scope of the analysis that can be performed.

Regional Effects

4.18 Four regional dummy variables were used to investigate the presence of regional effects; such effects could result from differences in factor markets and in water consumption levels within particular ACORN groups. No significant effects were found.

4.19 An alternative approach would be to use regional wage rates directly to weight employment-related costs. However, it is difficult to identify data that is relevant but not circular. It is not clear how relevant all-industry data is to an industry in which the tradition of national pay bargaining may still have an impact. Inspection of the all-industry data suggests that (apart, perhaps, from the South East), regional variations in remuneration would not warrant a direct adjustment. In addition, there are theoretical objections to such an approach.

Peak Demand

4.20 Problems of consistency and measurement with this factor have precluded analysis at this stage.

Company Structure

4.21 A dummy variable was included for water and sewerage companies; this amounts to a crude test for the existence of economies of scope. No significant effect was found.

Standards of Service / Quality at Tap

4.22 No account was taken of either standards of service or the quality of water at the tap. In the former case, the number of measures is large, and it would be impractical to incorporate them. In the latter case, no summary measures exist at the company level. In both cases, variation is likely to be more associated with capital costs than with operating costs (measures related to customer services may be an exception).

## 5 Models and Results

5.1 The investigations described in section 5 appeared consistent with the underlying model detailed in Appendix 2. Three versions are included for illustrative purposes. All three versions include the same independent variables; only the dependent variable differs. In version 1 the alternative estimates of water delivered are used to calculate unit operating expenditure. In versions 2a and 2b the company estimates of water delivered are used to construct unit operating expenditure and unit operating costs respectively[11].

5.2 The general format can be illustrated with Version 1:

AVOPEX = 17.4 + 16.8*WSZ + 10.3*TT + 0.1*PH - 1.9*BHSZ - 12.1*MNHH + 21.4*BHDIS

5.3 The dependent variable - AVOPEX - is operating expenditure per unit of water delivered ($p/m^3$). The independent variables are:-

**(a)** WSZ - the proportion of distribution input that is subject to treatment more complex than simple disinfection and is derived from treatment works whose mean daily output is less than 25 Ml/d;

**(b)** TT - the proportion of surface water treated by methods more complex than simple physical treatment, plus the proportion of ground water treated by more complex methods than simple disinfection;

**(c)** PH - average pumping head (expressed relative to distribution input);

**(d)** BHSZ - the average size of borehole sources, weighted by the proportion of water derived from such sources;

**(e)** MNHH - the proportion of total water delivered that is delivered measured to non-household properties;

**(f)** BHDIS - the proportion of distribution input that is derived from boreholes and is subject to simple disinfection only (ie the interaction between borehole water and simple disinfection)[12];

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11 Operating costs equals operating expenditure plus the costs of capital maintenance (where the latter comprises current cost depreciation plus the infrastructure renewals charge).

12 BHDIS is intended to capture groundwater that is subject only to disinfection. The measure derived will be biased to the extent that companies have borehole water which experiences only higher levels of treatment, **and** surface water that is subject only to disinfection. This reflects the limitations of the current data set, and will be corrected with the 1993 July Return. The effect is not thought to be large.

5.4 For each version, tables are included which compare companies' actual unit costs with those predicted by the model. These results are presented graphically for version 1. In this graph, companies are ordered by the implied increasing difficulty of operating environment.

5.5 In the tables, companies are ranked by the difference between their actual and predicted performance. Apparently "good" performer are at the top. By definition, around half the companies perform better than predicted, around half worse.

5.6 According to economic theory, efficiency should be expressed relative to a frontier, rather than to the average. All the companies except those actually on the frontier would then be observed to perform worse than predicted. Given the uncertainties of this exercise, that approach would probably not be appropriate. The use of the lower quartile might be a suitable compromise. More sophisticated techniques (such as the stochastic frontier approach) may also have a role to play[13].

5.7 The adjusted R squared figure shows that for version 1 around 81% of the variation in average operating expenditure is "explained" by the selected explanatory variables (having allowed for the number of such variables), for version 2a the figure is about 73%, and for version 2b just under 61%.

5.8 Explaining a high proportion of the variation in the dependent variable is not by itself evidence of a successful model. The model should also rationalise the data. By this criterion, version 1 looks more satisfactory than versions 2a or 2b. Both of these latter versions fail to find pumping significant (contrary to expectation), and appear to identify an implausibly large coefficient on the term selected to capture the impact of large customers on costs. Furthermore, whilst version 1 convincingly passes a test for heteroscedasticity, version 2a passes only marginally, and version 2b fails.

5.9 All three versions pass tests for normality and for functional form (indicating that no interaction terms have been omitted).

5.10 Given the extent of the difference - for some companies - between the company and alternative estimates of water delivered, and the wide variation in depreciation and the infrastructure renewals charge per unit of output, it is not surprising that the models produce considerably different results. Nevertheless, if we take the top eight companies in each ranking, we find that six companies are identified by both versions 1 and 2, and four companies by all three versions. Taking the bottom eight companies, the pattern is (coincidentally) the same.

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13 A review of such techniques is provided in Schmidt (1985).

5.11 This suggests that modelling is most likely to be useful for giving a broad indication of the positioning of a company, and that more confidence may be held in the results when they are repeated for a range of formulations. The results will need to be cross checked against an assessment of the company's performance relative to a group of companies with similar - or less helpful - operating environments. Account will also need to be taken of any specific factors not incorporated within the modelling.

## 6 Issues and general conclusions

6.1 The central issue raised by this study concerns the interpretation of the results of comparative studies. With the range of potential "explanatory factors" in the water industry, a set of 32 observations will inevitably produce an incomplete picture. There is a trade-off between the requirements of non-intrusive regulation (for instance, minimising the data requirements on companies) and the accuracy and comprehensiveness of the results.

6.2 For the water service, companies have indicated that they do not think that data should be obtained from beneath the company level. The costs of this are clear. There are, of course, some compensating benefits. When data obtained at the company level is used it is easier to maintain the link to the output actually received by customers. And it is important that companies retain incentives to improve their responses to difficult operating environments; it may not be appropriate (or possible) to identify in detail causal relationships in this area.

6.3 RAG 4 based cost information will allow the modelling of resources/ treatment and distribution separately. This offers the prospect of reducing the number of relevant explanatory factors at each stage of the modelling, and dealing with certain explanatory factors by eliminating certain categories of cost. Possible difficulties arise from inconsistencies in cost allocation, cost inter-dependencies, and the need to maintain the link to water delivered. However, the first problem should be minimised by clear accounting guidelines, and the relevance of the second is open to doubt when the list of explanatory factors includes items relating to asset size and configuration[14]. Data is still awaited from some companies, so analysis has yet to commence.

6.4 The 1993 July Return will provide the opportunity to collect explanatory factor information in a way that will allow the more thorough investigation of interactions between the size of works and the level of treatment. This may allow us to explain the apparently anomalous result for companies with borehole sources and a high proportion of simple disinfection.

6.5 However, in the light of the comments in 6.1, it would be unwise to expect these steps to produce a radical improvement in the level of the analysis. It is clear, therefore that modelling cannot by itself provide the definitive answer to questions about relative performance. The results will need careful interpretation alongside information on costs and operating environment provided at the level of individual companies and groups of companies.

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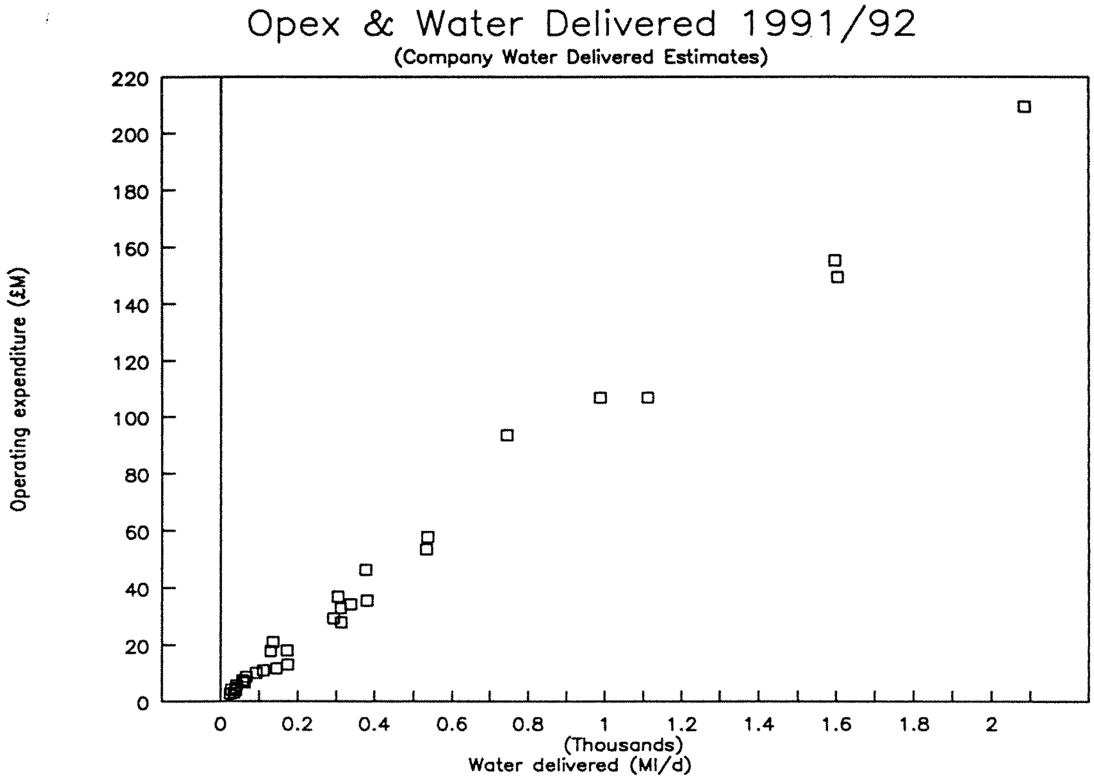
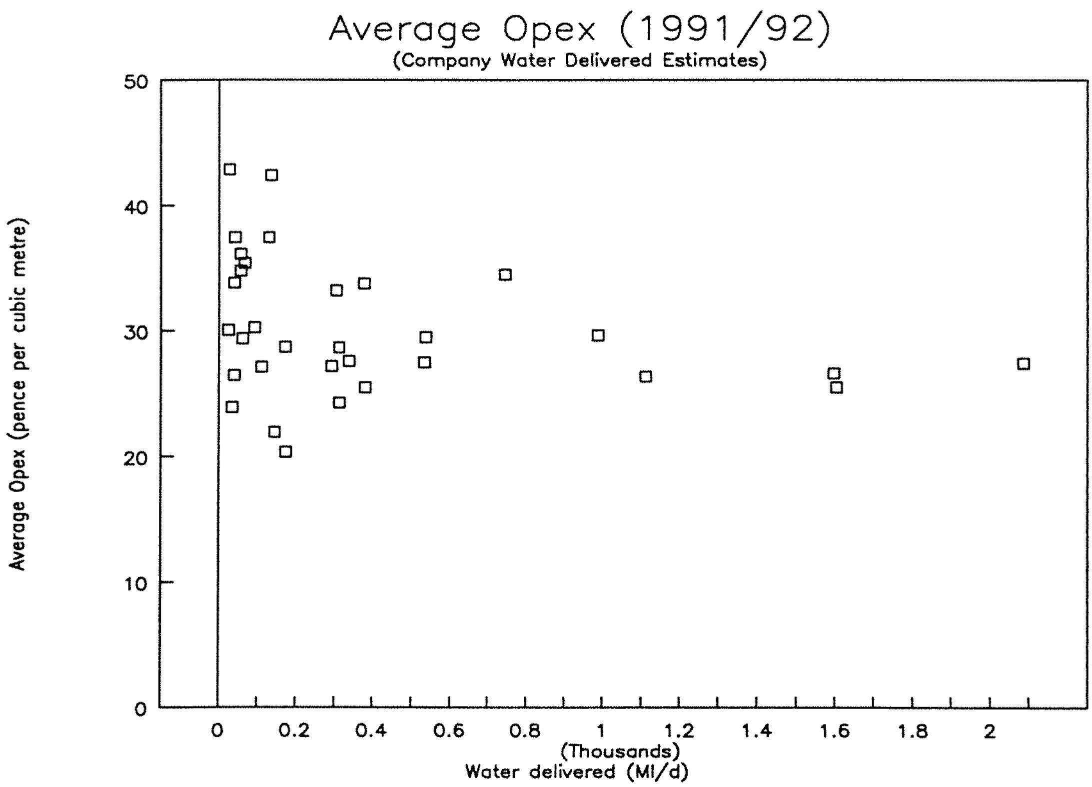
[14] For instance, lower pumping costs in water distribution may be balanced by higher costs as a result of more (and hence smaller) works. Such inter-dependencies should not matter so long as works size and pumping head are regarded as exogenous.

There will also be a need to take account of factors specific to individual companies.

6.6 A more general concern about the modelling approach arises from the fact that it identifies correlations, not causes. There may thus be a danger that modelling serves to explain away real variations in efficiency. There is no easy answer to this, beyond stressing the need to test the model against prior information on the plausibility of the nature of the relationships apparently identified.

# 7 APPENDIX 1


Opex & Water Delivered 1991/92
(Company Water Delivered Estimates)
Operating expenditure (£M)
0
20
40
60
80
100
120
140
160
180
200
220
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
Water delivered (Ml/d)


Average Opex (1991/92)
(Company Water Delivered Estimates)
Average Opex (pence per cubic metre)
0
10
20
30
40
50
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
(Thousands)
Water delivered (Ml/d)

# 8 APPENDIX 2

**Version 1** Dependent Variable: Average opex (alt. water del. estimates)

| | |
|---|---|
| Multiple R | 0.923 |
| R Square | 0.851 |
| Adjusted R Square | 0.815 |
| Standard Error | 2.496 |

Analysis of Variance

| | DF | Sum of Squares | Mean Square |
|---|---|---|---|
| Regression | 6 | 890.360 | 148.393 |
| Residual | 25 | 155.774 | 6.231 |

F = 23.815 Signif F = .000

Variables in the Equation ------------------------------------------------------------

| Variable | B | SE B | T | Sig T |
|---|---|---|---|---|
| Constant | 17.457 | 3.844 | 4.541 | 0.0001 |
| WSZ | 16.791 | 2.704 | 6.209 | 0.0000 |
| TT | 10.310 | 2.361 | 4.367 | 0.0002 |
| PH | 0.079 | 0.018 | 4.308 | 0.0002 |
| BHSZ | -1.887 | 0.401 | -4.703 | 0.0001 |
| MNHH | -12.136 | 5.958 | -2.037 | 0.0524 |
| BHDIS | 21.602 | 2.841 | 7.604 | 0.0000 |

**Version 2a** Dependent Variable: Average opex (co. water del. estimates)

| | |
|---|---|
| Multiple R | 0.884 |
| R Square | 0.781 |
| Adjusted R Square | 0.729 |
| Standard Error | 2.831 |

Analysis of Variance

| | DF | Sum of Squares | Mean Square |
|---|---|---|---|
| Regression | 6 | 716.033 | 119.339 |
| Residual | 25 | 200.409 | 8.016 |

F = 14.887 Signif F = .000

Variables in the Equation ------------------------------------------------------------

| Variable | B | SE B | T | Sig T |
|---|---|---|---|---|
| Constant | 26.893 | 4.360 | 6.168 | 0.000 |
| WSZ | 19.010 | 3.067 | 6.198 | 0.000 |
| TT | 4.973 | 2.678 | 1.857 | 0.075 |
| PH | 0.025 | 0.021 | 1.206 | 0.239 |
| BHSZ | -1.510 | 0.458 | -3.319 | 0.003 |
| MNHH | -20.770 | 6.758 | -3.071 | 0.005 |
| BHDIS | 16.874 | 3.222 | 5.237 | 0.000 |

**Version 2b** Dependent Variable: Average Opcosts (co. water del. estimates)

| | |
|---|---|
| Multiple R | 0.827 |
| R Square | 0.684 |
| Adjusted R Square | 0.609 |
| Standard Error | 5.777 |

Analysis of Variance

| | DF | Sum of Squares | Mean Square |
|---|---|---|---|
| Regression | 6 | 1809.618 | 301.603 |
| Residual | 25 | 834.332 | 33.373 |

F = 9.037 Signif F = .0000

Variables in the Equation ------------------------------------------------------------

| Variable | B | SE B | T | Sig T |
|---|---|---|---|---|
| Constant | 41.065 | 8.897 | 4.616 | 0.000 |
| WSZ | 31.467 | 6.258 | 5.028 | 0.000 |
| TT | 11.745 | 5.464 | 2.150 | 0.042 |
| PH | 0.015 | 0.043 | 0.349 | 0.730 |
| BHSZ | -2.628 | 0.929 | -2.830 | 0.009 |
| MNHH | -41.329 | 13.785 | -2.997 | 0.006 |
| BHDIS | 23.664 | 6.574 | 3.599 | 0.001 |

## VERSION 1

Alternative water delivered estimates

| | Opex (p/cu m) | Pred Opex (p/cu m) | Residual (p/cu m) |
|---|---|---|---|
| Cambridge | 30 | 36 | -5.9 |
| South Staffs | 28 | 32 | -3.9 |
| Yorkshire | 28 | 31 | -2.9 |
| Bristol | 31 | 34 | -2.6 |
| Severn Trent | 26 | 28 | -2.5 |
| Wessex | 34 | 36 | -2.4 |
| South West | 36 | 39 | -2.3 |
| East Surrey | 37 | 40 | -2.3 |
| York | 27 | 28 | -1.4 |
| North Surrey | 29 | 30 | -1.3 |
| Portsmouth | 22 | 23 | -0.7 |
| Three Valleys | 32 | 33 | -0.6 |
| North East | 31 | 31 | -0.2 |
| Hartlepools | 26 | 26 | -0.2 |
| Mid Southern | 33 | 33 | 0.2 |
| Wrexham | 38 | 38 | 0.5 |
| Thames | 30 | 30 | 0.6 |
| Southern | 29 | 29 | 0.6 |
| Suffolk | 36 | 35 | 0.6 |
| Welsh | 38 | 37 | 0.8 |
| Anglian | 32 | 31 | 0.9 |
| Essex | 29 | 28 | 1.0 |
| North West | 26 | 25 | 1.4 |
| Bmouth & W Hants | 23 | 21 | 1.7 |
| South East | 46 | 44 | 1.9 |
| Chester | 30 | 28 | 2.2 |
| Mid Kent | 42 | 40 | 2.3 |
| Folkestone | 42 | 39 | 2.4 |
| East Worcester | 41 | 38 | 2.4 |
| Tendring Hundred | 39 | 36 | 3.1 |
| Sutton District | 38 | 35 | 3.1 |
| Northumbrian | 30 | 27 | 3.3 |

## VERSION 2a

Company water delivered estimates

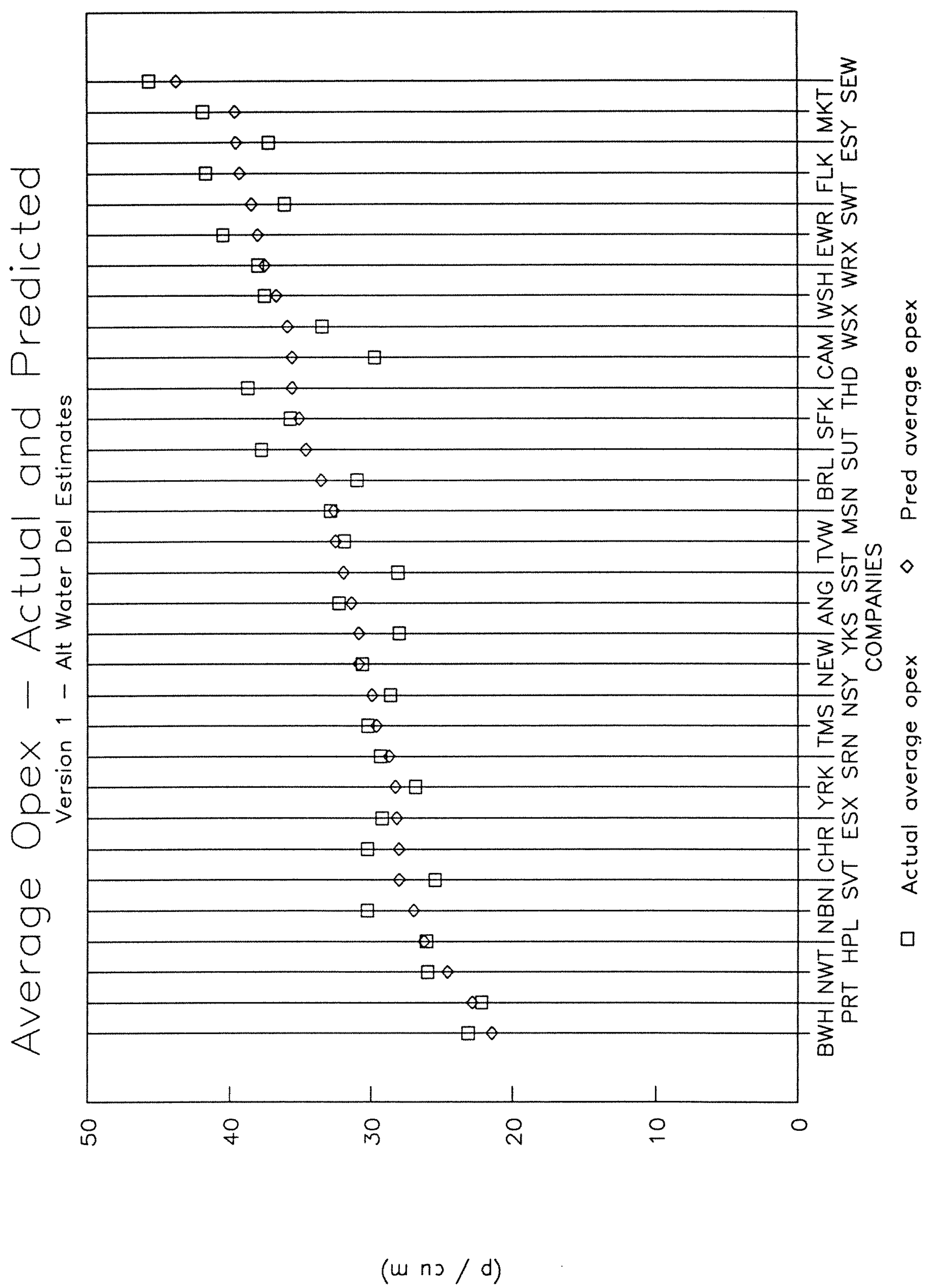
| | Opex (p/cu m) | Pred Opex (p/cu m) | Residual (p/cu m) |
|---|---|---|---|
| Cambridge | 29 | 35 | -5.8 |
| East Surrey | 30 | 34 | -3.8 |
| Bristol | 27 | 31 | -3.7 |
| South Staffs | 24 | 28 | -3.2 |
| Yorkshire | 26 | 30 | -3.2 |
| South West | 34 | 37 | -3.1 |
| North Surrey | 27 | 29 | -2.3 |
| Portsmouth | 20 | 23 | -2.2 |
| Southern | 28 | 29 | -1.0 |
| Wessex | 33 | 34 | -0.9 |
| Severn Trent | 26 | 26 | -0.7 |
| Anglian | 30 | 30 | -0.4 |
| Mid Southern | 29 | 29 | -0.2 |
| Three Valleys | 30 | 30 | -0.0 |
| York | 26 | 27 | -0.0 |
| Wrexham | 34 | 34 | 0.1 |
| Thames | 27 | 27 | 0.1 |
| Bmouth & W Hants | 22 | 21 | 0.5 |
| North East | 29 | 28 | 0.6 |
| Mid Kent | 37 | 37 | 0.6 |
| Welsh | 34 | 34 | 0.7 |
| Northumbrian | 26 | 25 | 1.0 |
| North West | 27 | 25 | 1.4 |
| Suffolk | 35 | 34 | 1.5 |
| South East | 42 | 40 | 2.1 |
| Folkestone | 37 | 35 | 2.1 |
| Essex | 28 | 25 | 2.2 |
| East Worcester | 36 | 34 | 2.2 |
| Hartlepools | 24 | 21 | 2.6 |
| Chester | 30 | 27 | 2.9 |
| Sutton District | 35 | 31 | 3.5 |
| Tendring Hundred | 43 | 36 | 6.6 |

## VERSION 2b

Company water delivered estimates

| | Opcost (p/cu m) | Ped Opcost (p/cu m) | Residual (p/cu m) |
|---|---|---|---|
| South West | 44 | 55 | -10.5 |
| Cambridge | 39 | 47 | -8.3 |
| Bristol | 36 | 44 | -8.1 |
| North Surrey | 36 | 43 | -7.7 |
| Thames | 33 | 40 | -6.6 |
| Welsh | 46 | 51 | -5.1 |
| South Staffs | 33 | 36 | -3.5 |
| York | 37 | 40 | -3.2 |
| North East | 39 | 41 | -2.3 |
| Portsmouth | 28 | 30 | -1.6 |
| Mid Kent | 49 | 50 | -1.3 |
| Wessex | 47 | 48 | -0.6 |
| East Surrey | 50 | 50 | -0.3 |
| Northumbrian | 36 | 36 | -0.1 |
| Bmouth & W Hants | 27 | 26 | 0.2 |
| Southern | 39 | 39 | 0.6 |
| Yorkshire | 43 | 43 | 0.6 |
| Mid Southern | 36 | 35 | 0.7 |
| Three Valleys | 41 | 40 | 0.8 |
| Sutton District | 46 | 45 | 0.8 |
| Severn Trent | 37 | 36 | 1.6 |
| Hartlepools | 30 | 28 | 1.7 |
| Anglian | 45 | 43 | 1.8 |
| Folkestone | 47 | 45 | 1.9 |
| Essex | 36 | 34 | 2.3 |
| East Worcester | 45 | 42 | 3.1 |
| Suffolk | 51 | 47 | 3.8 |
| North West | 40 | 35 | 4.3 |
| Wrexham | 55 | 50 | 4.5 |
| Tendring Hundred | 58 | 51 | 6.3 |
| South East | 69 | 60 | 9.6 |
| Chester | 56 | 41 | 14.6 |

Note:
Opcost equals opex plus cc depreciation and the infrastructure renewals charge


Average Opex – Actual and Predicted
Version 1 – Alt Water Del Estimates
50
40
30
20
10
0
(p / cu m)
BWH NWT NBN CHR YRK TMS NEW ANG TVW BRL SFK CAM WSH EWR FLK MKT
PRT HPL SVT ESX SRN NSY YKS SST MSN SUT THD WSX WRX SWT ESY SEW
COMPANIES
Actual average opex
Pred average opex

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