OFFICE OF GAS AND ELECTRICITY MARKETS

PRODUCTIVITY IMPROVEMENTS IN DISTRIBUTION NETWORK OPERATORS

Final Report

Submitted by:

CAMBRIDGE ECONOMIC POLICY ASSOCIATES LTD

November 2003

CONTENTS

GLOSSARY

BT	British Telecom
CAGR	Compound annual growth rate
CC	Current cost
CCA	Current cost asset base
CCD	Current cost depreciation
COLS	Corrected Ordinary Least Squares
CRS	Constant returns to scale
DNO	Distribution network operator
DPCR	Distribution price control review
DTe	*Dienst uitvoering en toezicht Energie* (the Dutch energy regulator)
GWh	Giga watt hours (10^6 kWh)
HC	Historic cost
MEA	Modern equivalent asset
NBV	Net book value
NGC	National Grid Company
NIESR	National Institute of Economic and Social Research
Ofwat	Office of Water Services
ONS	Office of National Statistics
opex	Operating expenditure
OLS	Ordinary least squares
ORR	Office of the Rail Regulator
PFP	Partial factor productivity
RAV	Regulatory asset value
RPI	Retail price index
RUOE	Real unit operating expenditure
TFP	Total factor productivity
totex	Total expenditure, which includes operating expenditure and a measure of capital
TWh	Terawatt hours (10^9 kWh)
VRS	Variable returns to scale
WASCs	Water and sewerage companies
yoy	Year on year

EXECUTIVE SUMMARY

The next price control period for the Distribution Network Operators (DNOs) begins in April 2005, and Ofgem began the process for reviewing these controls several months ago. As part of this process Ofgem asked CEPA to undertake a study to forecast productivity growth for the UK economy, and for the UK DNOs as a sector to inform its assessment of efficiency and costs as part of the distribution price control review for the period 2005/6 to 2009/10.

The top down assessment of productivity set out in this report will complement Ofgem's other cost assessment work that is underway. This includes comparative analysis of performance of DNOs through top-down benchmarking, as well as bottom up modelling, and also analysis of the DNOs' actual costs and forecast costs. It will be for Ofgem to decide how it uses the results of this study in the overall cost assessment.

Why Estimate TFP and PFP?

Total Factor Productivity (TFP) measures the efficiency with which companies, sectors, or countries use all the inputs in their production processes (which includes capital and operating expenditure, labour raw materials etc) to produce outputs that are valued by customers. Forecasts of future trends in Total Factor Productivity can be useful in making price control decisions, because over the longer term, when performance of DNOs has significantly converged, it can be appropriate for the "X" factor in an RPI-X regulatory formula to approach expected TFP growth, less the expected TFP growth in the economy. Partial Factor Productivity (PFP) measures assess the efficiency with which a single input is used, and operating efficiency is a useful Partial Factor Productivity measure that can be used to compare performance of firms and industries.

The performance of DNOs are unlikely to have converged exactly, so while estimates of TFP and PFP growth may not be used directly in determining price controls, they can inform Ofgem about the possible scope for efficiency savings available to the DNOs as a group over the forthcoming price control period. The estimates of TFP will be particularly useful as Ofgem will undertake an analysis of total costs (operating expenditure plus capital expenditure) in this price control review. The TFP estimates will inform this analysis.

Methodology

We have measured TFP and PFP using Tornqvist indices, which are the ratio of a weighted combination of outputs (such as electricity distributed or quality), to a weighted combination of inputs (such as capital and operating costs). Our productivity growth estimates are all based on forms of this index. Estimates of TFP growth rely on a number of detailed assumptions including:

- the importance of scale economies. There is some evidence of constant returns to scale in distribution but it is not conclusive, so we have assumed limited economies of scale in our TFP estimates.
- how quality should be measured and the weight that should be placed on it. We have constructed quality indices for two of the sectors (water and electricity), and used estimates of the value customers place on quality to weight it in our productivity estimates.

Estimates of trend productivity growth

Estimates of the historic trend in productivity, adjusted for any exceptional factors, are a useful guide to future performance. We have made five different types of estimate of historic trend productivity growth to inform our judgements on future productivity growth:

- **The DNOs**. Data from the regulated accounts of the DNOs, provided by Ofgem, have been used to estimate TFP growth and changes in operating efficiency over different time periods.
- **The UK economy**. The data published by the National Institute of Economic and Social Research (NIESR) has been used to estimate a historic trend rate of TFP growth in the UK economy.
- **UK privatised utilities**. Using data provided by Ofgem and other published sources including regulators, and regulatory accounts, we have made estimates of productivity growth for electricity transmission, water & sewerage, rail, and telecoms. Estimates of UK water productivity in particular are distorted by the major investments in quality that have been made and are still underway, and we have therefore used a quality measure as an output variable in our TFP and PFP estimates.
- **International distribution utilities**. There are significant differences between the structure and regulation of electricity network utilities in different countries, which can make it difficult to directly compare costs in different countries, but trends in productivity can more easily be compared. We have made estimates of productivity growth in Norwegian and US distribution utilities.
- **Sectoral and composite sectoral estimates**. The data published by The National Institute of Economic and Social Research (NIESR) to estimate productivity growth for the UK economy contains disaggregated data allowing sector estimates of productivity growth to be made. We have also undertaken a composite sector or "Nature of Work" assessment. This estimates trend TFP by comparing DNOs to the rest of the economy using a weighted average of TFP estimates for different activities.

These backward looking estimates are supplemented by two forward looking estimates:

- **Investment analyst survey**. Investment analysts make judgements of productivity trends to make financial projections for utility companies. We conducted a survey of utility investment analysts to assess the market's view of productivity growth.
- **Comparator companies**. Using published information, supplemented by discussions with company representatives, we assessed productivity gains that companies in other sectors expect to

make. Expected productivity gains in comparator companies in the energy, mining, chemical, and engineering sectors, provide an alternative forward-looking assessment of growth.

Summary evidence

A summary of the estimates of trend productivity growth is set out in the table below.

Estimate	TFP	PFP opex	Comments
UK economy	1.3%		Trend growth rate over 1974-99, and over different business cycles calculated on NIESR data.
DNOs	4.2%	7.7%	Trend growth for last ten years, based on data from regulated accounts
England & Wales Water & Sewerage	2.6%	5.0%	Quality adjusted figure for TFP using capex weighting, based on range of estimates for 1995/6-2001/2
England & Wales Transmission (NGC)	2.4%	4.9%	Trend growth for last eleven years, based on data from regulated accounts
US Distribution	2.2%	0.5%	Trend growth based on ten years of data from FERC
Norwegian Distribution	0.2%	1.6%	Trend growth based on six years of data from Norwegian regulator
Composite sector	2.0%		Weighted average of growth from related sectors based on trend growth derived from NIESR dataset
UK Utilities sector (NIESR data)	3.4%	9.0%*	Utilities sector growth derived from NIESR data set, last ten years' data
German Utilities (NIESR data)	1.2%	4.7%*	NIESR data set, last ten years' data
Analyst survey	1.5%	2.0%	Median expectations of city analysts from a CEPA conducted survey
Company expectations in related sectors	2.3%		Average productivity improvements expected by related companies based on survey e.g. BP

*labour productivity growth, not operating costs.
All data volume adjusted, except for labour productivity estimates.
Source: CEPA

Conclusions

We estimate that UK TFP growth will continue its trend, and that productivity will improve by around 1.3%.

The evidence shows that DNOs have achieved significant productivity growth since privatisation, and the trend has continued in recent years. Indeed, exceptional improvements were achieved in 1999/00-2000/01, following the DNOs' response to the last review of their price controls, which means that trend performance was higher in the last five years than in the previous five (trend TFP growth was 2.7% in 1991/2-1996/7, compared to 5.2% in the period 1996/7-2001/2. Trend growth in the operating efficiency PFP measure for those time periods was 4.9% and 9.2% respectively). While these exceptional gains in 1999/00 – 2000/01 are likely to be the result of real cost reductions, it is unlikely that such substantial cost reductions are likely to be available in future. Estimates for UK water, and the utilities sector as a whole are also likely to be above the future trend growth, so we use the lowest of these estimates (i.e. the UK utilities sector as a whole) as the upper bound for our expectation of future productivity growth.

This gives an upper bound for TFP performance of 3.4%, and for operating efficiency (PFP) of 5%. Most other estimates of future TFP performance lie in a relatively narrow range which is above the growth in TFP for the economy. The lowest of the TFP estimates is the trend growth in German utilities TFP, which provides a lower bound for our TFP estimate of 1.2%, which from our survey is similar to the average analyst view of 1.5%[1]. Our survey of analysts' views on operating costs provides the lower bound for our PFP estimate, at 2.0%.

For the purposes of price controls, the productivity estimate for the UK economy needs to be deducted from the industry specific estimates. This is because the price controls are indexed to RPI, which in a competitive economy reflects the combination of the change in input prices and changes to Total Factor Productivity. The X factor in an RPI-X price control should therefore only reflect expected productivity growth over and above that expected for the economy as a whole.

We estimate that over the next price control period (2005-2010) TFP growth for the British DNOs will lie in the range 1.2-3.4%, with a central estimate of 2.4%, or approximately one percentage point above the estimate for the UK economy. We expect operating efficiency (the PFP measure), to be in the range 2.0-5.0%, with a mid-point of 3.5% as the central estimate based on this top-down evidence. These ranges are set out in the table below.

[1] The Norwegian results are excluded as being an outlier

	Range	Central estimate
Expected TFP growth for UK DNOs	1.2% - 3.4%	2.4%
Expected TFP growth for UK economy		1.3%
DNO TFP growth – UK economy TFP growth		1.1%
Expected growth in operating efficiency for UK DNOs	2.0%-5.0%	3.5%
DNO operating efficiency growth – UK economy TFP growth		2.2%

Source: CEPA

PART I – METHODOLOGY

1. INTRODUCTION

This report has been prepared by Cambridge Economic Policy Association (CEPA) for Ofgem as a contribution to its thinking on approaches to the forthcoming Distribution Price Control Review (DPCR). The next price control period for electricity distribution network operators (DNOs) begins in April 2005. Under the current plan, we understand that initial proposals for the DNOs will be published in June 2004 and final proposals in November 2004. In advance of the formal review process, Ofgem has developed its thinking on how to improve the overall framework for price controls applying to all energy network businesses, and the objectives, key issues and principals to be used in the forthcoming price review of DNOs. As part of this process, Ofgem has determined a number of high-level principles for the review. As outlined in their June document "Developing Monopoly Price Control Conclusions", these include:

- transparency in how the incentive regulation framework operates and adapts;
- predictability in its application, and consistency over time and across companies, in particular to avoid perverse incentives; and
- sufficient flexibility to cope with uncertainties and changing circumstances, enabling companies to continue to develop and operate their networks on an economic, efficient and coordinated basis and can respond to the needs and requirements of their customers.

It is clear that judgements about what determines an efficient level of expenditure are crucial to the outcome of the review and we understand that as part of its cost assessments. This study is one of a number of studies and analyses Ofgem is undertaking to inform its judgements.

In particular, we were asked to assess the potential for gains in total factor productivity (TFP) in the British electricity distribution sector over the period of the next price control review (2005-2010), distinguishing between those that can be expected to arise in the UK economy as a whole and those that are industry specific. The study is informed by analysis of data provided by Ofgem on the DNOs and other publicly available information.

This report is structured as follows. In Part I of this study, we:

- set out the rationale for estimating TFP in the context of utility regulation;
- summarise the methodology, and place it in the context of other work in this area; and
- highlight some important methodological issues associated with TFP estimation.

Part II focuses on reporting our estimates of TFP growth, based on a number of different analyses. Part III sets out our forecasts for TFP growth. Part IV contains a number of annexes with source data and other supplementary information. Full terms of reference are set out in Annex 1.

2. Productivity and Regulation

Productivity is the relationship between the outputs of goods and services of a company, industry or economy and the input of resources used to produce them. An entity can be said to have become more productive if it is able to produce a greater level of outputs for a given level of inputs or, conversely, if it is able to produce the same level of outputs for a lower level of inputs.

2.1 Total Factor Productivity

Total factor productivity (TFP) takes into account all the factors of production (e.g. capital, and labour) used to produce the goods and services. TFP growth therefore captures the component of the change in output that is not explained by changes in inputs. TFP indices provide a way of comparing the efficiency with which companies / industries deploy their inputs in a multi-input, multi-output environment. They can be used both to compare firms / industries at a specific point in time and over time. For practical reasons, the input variables are monetised (e.g. by using operating and capital expenditure rather than units of labour and capital employed) or unit costs are calculated. In these cases, trends over time are driven by movements in input costs as well as by changes in physical productivity. Consequently, when TFP indices are compared across industries, consideration needs to be given as to whether the trends in relative input prices are likely to be sufficiently similar, or whether some adjustment needs to be made.

There are a variety of ways of calculating TFP indices, of which the most common in empirical literature is the Tornqvist methodology. However, they all essentially provide a ratio of measures of output to measures of input, with the difference being the methodologies used to weight inputs and outputs. The Tornqvist index is sufficiently flexible that it allows incorporation of multi-input, multi-output measures. Quality measures, for example, are one additional variable that can be included in TFP indices. The definition of the Tornqvist index is set out in Annex 2.

2.2 Partial Factor Productivity

It is important to distinguish between TFP, as described above, and Partial Factor Productivity (PFP). The latter compare the ratio of a single output to a single input across firms and / or over time. Labour productivity and unit operating costs are two examples. However, as partial productivity measures are often impacted by factor substitution effects (e.g. capital expenditure is substituted for operating expenditure resulting in a decline in unit operating costs) they can be misleading. Nevertheless, due to the difficulties associated with compiling meaningful TFP indices, particularly the capital input, partial productivity measures are often used. For example, Australian regulators (e.g. the Office of the Regulator General, Victoria (ORG)) have used them to examine many aspects of the efficiency of distribution utilities and previous studies commissioned by UK regulators into the productivity trends of network utilities have tended to focus on real unit operating expenditure (RUOE).

In this report, we will make estimates of trend TFP, as well partial factor productivity for two input variables, capital and operating costs. The PFP opex index is the inverse of RUOE, and the trend of both indices measures the same effect.

2.3 The Role of TFP in Utility Regulation

When a utility is subject to RPI-X regulation, the real change in prices is essentially pre-determined for the duration of a price control period.[2] A key issue is how the X factor should be determined[3]. The typical process at present is for regulators to assess company business plans, make judgements about capital expenditure needs, make assessments about the scope for cost reductions, and then to set an X factor that provides the company with sufficient expected revenue to cover costs and earn a "reasonable" return on capital employed. In addition, X must be consistent with the provision of the required level of service to consumers and other key outputs.

TFP indices provide the potential for an alternative approach. If initial prices are set at an appropriate level, and X is set at a level that reflects the long term trend in TFP for the industry, then a company should be able to earn an appropriate rate of return. This provides the rationale for setting X factors on the basis of TFP growth in the long term.

It should, however, be noted that X factors should reflect only *differences* between expectations of TFP growth in the industry concerned, and the economy as a whole. This is because prices are indexed against changes in the retail price index (RPI), and this is equal to the change in input prices less the change in productivity in the economy as a whole.[4] Further details of this are set out in Annex 3.

A TFP approach to setting X factors is only really appropriate when company costs have converged on an efficiency frontier, or have at least been given an opportunity to do so. If companies vary greatly in their level of efficiency, it may be appropriate to impose different price reductions on different companies, depending on the scope for cost reductions.

A TFP trend can, however, indicate the extent to which efficient companies, which are already on the efficiency frontier, can reduce costs over time. Trend TFP growth, however, ought to distinguish between movements towards the frontier, and movements of the

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[2] Unless there are exceptional circumstances. In the UK water industry, companies can request an interim determination between price reviews under certain conditions.

[3] In practice the X factor comprises an initial price reduction (P0) and an annual reduction (X)

[4] This is set out in Uri, N. (1999), and in particular equation 28 (p 45). For completeness, a full specification of X would be expected gain in industry efficiency – expected gain in whole economy efficiency + change in whole economy input prices – change in industry input prices.

frontier. If it does not do this, an X factor based on trend growth would be unfair to frontier firms that would not be able to achieve 'catch up' efficiency savings available to firms behind the frontier. This would ultimately adversely affect consumers.

For British DNOs, it is unlikely that efficiency has converged to such an extent. This means that it is not appropriate for expectations of TFP to determine all price controls of DNOs. But a trend in TFP can provide a lower bound for appropriate X factors, and indicate the appropriate level of X for a regulated firm that is on the efficiency frontier.

Productivity trends, therefore provide regulators with a tool to assess efficiency that can supplement other assessments, such as comparative benchmarking analysis, and bottom-up estimates of efficiency, and engineering studies.

3. METHODS FOR ESTIMATING PRODUCTIVITY GROWTH

3.1 Previous work

A number of studies aimed at assessing the potential for productivity improvements in the UK's regulated network utilities have been conducted over the past few years; Ofgem, ORR and Ofwat have all commissioned such studies.[5] Three main data sources have been used in these studies:

- the historic performance of the UK economy as a whole, usually based on the National Institute of Economic and Social Research (NIESR) productivity data set (as used, for example, in O'Mahony (2002)).
- the historic performance of selected UK regulated network industries; and
- "nature of work comparisons", where a particular industry is deemed to be represented by a weighted average of a number of other industries. Estimates of productivity trends are made by weighting estimates for each sector by the deemed contribution of that sector to the regulated company's activities.[6]

The analysis for this study builds on this work, using some additional data sources to obtain estimates on trend productivity, as well as examining total costs as well as real unit operating expenditure (RUOE).

3.2 This study

Ofgem's requirement from this study is to gain a picture of productivity changes in the British electricity distribution sector and an assessment of the potential for further gains over the period of the next price review. In order to achieve this, the methodology provided by previous such reports for UK regulators needs to be enhanced. We have used the following six-step methodology to inform our overall judgement on the scope for TFP improvements by DNOs.

3.2.1 Assessment of trend TFP growth for the DNOs

We have used aggregate data from Ofgem on the DNOs to calculate productivity growth in both operating expenditure (opex) and a measure of total expenditure for the post-privatisation period. Again placing greater weight on the performance over the last five years, we have then assessed whether there are any reasons to believe that the trend in TFP

[5] See Mazars Neville Russell (2001), Europe Economics (1998), Europe Economics (2003), and Oxera (2003).

[6] For example Europe Economics (2003).

performance up until 2010 will differ significantly from the recent trend. Such reasons could include changes in technology and reduced scope for cutting costs following privatisation. (See Chapter 5).

3.2.2 Assessment of trend TFP for the UK economy:

Using data compiled by O'Mahony, and available from NIESR, we have calculated the trend in TFP performance for the UK economy as a whole since 1950 and adjusted the results to take account of economies of scale. Placing greater reliance on more recent performance, we have then assessed whether the trend for the UK economy could reasonably be expected to be maintained over the coming years. (See Chapter 6).

3.2.3 Assessment of trend TFP growth for the privatised UK network utilities

The UK privatised network utilities provide a reasonable comparator group for the DNOs as their ability to realise TFP improvements is affected by many shared characteristics, and in particular: legacy inefficiency resulting from state ownership; the importance of previous decisions on fixed investment; universal service obligations and similarities in nature of work; and the regulatory and competitive environment. We have assessed the TFP efficiency improvements realised in the other UK privatised network utilities – electricity transmission, fixed line telecommunications, railways and water and sewerage[7] - and assessed whether there are any implications for the DNOs going forward. However, the results need to be interpreted with care as the degree of legacy inefficiency and need for capital investment following privatisation in particular are likely to have varied significantly across industries. (See Chapter 7).

3.2.4 Sectoral estimates and composite sectoral estimates

The NIESR dataset used to estimate whole-economy TFP growth also contains sectoral data, and can be used to provide an estimate of trend industry TFP growth.

The nature of work comparison undertaken in the studies commissioned for other UK regulators and by Ofgem with respect to Transco[8] essentially benchmarked the relevant industry against a composite of industries weighted to reflect the nature of work of the relevant industry. For completeness, we have replicated this methodology for the DNOs, basing the weightings of the industries on expert industry judgement. However, the methodology does involve a degree of circularity and does not examine the underlying cost structure of firms.

These productivity trend estimates are set out in Chapter 9.

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[7] Gas has been excluded due to data inadequacy.

[8] *Mazars Neville Russell, 'Transco Price Control Review 2002-2007', commissioned by Ofgem, September 2001*

3.2.5 Assessment of trend TFP growth in international electricity distribution

We have selected a number of international distribution companies from well developed markets and for which data was available: the 25 largest DNOs from Norway and the 50 largest DNOs (by output MWh) in the US. The resulting TFP trend for these companies can provide guidance as to the likely rate of improvement in the international efficiency frontier for the sector. These estimates are set out in Chapter 8.

3.2.6 Surveys of expected cost reductions

We have supplemented the above analysis on historic productivity trends with two surveys that aim to capture views on underlying costs, which are reported in Chapter 10:

- Analyst survey: We have reviewed the efficiency savings forecast for the listed UK DNOs by ranked electricity industry analysts as published in their latest reports. We have then supplemented this with interviews with a number of individual analysts. Analysts' views provide insights into the scope for efficiency savings as they are in close contact with the companies and generally undertake detailed modelling of companies' cost structures.

- Company survey: We have also reviewed the expected improvements by companies in non-regulated sectors, to obtain another forward-looking assessment of potential TFP growth. Companies selected were in other capital intensive industries, or where the activities of the companies are related to the activities of DNOs.

This study therefore adds three additional components to the studies previously carried out for UK regulators. In particular:

- In addition to analysis of partial factor productivity measures, we estimate measures of total factor productivity;

- We have included an assessment of TFP trends in a group of international electricity distribution companies; and

- We have introduced a forward-looking component to the analysis by incorporating surveys of analyst and company expectations of the scope for future productivity gains.

- In some of our estimates, we have reflected output quality in our assessments of TFP growth.

4. METHODOLOGICAL ISSUES

This chapter comments on a number of methodological issues that arise in the practical calculation of TFP growth estimates.

4.1 Trend vs compound annual growth rates

The productivity numbers are reported both in terms of the compound annual growth rate (CAGR) over the period considered and the fitted trend.[9] In many instances the difference between the two results is minimal. However, in a number of cases the differences are significant. Where this is the case, we place greater reliance on the trend results as the CAGR figures depend exclusively on the start and end point and so are obviously highly dependent on the period chosen.

4.2 Quality

Quality improvements lead to increased capital and/or operating costs. Without adjustment, estimates of TFP growth will be distorted downwards: greater cost savings could have been achieved had there been no change in quality. Quality improvements are often made either to meet new legal obligations, or at the request of the regulator.

A good example of this is the UK water industry. It will be seen below that the enormous capital programme has meant that TFP has grown at best only very modestly. This capital programme has been designed to improve quality. In order to reflect this in our TFP estimates, it is necessary to make an assessment of the change in quality, so that inputs will be a weighted average of normal "volume" measures, combined with quality.

There are a number of methodological issues that arise with quality measures:

- the choice of quality variables. We have attempted to choose quality variables that matter to customers. These are typically ones which regulators have chosen to monitor, and data on these variables is therefore readily available;
- transformation of quality variables so that increases in quality are reflected in an increase in the index. The mathematics of transformation of indices is straightforward, and where necessary, we have typically taken the inverse of a variable (e.g. with minutes lost, the index is 1/minutes lost). This transformation does not, however, necessarily reflect the way that customers value this aspect of quality;

[9] We fitted the trend to the natural logarithm of the Tornqvist index. Trend annual growth can then be expressed as exp(β)-1, where β is the estimated trend rate of growth of the log series.

- determining the weights to use for quality and other variables in the Tornqvist index. The precise impact of quality change on our estimate inevitably depends on the weights attributed to quality. Ideally, this should reflect the value that customers place on quality compared to other characteristics, and for those sectors where we have made quality adjustments we have found proxies for the quality weights.

4.4 Economies of scale

If there are economies of scale, unadjusted estimates of TFP growth will overstate the underlying trend (if volume is increasing). For capital intensive industries such as the network utilities, when there is excess capacity, the marginal cost of supplying another customer with energy or supplying another train is small, so economies of scale are considerable for small increases in output. However, when there is not excess capacity, or the increase is large enough so that additional investment is necessary, the need to expand networks means that economies of scale are considerably reduced. In infrastructure industries, these characteristics mean that marginal costs typically are far lower than average costs.

It is also possible that there could be diseconomies of scale, through increased congestion, that cannot always be relieved through additional investment (e.g. in rail).

The importance of these volume effects varies across industries and clearly depends on both the elasticity of scale and the extent to which volumes have changed over the period concerned. Volume adjustments can be made using the following formula:

$$\text{Volume-adjusted TFP} = \text{Unadjusted TFP} + (1 - 1/\varepsilon) \times (\text{change in outputs over the period})$$

where ε is the estimated elasticity of scale for the industry[10]. With $0<\varepsilon<1$, the volume adjusted TFP growth will be lower than the unadjusted rate (provided that volume growth is positive).

Estimating the potential economies of scale that can be realised simply by volume growth is clearly an important judgement in the formation of X factors. However, the econometric estimation of scale economies in most sectors is not straightforward, and to date it appears that very limited assessment of this has been done systematically by UK regulators. Work done, for example, for the Office of the Rail Regulator, comparing reductions in operating expenditure across sectors, has relied on an assumption that the scale elasticity is 0.9. As a base case, in the absence of reliable evidence, and for all the economy wide estimates, we have used this 0.9 assumption. However, it should be noted that there is little empirical support for this.

We have reviewed evidence for economies of scale in DNOs (see Section 5 below, and Annex 5), as well as making our own cross-section analysis. While there is some uncertainty

[10] If the elasticity of scale is 0.9, it means that if output increases by 1%, costs will increase by only 0.9%.

about the scale parameter, the impact on our estimates is limited for the range of plausible estimates for the parameter. We have used a value of 0.85, at the centre of a range of 0.7-1. For the water industry, the low growth in water volume means that the scale parameter has little impact.

For the purpose of setting X factors in a mature and stable industry, scale economies may matter less. If volume growth in the future is expected to be at similar levels to the past, and scale economies are not expected to change much, then it would be necessary only to assess unadjusted TFP growth. An estimate of the elasticity of scale economies is necessary, however, if comparisons are made between industries.

4.5 Measuring the capital stock

Defining an appropriate measure of the capital employed is a challenge for all TFP studies; and difficulties in doing so have often resulted in the reliance on partial productivity measures such as RUOE.

Capital employed as defined by historic cost accounting conventions does not provide an appropriate measure. This is because assets are included at cost in the year in which they are purchased. No adjustment is made for price inflation for assets purchased in different years. Capital employed defined under current cost accounting conventions does not suffer from this problem. The current cost value of an asset is the cost of an asset of equivalent productive capability that would last as long as the asset being valued, i.e. it is the value of a 'modern equivalent asset' (MEA). It is possible, though, that assets that are not used and useful are included in the asset base, so that the MEA value overstates the value of useful capital.

One further asset definition that could be used for measuring the capital stock in UK regulated industries is the regulatory asset value (RAV). This is the value of assets on which regulators allow a return in determining price caps. It does, therefore, have a link with the cost of provision of the service to customers. However, the methodology used for setting the initial RAV at privatisation and updating it in subsequent years differs by industry, which means that changes in the RAV (which would affect estimates of the change in TFP) are not comparable.

For example, the water companies were privatised with an initial RAV of around 20% of current cost net book value (CC NBV). In other sectors, old assets are replaced with newer assets, so over time the discount to RAV disappears, as new assets are included in the RAV at their CCA value. This does not happen in water. Many of the assets are deemed to remain in service indefinitely, and will not be replaced. Maintenance expenditure to keep them in service is accounted for with an 'infrastructure renewals charge', which is effectively capital expenditure depreciated in the year in which it is incurred. This means that the RAV remains permanently below the CCA value, which means that the contribution of capital to TFP growth will be understated.[11]

In our analysis of specific companies, we have chosen to use the current cost value of tangible assets as the measure of capital value. For the international companies where we have calculated TFP growth estimates, only HCA data was available. In these cases, we have estimated CCA assets using HCA data. The method used to do this is set out in section 8 below.

4.6 Exceptional and extraordinary items

Since privatisation, most companies' regulatory accounts include exceptional / extraordinary items in at least some years. These items can be a result of a number of factors, including:

- redundancy costs, where there is a significant reduction in the workforce;
- the 'windfall' tax; and
- other one-off cost shocks (positive or negative).

We prefer not to make any adjustments to operating costs in our analysis for these items, even though in some cases they are significant. The reasons for this are twofold. First, as they are one-off events, they will not affect the long-term trend in productivity improvement; Second, many of these items, such as restructuring costs, are genuine costs that should be reflected in any long-term assessment of efficiency. All our assessments include exceptional and extraordinary items, except for National Grid where data was provided to us excluding exceptionals.[12]

4.7 Business cycle

Due to the high costs associated with redundancies / recruitment and mothballing / constructing capital stock, it is common practice among firms of all types to alter their utilisation rates of production factors in line with cyclical changes in demand rather than actually alter the level of production factors employed. Some of the movement in utilisation rates – for example, overtime payments and the hire of equipment - will be captured in the level of operating costs. However, some utilisation rates, particularly the level of utilisation of capital stock, are difficult to capture. Consequently, to the extent that movements in capacity utilisation go undetected by the input variables, the resulting TFP growth figures will be biased in a pro-cyclical manner. In other words, TFP figures will be biased upwards

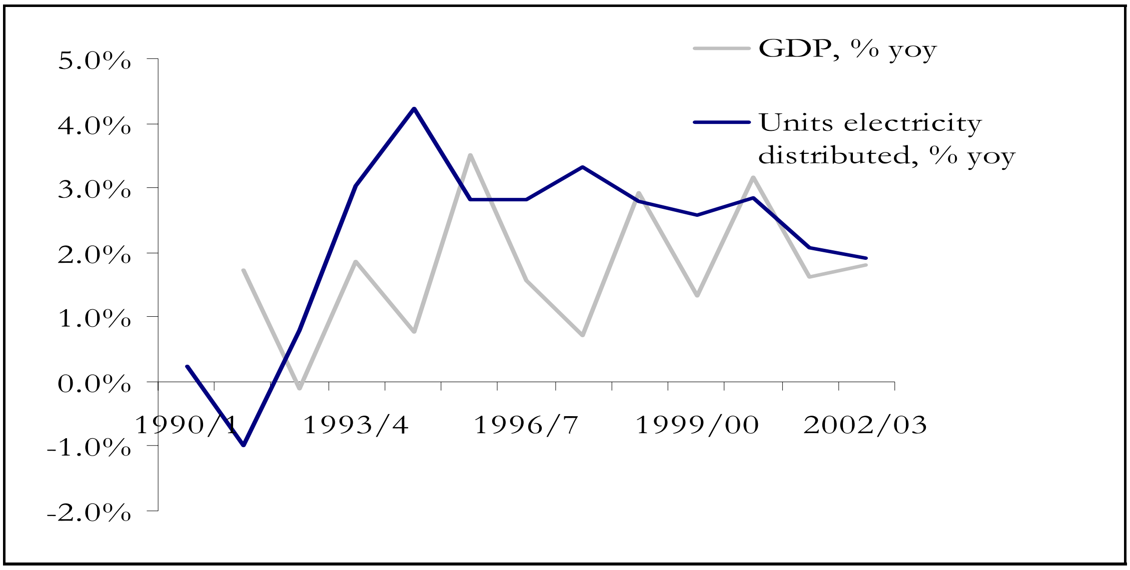
[11] Use of the RAV in TFP rather than CCA would mean that the rate of growth of capital would be higher, but the weighting in the TFP would be lower. These effects might offset each other, so that a "raw" definition of capital could be used. Our calculations for the water industry show that they do not in this case (see Chapter 7 below).

[12] Windfall taxes are not included in operating costs.

in boom periods and downwards during recessions. These effects are not corrected for in the adjustments for scale discussed above, which reflect the elasticity of total costs to scale, rather than short term movements in costs associated with utilisation.

There are two possible methods for overcoming this problem. The first, and most widely used in empirical studies, is to ensure that the period examined covers a whole number of full business cycles. In this way, the under and over statements of TFP cancel each other out. An alternative approach would be to incorporate a capacity utilisation variable into the analysis. However, this latter approach is subject to data availability problems.

Figure 1: Electricity distribution and the business cycle



Source: ONS and Ofgem

For this study we have chosen not to adjust for the business cycle in our analysis of TFP at the sectoral level. The reason for this is primarily that the level of output of network utilities tends to be reasonably immune to the business cycle (Figure 1 provides an illustrative example of the UK electricity distribution business).

However, at the whole economy level, the cyclicality in TFP is more pronounced. For our analysis of whole economy TFP we have therefore sought to ensure that a whole number of full business cycles are incorporated in the analysis of historic performance and that economists' forecasts of GDP performance are incorporated into our assessment of the likely short-term performance going forward.

4.8 Input weights

In constructing the Tornqvist indices, we have used revenue weights for the inputs. So where capital and operating costs are the inputs, we have used operating costs as a share of revenue as the weight on operating costs, and 1-(operating cost/revenue) for the capital input weight. Weights can be chosen to vary over time, or be fixed. If weights vary, the change in the input index reflects both the weighted average change in the inputs, as well as the change in the weights, and the impact of the change in weights is dependent on the choice of the base year. To avoid this, we have chosen to fix the weights using the average revenue share over the period examined.[13]

[13] It is straightforward to show that the % change in TFP index= (capital weight)(%change in capital input) + (opex weight)(% change in opex) + (change in opex weight)(ln(opex)-ln(capex)). The last of these terms is dependant on the choice of how the input variables are normalized.

PART II: ESTIMATES OF TREND PRODUCTIVITY GROWTH

5. TREND PRODUCTIVITY GROWTH FOR THE UK DNOS

The first step in our analysis involved assessing the historic TFP performance of the fourteen UK DNOs in aggregate. This subsection details the data used to calculate the Tornqvist indices, presents the results and then considers how good a guide historic performance is likely to be for the period 2005-10.

5.1 The dataset

The data used for the analysis are drawn from the regulatory accounts of the DNOs as provided by Ofgem. The series used are detailed in Figure 2 below.

Figure 2: DNO dataset

Series	Time period available	Notes
Input variables		
CC operating costs, £m	1990/1 – 2001/2	
CC tangible assets, £m	1990/1 – 2001/2	CC adjustment made for 2000/1 - 2001/2 as figures reported on HC basis.
Output variables		
Customer numbers, m	1990/1 – 2002/3	
Units distributed, GWh	1990/1 – 2002/3	
Network length, '00km	1997/8 – 2002/3	
Other		
Revenue, £m	1990/1 – 2001/2	
Quality variable: Minutes lost	1991/2 – 2001/2	Inverse of series used

Source: Ofgem data, CEPA calculations

The three output variables considered – customer numbers, units distributed and network length - are those used by Ofgem in the 1999 DPCR to benchmark opex. However, due to the short time series available for network length, we decided to omit this variable from our productivity analysis to enable a longer time horizon to be considered. Crosschecking the results including and excluding network length for the shorter time horizon (1997/8-2001/2) revealed that the impact on the estimated productivity growth level was minimal (less than 0.1 percentage point). The two remaining output variables were attributed weights of 2/3 and 1/3, respectively, reflecting their relative weights in the composite scale index used by Ofgem in its 1999 DPCR.

For the TFP calculation, the two input variables were weighted by revenue (i.e. opex/revenue and 1-opex/revenue). For the period under consideration, the average weighting of operating expenditure was 0.47.

The impact of scale economies on distribution companies is of some importance. Ideally, detailed econometric analysis of panel data, or alternatively expert engineering analysis should be used to assess the extent to which productivity growth can be attributed to exploitation of scale economies. One estimate that can be used is the static relationship between costs and scale for distribution companies. One way to estimate this is to do a regression of ln(total costs) against ln (scale variable), and the coefficient on the scale variable will represent the elasticity of scale. For UK DNOs, this gives a scale estimate of approximately 0.7, indicating that an increase of 1% in output will increase costs by 0.7%.[14] Clearly, the static relationship between unit costs of firms and their size may not reflect the impact on costs of an individual firm increasing its size, but nevertheless it provides one tangible estimate of the impact of scale.

This cross-sectional estimate is, however, at the lower end of what we consider the scale elasticity to be. Work on the Swiss distribution sector by Filippini, Wild & Kuenzle (2001) indicates that scale elasticity is around 0.93.[15] Our estimate of scale elasticity for US distribution companies is around 0.82. Kelly (2001) reports on a number of studies, and in particular that of Kwoka (2000). Kelly argues that there is little evidence of economies of scale in distribution, but that there is a cost penalty for very small distribution companies, i.e for companies with less than 8,800 customers, and also a cost penalty for customers that serve 2.9m customers or more. Between these levels, it is argued that returns are effectively constant.

The purpose of adjusting for scale is to improve interpretation of historical data. Given that we have observed economies of scale in the industry to date, it is appropriate that an adjustment should be made to our productivity growth estimates. The evidence from studies above, combined with our cross-sectional estimate indicates that a scale elasticity of around 0.85 is reasonable, and gives a downward adjustment to TFP estimates of around 0.2-0.3 percentage points.

Over the period examined, most DNOs have improved quality by reducing minutes lost by customers, and in some cases minutes lost are less than half of what they were ten years ago. There is a cost associated with this improvement, and it is therefore important to reflect the improvement in assessments of TFP growth. Our quality index was constructed using 1/minutes lost, so that the index increases as quality improves. There is, however, an issue

[14] This estimate implies that economies of scale are not as great as implied by Ofgem's analysis of distribution costs in the 1999 distribution review, but this was based on controllable operating costs only, rather than total costs as used here.

[15] The paper uses "returns to scale", which is the inverse of scale elasticity.

about the weighting of the quality measure in the Tornqvist index. Ideally, the weight should reflect the value of quality compared to other outputs, but it is not straightforward to assess this. One approach would be to use a value of minutes lost, but using a value of lost load of around £2.80/kWh, and around 14GWh of lost electricity, implies a total value of quality of around £40m. This would imply a weighting of around 2% compared to other outputs. Another way of estimating an appropriate weight is the variation in revenue which Ofgem considers to be appropriate in price controls – a variation of +/- 2%, or 4% in total. In our quality adjusted TFP calculations, we have used the higher of these weightings. This weighting on quality means that the impact of quality on the TFP estimates is relatively low.

In theory, mid-year estimates of stock variables should be used to calculate TFP. These are not available, and our calculations indicate that the appropriate correction would have an insignificant effect on TFP.

5.2 Summary results

Figure 3 below sets out a summary of the overall performance of DNOs over a ten year period since 1991/2. Over the ten year period, operating costs have reduced considerably, as indicated by the partial productivity measure, while capital efficiency has changed relatively little. As a result, TFP growth, has been between the two, at 4-4.5%, depending on the precise methodology. Adjusting for quality increases this estimate by only approximately 0.1%.

This is illustrated below in Figure 8. It is clear from the chart that the trend in productivity growth has not been static over the period, and on the basis of this data, unit operating costs have declined substantially in the second part of the period. An analysis of the productivity trend in two separate five year time periods confirms this (Figure 4 and Figure 5). However, the underlying data shows that there was a substantial decline of around 30% in operating costs between 1999/2000 and 2000/1 – the beginning of the present price control period. There is also a noticeable reduction in operating costs in 1994/95 and 1995/6 which illustrates that significant reductions were to be expected as part of the price control cycles. A part of this decline was a result of the change in the treatment of metering activities, which removed revenues of around £100m. We have adjusted for this change in the figures reported below, but even so there was still exceptional performance in 2000/01. We therefore set out a separate table for the last five years, excluding the break year.

Another feature of the data is the dispersion in productivity performance of the different DNOs. This can be seen from Figure 9. Average TFP growth for DNOs ranges between 0.5%pa and 7%pa. Estimates of average PFP (operating costs), which is effectively the same as Real Unit Operating Expenditure, have a similarly wide range.

Figure 3: Aggregate productivity growth estimates for DNOs,1991/2-2001/2

1991/2-2001/2	CRS		Volume adjusted	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	4.4%	4.3%	4.2%	4.1%
TFP inc. quality*	4.5%	4.4%	4.3%	4.2%
PFP, opex only	7.9%	7.9%	7.7%	7.7%
PFP, capital only	1.5%	1.2%	1.3%	1.0%

Source: CEPA calculations

Figure 4: Aggregate productivity growth estimates for DNOs, 1991/2-1996/7

1991/2-1996/7	CRS		Volume adjusted	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	3.4%	2.8%	3.2%	2.6%
TFP inc. quality*	3.5%	2.9%	3.3%	2.7%
PFP, opex only	6.2%	5.1%	6.0%	4.9%
PFP, capital only	1.0%	5.2%	0.8%	0.6%

Source: CEPA calculations

Figure 5: Summary Aggregate productivity growth estimates for DNOs,1996/7-2001/2

1996/7-2001/2	CRS		Volume adjusted	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	5.5%	5.5%	5.3%	5.2%
TFP inc. quality*	5.5%	5.5%	5.3%	5.2%
PFP, opex only	9.6%	9.4%	9.4%	9.2%
PFP, capital only	2.0%	2.1%	1.8%	1.8%

Source: CEPA calculations

Figure 6: Summary Aggregate productivity growth estimates for DNOs,1996/7-2001/2, excluding 2000/1

1996/7-2001/2 excluding 2000/1	**CRS**		**Volume adjusted**	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	2.7%	2.2%	2.5%	2.0%
TFP inc. quality*	2.9%	2.4%	4.2%	2.2%
PFP, opex only	4.2%	3.3%	4.0%	3.0%
PFP, capital only	1.3%	1.3%	1.3%	1.1%

Source: CEPA calculations

Figure 7: Summary Aggregate productivity growth estimates for DNOs,1991/2-2001/2, excluding 2000/1

1991/2-2001/2 excluding 2000/1	**CRS**		**Volume adjusted**	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	3.1%	3.3%	2.9%	3.1%
TFP inc. quality*	3.2%	3.4%	3.0%	3.2%
PFP, opex only	5.4%	6.0%	5.2%	5.8%
PFP, capital only	1.1%	0.9%	0.9%	0.7%

Source: CEPA

Figure 8 Chart of aggregate productivity for DNO

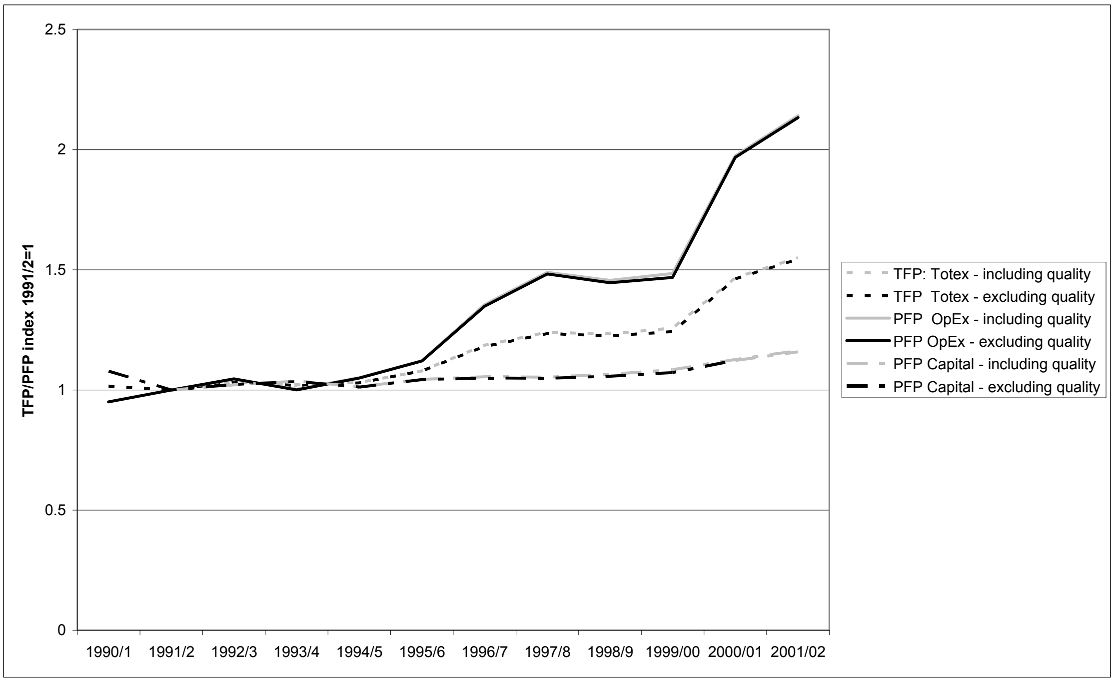
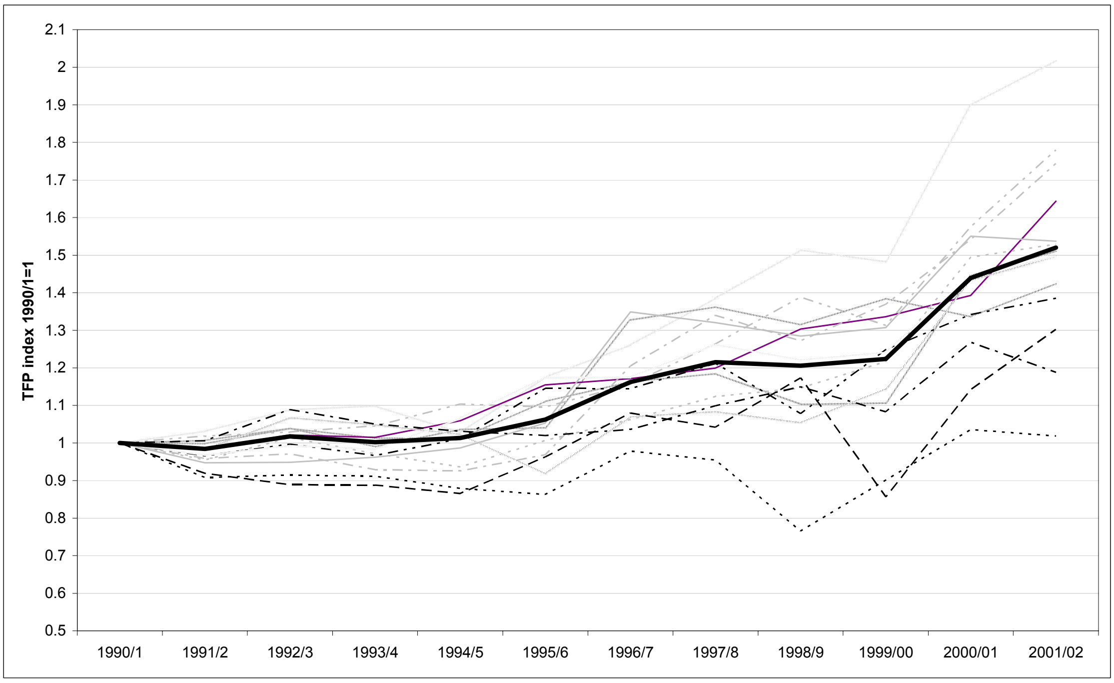


Figure 9: TFP trend for individual DNOs



5.3 Assessment

In the figures above, we show the Compound Average Growth Rate of TFP, as well as the trend figures. The CAGR estimate relies on the precise beginning and end years chosen for the study, and the values of the index in these years is influenced by the regulatory cycle. We therefore prefer to use the trend figures.

The Partial Factor Productivity figures show that there has been a strong real annual reduction in operating expenditure. Over the whole period examined, operating efficiency has improved by nearly 8%. Capital expenditure in networks, however, has ensured that the contribution of capital has improved only slightly (and on a volume adjusted basis has reduced).

The unadjusted trend growth of TFP is 4.3%. Allowing for scale effects, this reduces to 4.1%. As discussed above, quality has improved, and adjusting for this, our central case estimate of TFP growth is around 4.2%. This is, however, sensitive to the precise assumptions used for scale elasticity and quality.

As discussed above, 1999/00-2000/01 may be regarded an outlier, and in addition, trends were different for different time periods. The trends for these time periods, with and without the structural break are set out above. These tables indicate that

- trend operating performance (volume adjusted) was around 5% in the early years, increasing to around 9% in the second period, although this would be 3% if the exceptional 2000/01 data were excluded.
- the ten year trend in opex PFP is 7.7%, reducing to 5.8% if 2000/01 data is excluded;
- trend TFP growth increased from 2.5-3.0% in the first period to 5-5.5% in the second period, although this would be only 2-2.5% if the 2000/01 data were excluded; and
- the ten year trend in TFP is 4.2%, reducing to 3.2% if 2000/01 data is excluded.

Interpretation of these results depends, therefore on whether the significant change in 2000/01 is included in the trend. Our discussions with Ofgem have indicated that they could realistically be the result of improved productivity, and in particular in response to the last price control settlement DPCR 3. These changes happened to occur in one particular year, as a result of the response to the price review, but they could equally have been spread across a number of years. It therefore does seem appropriate to include the data from this exceptional year in the longer term trend. This does, however, mean that exceptional productivity gains are captured in the later rather than earlier years, so it is more appropriate to use a longer term ten year trend, rather than using the recent performance estimate. This issue is discussed further in the conclusions to the report.

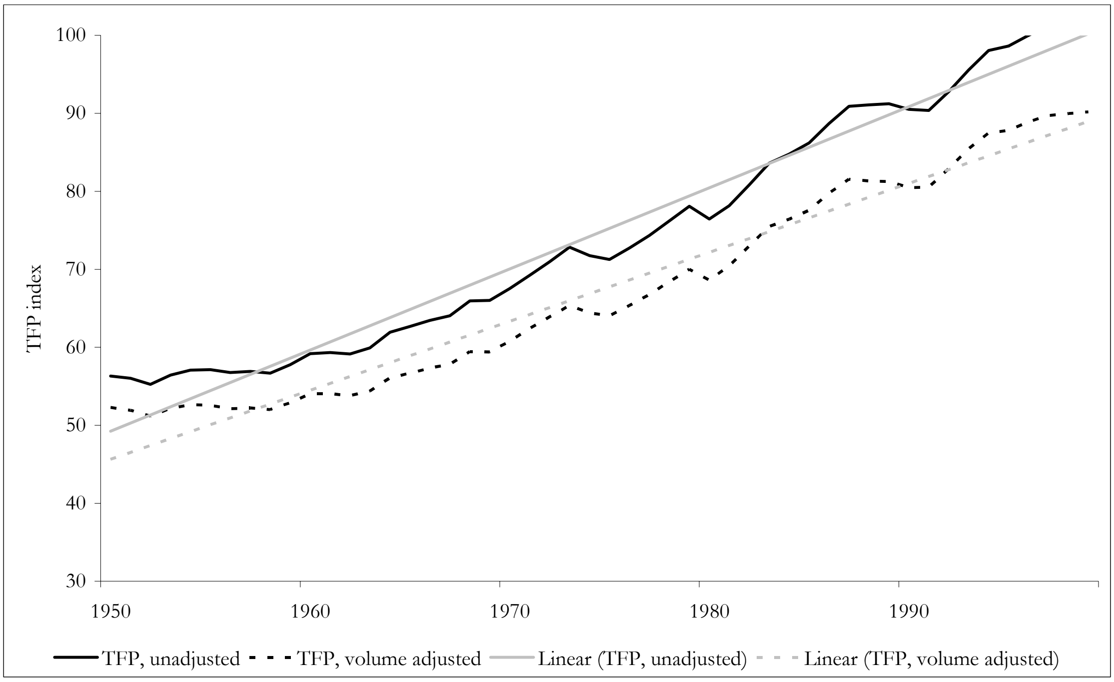
6. Trend Productivity Growth for the UK Economy

This section estimates the trend in TFP for the UK economy as a whole and assesses how good a guide recent performance is likely to be to performance over the coming years. The analysis is based on data produced by the National Institute of Economic and Social Research (NIESR)[16] for the period 1950-1999.

The NIESR dataset is the most comprehensive set of TFP indices calculated on a consistent basis for the economy as a whole and the main industrial groupings for the UK, US and France, and has consistent series on growth rates, levels of labour productivity, capital stocks, and total factor productivity over a 50 year period. We have therefore used this in preference to the labour productivity statistics compiled by the ONS as capturing the impact of capital investment is key, particularly in capital-intensive industries such as electricity distribution.

It is important to note, however, that the NIESR dataset assumes constant returns to scale (CRS). In reality, however, there may be significant scale effects, although these may not be as pronounced at the economy wide level as for individual sectors. We have therefore calculated the TFP trend both on the basis of CRS and taking account of scale effects.

Figure 10: UK whole economy TFP index



Source: NIESR

[16] See O'Mahony & Boer (2002).

Figure 10 shows the TFP indices for the UK economy on the basis of CRS and VRS, with the fitted trend line in each case, while Figure 12 shows the 7 year moving average of the growth in TFP.

The trend rate of TFP growth for the period is 1.4% per annum. Although this provides a good indicator of the long-term TFP growth potential of the UK economy, some refinement is necessary in order to assess the likely performance over the period of interest, 2005-10. First, greater emphasis should be placed on more recent years and, second, consideration needs to be given to whether there is likely to be a near-term fundamental shift in performance.

With respect to the former, we consider UK performance over four time periods:

- ***1974-1999***: It is widely held that a structural break in UK TFP performance occurred in 1973 following the oil crisis. Consequently, our analysis should emphasise the period from 1974 at the earliest.
- ***1979-1999***: The process of economic liberalisation and deregulation only commenced in the UK in 1979 with the advent of the Thatcher government. There therefore may be a case for considering data only from this point.
- ***1990-99***: This period arguably captures one complete business cycle (Figure 13) and so provides an estimate of trend TFP growth of the most recent full business cycle for which data are available.
- ***1995-99***: Finally, we also examine the most recent five years for which data are available.

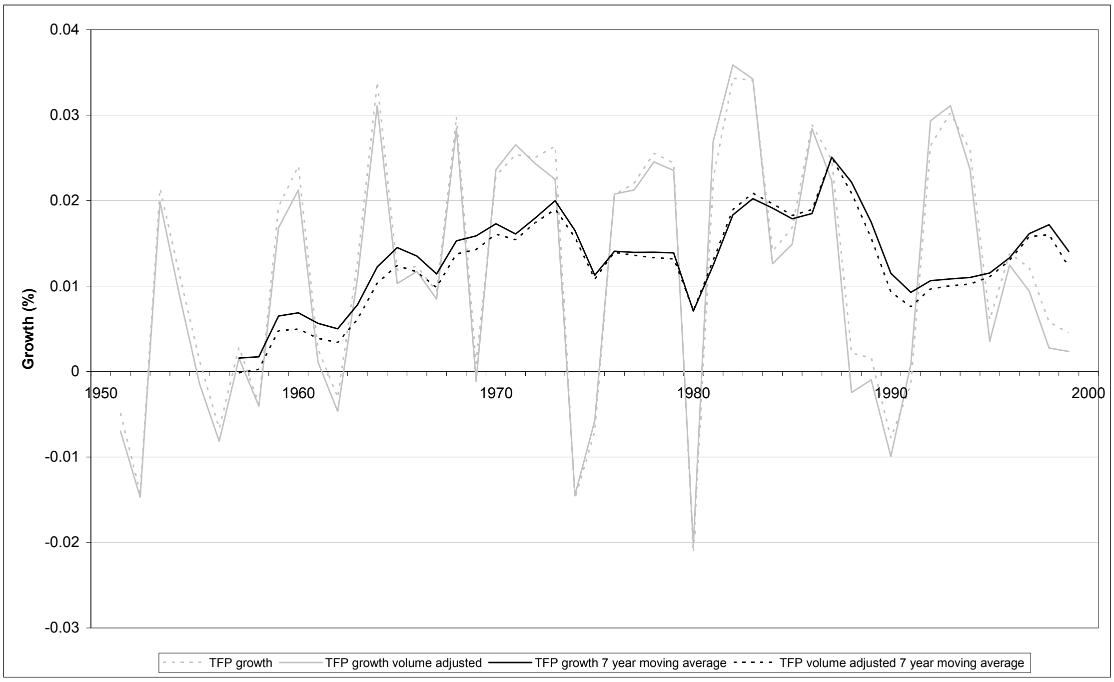
The trend TFP growth rates for each of the four periods are presented in Figure 11.

Figure 11: UK whole-economy TFP growth

	TFP, CRS	TFP, volume adjusted
1974-1999	1.43%	1.36%
1979-1999	1.36%	1.27%
1990-1999	1.36%	1.28%
1995-1999	0.91%	0.67%

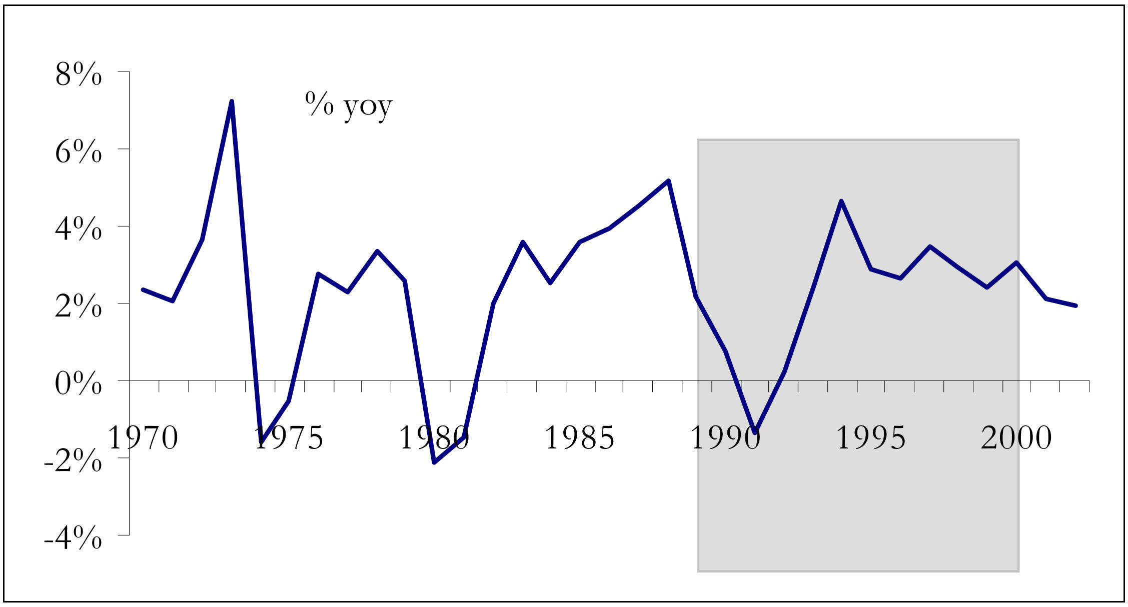
Source: NIESR data and CEPA calculations

Figure 12: UK whole-economy TFP growth



Source: NIESR and CEPA calculations

Figure 13: UK real GDP growth



Source: ONS

As can be seen from Figure 11, the trend in TFP growth is reasonably invariant to the time horizon chosen post 1974, with the exception of the last five years. The marked slowdown in growth in the period 1995-1999 reflects the slowdown in GDP growth in those years, in other words, it reflects TFP growth in the down cycle only of the most recent business cycle for which we have data. It does not represent a structural break. Consequently, emphasis should not be placed on this apparent reduction in the TFP growth trend. Instead, we focus on the trend growth rate over the latest whole business cycle, 1.3% on a volume-adjusted basis.

Clearly, whether recent trend growth rate is likely to be sustained over the period 2005-10 will depend on growth prospects for the UK economy. While expectations for 2003 have been weak, most forecasters expect growth to recover in 2004, and forecasts for the period 2005-10 are in line with UK trend GDP growth, in the range 2.4-2.5% (HM Treasury 2003).

We therefore conclude that, for the UK economy as a whole, TFP growth is likely to be in line with the long term historic growth rate of 1.3%.

7. Trend Productivity Growth for Other UK Regulated Network Utilities

The UK privatised network utilities provide a reasonable comparator group for the DNOs as their ability to realise TFP improvements is affected by many shared characteristics, and in particular: legacy inefficiency resulting from state ownership; the importance of previous decisions on fixed investment; universal service obligations and similarities in nature of work; and the regulatory and competitive environment.

This section examines the TFP performance of other UK privatised network utilities, in particular:

- electricity transmission;
- the water and sewerage industry;
- fixed line telecommunications; and
- rail infrastructure.

The methodology followed is, as far as possible, identical to that conducted for the analysis of the DNOs' TFP performance to enable direct comparison of the results. For each industry, consideration is given as to the extent to which the results inform the assessment of the DNOs' future TFP performance. In particular, consideration is given to the stage the industry is at in terms of restructuring and deregulation, the industry's business cycle and any industry-specific factors.

7.1 Electricity transmission

The National Grid Company was established at the time of electricity industry restructuring in 1990 as the transmission owner and operator for England & Wales. Initially owned by the Regional Electricity Companies, it was independently listed in 1995.

7.1.1 The dataset

The data on electricity transmission was provided to us by Ofgem. In addition to regulated business, the data contain information on non-regulated activities, but this represents an extremely small proportion of the activities, and the split is not available. From 1997/8, National Grid accounted for Transmission System Services, essentially associated with incentive schemes for undertaking system operation roles. These are of a different nature from the network ownership and operation business, and so we have removed them from our analysis.

The quality measure used here was system availability, which is bounded above by 1. Clearly this could be supplemented by other measures such as deviations outside statutory voltage levels; we have used a single measure for simplicity. In the quality adjusted TFP measure, we have used a 4% weighting on quality, as for the DNOs.

Figure 14: NGC dataset

Series	Time period available	Notes
Input variables		
CC operating costs, £m	1990/1 – 2001/2	Excludes exceptionals and TSS costs
CC tangible assets, £m	1990/1 – 2001/2	2001/2 figure estimated as accounts only available on HC basis
Output variables		
Electricity requirements, TWh	1990/1 – 2001/2	
Other		
Revenue	1990/1 – 2001/2	
Quality variable: Average system availability, %	1990/1 – 2001/2	

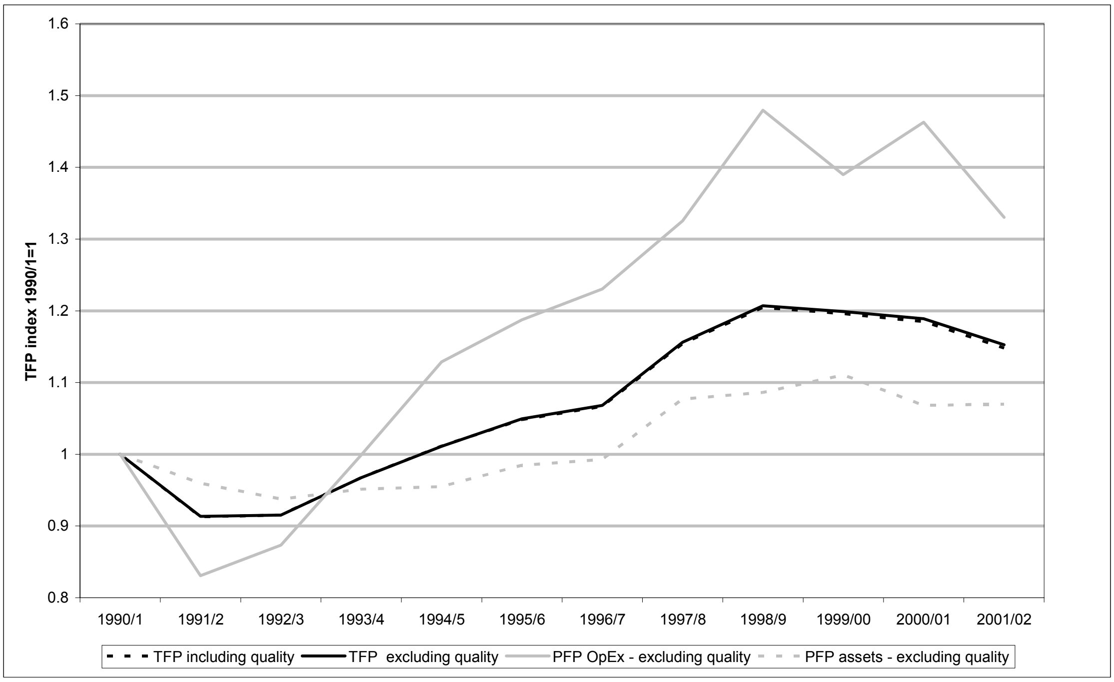
7.1.2 Summary results

Figure 15: Summary results for NGC

1990/1 – 2001/2	CRS		Volume adjusted	
	CAGR	Trend	CAGR	Trend
TFP	1.3%	2.6%	1.2%	2.5%
TFP including quality	1.3%	2.6%	1.1%	2.4%
PFP, opex only	2.6%	5.0%	2.5%	4.9%
PFP, assets only	0.6%	1.4%	0.5%	1.2%

Source: CEPA calculations

Figure 16. National Grid Productivity trends.



Source: CEPA

7.1.3 Assessment

NGC has shown a marked improvement in operating costs, with opex Partial Factor Productivity showing a trend improvement of approximately 5% pa. Including the impact of capital efficiency, though, means that TFP has grown at a slower rate of 2.4%. The low weighting on quality means that this does not have a significant impact on the results.

The TFP measure probably understates the impact of NGC's productivity improvements. We have focused our analysis on the network activities (Transmission Operations), and have not included the impact on system operations as a result of the uplift incentive schemes, and more recently its expanded role in the operation of the balancing market.

7.2 Water and sewerage

The water industry in England & Wales comprises ten water and sewerage companies (WASCs), and fourteen water only companies. The industry was privatised in November 1989, and price-cap regulation established for the industry at the same time, with prices set every 5 years.

Most customers in England & Wales are served by the ten WASCs, with the remaining companies accounting for only 6% of regulatory capital value. In addition, we consider that these companies are less representative than the larger companies in comparing performance to DNOs. We have therefore focused our attention on these companies. We have, however, undertaken the analysis separately for water, sewerage, and the combined service.

As an output variable, we have used volume of water delivered to customers.[17] This is the natural physical output that customers value. Other studies have used alternative measures, and in particular, Europe Economics (2003) has used a measure of "base service" against which to measure productivity improvements. This is used to assess the cost of providing a constant service, and excluding the cost of providing enhanced service (e.g. for additional quality). This approach does have value in measuring how well companies are performing what regulators have asked them to do, and avoids the need to adjust separately for quality. However, additional insights into productivity growth can be gained by understanding the costs of providing what customers care about – water delivered – and separately adjusting for quality depending on the value attributed to it.

There are two important issues that need to be reflected in our assessment of water industry TFP:

- the size of the regulatory asset value compared to the CCA asset base distorts the assessment of TFP, and
- since privatisation, the sector has undertaken a large investment programme to improve quality.

The discount of the RAV to the CCA asset base is important – on privatisation, the RAV was around 20% of the CCA asset value. This difference persists, and the regulatory framework ensures that it will continue. What this means is that if the share of capital costs in the overall calculation of TFP is determined with reference to actual revenues, which are based on allowing a return on the RAV rather than the CCA asset base, it will understate the capital intensity of the industry. This would distort the estimate of TFP growth, placing a higher weight on operating expenditure rather than the capital invested in the business.

Because of the significance of this in the water industry, we have adjusted our weightings of the inputs in our TFP estimation, so that the weights reflect the underlying CCA value of assets, rather than the RAV value. This decreases TFP growth estimates by about 0.5%.

[17] The water delivered measure we used is water input into the system, less leakage, less water used within the system.

As described in the methodology section above, in addition to "raw" TFP estimates, we have adjusted for changes in quality in our assessment. To do this, we have constructed a quality index, which is based on data supplied by Ofwat on:

- the number of properties at risk of low pressure
- the number of unplanned interruptions
- number of properties subject to sewer flooding
- billing contacts not responded to (a measure of customer service)
- written complaints not responded to (a measure of customer service)[18]

A quality index has been constructed from these data, with highest weights placed on the first three variables.

We considered two ways to estimate the weight placed on quality in the output index:

- a weight reflecting the value of inputs used to obtain the increases in quality. Using data provided by Ofwat[19], we calculated the proportion of capital expenditure used for system enhancement for quality, and for other purposes. For water, this proportion is 50%, for sewerage, 32%, and on average, 42% for water and sewerage together.
- a weight reflecting customers' valuations of quality. In a survey conducted for Water Voice by MORI in August 2002, customers expressed general satisfaction with levels of quality. Customers would be prepared to pay for some specific additional quality measures, but less than one in eight people said that they would be prepared to pay more than £5 for additional quality.[20] This indicates that a reasonable maximum weighting on quality could be considered to be 2.1%, or £5 as a proportion of the average customer bill of £234.[21]

There is clearly a very wide gap between these two estimates, and as will be seen below, this will have a very significant impact on the quality adjusted TFP estimates. The choice between these two weights should reflect the purpose for which estimates are being used. In this study, we are attempting to measure trend industry efficiency to compare with other industries, and this means that a weighting reflecting the cost of quality enhancements

[18] Number of customer complaints is also a potential measure, but can be distorted in specific years by environmental factors (e.g. drought).

[19] In Financial Performance of the water companies in England & Wales, published annually by Ofwat.

[20] Environment, Food, and Rural Affairs Committee, Water Pricing Inquiry,. Memorandum of Evidence by Water Voice, 17 October 2003.

[21] Setting water and sewerage price limits for 2005-10: Overview of companies' draft business plans Ofwat, 16 October 2003.

should be used, rather than one which reflects the value of those enhancements by customers.

As with electricity, we have made adjustments for scale effects using the static relationship between size and costs exhibited by a cross-section of data. For water, our cross-section estimate of scale elasticity is 0.77, and we have used this to make our volume adjustments. However, low volume growth means that this estimate has little effect on the overall estimate of productivity growth.

7.2.1 The dataset

The data used for the analysis are drawn from the regulatory accounts of the water and sewerage companies (WASCs) as published by Ofwat. The series used are detailed in Figure 17 below. Although much of the data is available for 10 years or more, we have restricted our calculations to the period since 1994/5. This is the time from when we have a consistent time series for all variables. In addition, it eliminates the period shortly after privatisation when greater potential efficiency savings were available.

Figure 17: Water and sewerage dataset

Series	Time period available	Notes
Input variables		
CC operating costs, £m	1991/2 – 2001/2	
CC net MEA, £m	1990/1 – 2001/2	
Output variables		
Customer numbers	1995/6 – 2002/3	
Water delivered, sewerage collected, Ml/day	1993/4 – 2001/2	Data for water delivered extends back to 1991/2
Other		
Revenue, £m	1991/2 – 2002/3	
Post-tax allowable return on capital, %		
RAV, £m	1991/2 – 2001/2	Split between water and sewerage assumed to be in same proportions as for net MEA
Quality variables	1991/2-2001/2 (but consistent data since 1994)	Inverse of series used

Source: Ofwat

7.2.2 Summary results

The results for the WASCs in aggregate are provided in Figure 18 below, with separate data for water, sewerage, and water and sewerage combined. Figure 20 shows the results with quality adjustment using the capex weighting, which places a lower weighting on the quality variable.

Figure 18: Aggregate productivity growth for water and sewerage industry, 1994/5 – 2001/2

1994/5 – 2001/2	CRS		Volume adjusted	
	CAGR	**Trend**	**CAGR**	**Trend**
Water and sewerage				
TFP	-0.1%	-0.3%	-0.1%	-0.3%
TFP including quality	6.1%	7.7%	6.1%	7.7%
PFP, opex only	2.0%	1.3%	2.0%	1.3%
PFP, opex only, including quality	8.3%	9.4%	8.3%	9.4%
PFP, assets only	-0.5%	-0.6%	-0.5%	-0.6%
Water only				
TFP	-0.8%	-1.0%	-0.8%	-1.0%
TFP including quality	5.4%	10.2%	5.4%	10.2%
PFP, opex only	2.0%	1.7%	2.0%	1.7%
PFP, assets only	-1.8%	-1.9%	-1.7%	-1.8%
Sewerage only				
TFP	0.4%	0.3%	0.4%	0.3%
TFP including quality	2.9%	1.5%	2.9%	1.5%
PFP, opex only	2.0%	0.9%	2.0%	0.9%
PFP, assets only	0.2%	0.2%	0.2%	0.2%

Source: CEPA calculations

Figure 19: Aggregate productivity growth for water and sewerage industry, 1995/6 – 2001/2

1996/7– 2001/2	CRS		Volume adjusted	
	CAGR	Trend	CAGR	Trend
Water and sewerage				
TFP	0.3%	0.7%	0.3%	0.7%
TFP including quality	4.2%	4.3%	4.2%	4.3%
PFP, opex only	1.4%	1.6%	1.4%	1.6%
PFP, opex only, including quality	5.3%	5.2%	5.3%	5.2%
PFP, assets only	0.1%	0.5%	0.1%	0.5%

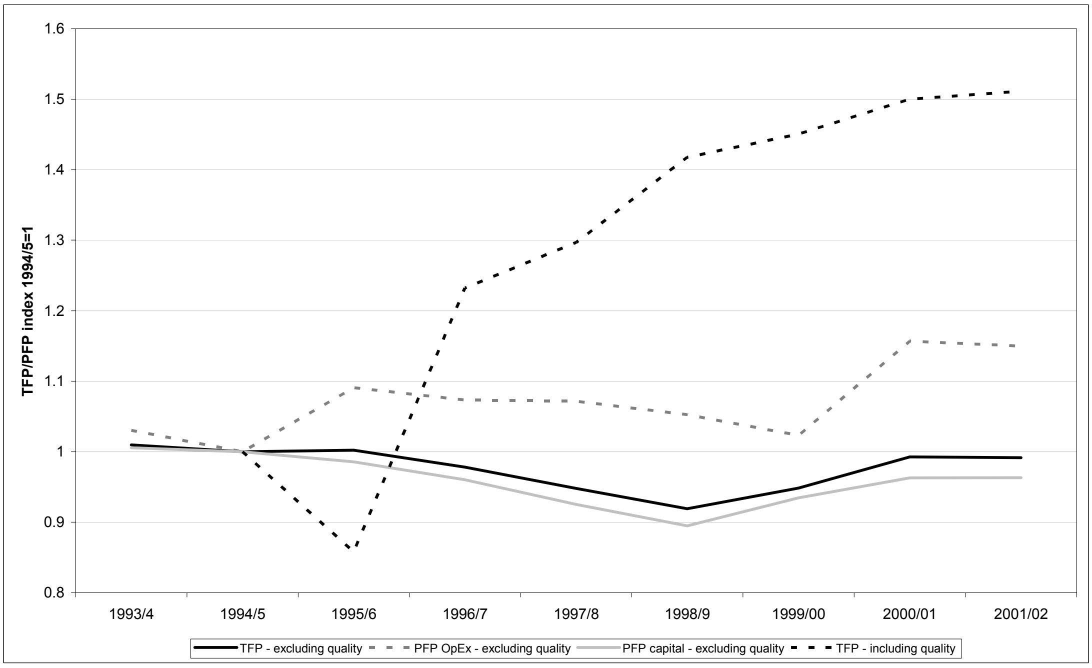
Source: CEPA

Figure 20. Aggregate productivity growth for Water & Sewerage companies with customer value weighted quality adjustment

	CAGR	Trend	CAGR	Trend
TFP growth including quality adjustment				
Water and sewerage	0.2%	0.1%	0.2%	0.1%
Water only	-0.6%	-0.5%	-0.6%	-0.5%
Sewerage only	0.5%	0.4%	0.5%	0.4%

Source: CEPA

Figure 21. Trend Productivity Indices for the England & Wales Water & Sewerage Companies.



Source: CEPA

7.2.3 Assessment

One of the main features of the water industry in the years since privatisation has been the immense capital programme, which is set to continue over the coming years. A major driver behind this has been the need to improve quality, in part determined by EU legislation. The industry CCA asset value has grown over this time from £130bn to over £180bn.

This growth in the use of capital means that raw TFP growth figures show that TFP productivity has declined very slightly. For water and sewerage combined, TFP has declined by 0.3%pa, with a larger decline for water, and a slight growth in TFP for sewerage. The PFP estimates show that there has been a modest improvement in operating efficiency, but a decline in capital efficiency, largely reflecting the capital spending programme.

Including quality, using the capex weighting, shows that trend growth is much higher, at 7.7%pa. This figure will include exceptional productivity gains made in the early years following privatisation. We have therefore calculated trend growth using data from the last five years, shown in Figure 19, which is likely to give a more reliable assessment of the trend for the next five years.

Our base PFP opex productivity growth estimates are around 1.3-2%. These are lower than have been estimated by other studies, and in particular Europe Economics (2003) have calculated cost savings for water companies in the range 1.7-6.5%, with an average level that is around 5%.

The reason for the difference between these estimates and ours is probably the measure of the output variable. As discussed above, Europe Economics use a measure of "base service", and assess the cost of delivering this, whereas our 2% trend estimate refers to the unit costs of delivering water to customers. Our PFP opex growth estimate including the adjustment for quality (with capex weighting) is between 8.3-9.4%. The trend for the last five years is 5.2-5.3%.

7.3 Gas network activities

The network infrastructure activities of British Gas, subsequently Lattice, and now owned by NGT also provide an obvious comparison for the DNOs. The business has, however, been extensively restructured over the last few years, and hence consistent time series data has not been made available to us. We have, therefore, not included any gas industry comparisons in this work.

7.4 Fixed line telecommunications

BT was formerly the government owned monopoly telecoms provider. It was privatised in 1984, and since then the industry has exhibited enormous structural and technical change. In assessing the change in TFP for BT, we have considered the regulated network segments of the business, and in particular have obtained data on the following segments:

- network;
- access; and
- retail systems.

7.4.1 The dataset

We have obtained all data on BT from its regulatory accounts, supplied to us by BT. We have used data only from 1997/8, as data is not available on a consistent basis prior to this. Operating costs have been taken as the sum of the operating costs for the three business segments identified above, excluding inter-business transfers. For the output data, we have used a weighted average of two outputs: the number of exchange lines, and the number of call minutes. As the BT network is used for routing calls not originated by BT customers, calls made by call carriers is used.

Figure 22: BT dataset

Series	Time period available	Notes
Input variables		
CC operating costs, £m	1997/8 – 2001/2	
CC tangible fixed assets, £m	1997/8 – 2001/2	
Output variables		
Number of exchange lines, '000s	1983/4 – 2001/2	End period data
Call minutes, m	1997/8 – 2001/2	Includes local, national, international and calls to mobiles
Other		
Revenue	1997/8 – 2001/2	

7.4.2 Summary results

Figure 23: Summary results for BT

1997/8 – 2001/2	CRS		Volume adjusted	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	11.2%	13.2%	11.2%	13.2%
PFP, opex only	9.4%	11.9%	9.3%	11.9%
PFP, asset only	16.8%	17.1%	16.8%	17.0%

Source: CEPA calculations

7.4.3 Assessment

BT has achieved impressive growth in total factor productivity. Not only has operating performance improved, but the limited capital spending means that capital efficiency has also improved markedly. While the changes in BT's TFP are interesting, we do not think it appropriate to place much weight on them in forming views about the estimates of DNO TFP growth:

- the industry is subject to much faster technological change, so the business environment is very different;
- asset lives are shorter, because of the technological change;
- the time frame over which reliable data is available is relatively short; and

- the company has had well publicised financial problems, which while they did not relate primarily to the regulated part of the business may have caused distortions.

7.5 Rail Infrastructure

Railtrack was established as the owner and operator of the railway network infrastructure in 1994, and was listed on the stock market in 1996. It was placed into administration in 2001, and Network Rail Ltd subsequently acquired Railtrack plc in 2002. It is regulated by the independent rail regulator.

7.5.1 The dataset

The source for all the productivity data was Railtrack's regulatory accounts. The input variables used to construct our TFP index were the appropriate operating costs and CCA assets, as with other network industries, with weights derived from revenue shares as before. For outputs, we used a mix of passenger and freight train usage of the network. In this case, we were able to apply revenue weights to the outputs to reflect the value of their respective contributions to output.

Scale effects for rail infrastructure also need to be estimated. Many academic studies have provided estimates of the extent of economies of scale (and density) in the rail industry. In most cases estimates have been made for railway systems, rather than rail infrastructure, and in general increasing returns to scale and density have been observed. However, some evidence of diseconomies have been noted by some authors for high-density systems in Europe, including Britain.

Few estimates exist for rail infrastructure costs alone. NERA (2000) found strong evidence of increasing returns to scale and density for US Class I railroad infrastructure provision. In particular, the coefficient on the traffic density coefficient indicated that an increase in traffic levels of 10% (on a fixed network) would lead to a 6% fall in unit costs. Separate analysis of Railtrack's costs - conducted as part of the 2000 Periodic Review of the company's finances - found only 17% of the company's maintenance and renewal costs to be related to traffic volumes, though this analysis was conducted prior to the Hatfield accident (see Pollitt and Smith, 2002). With mixed evidence, the estimates below assume a scale elasticity of 0.9.

In this analysis we have not included a quality variable, although clearly with developments in the industry, it is extremely important to do so. Many of the obvious quality variables (e.g. % of trains more than 5 minutes late, congestion measures) relate to the train operators rather than Railtrack's operations.

Figure 24: Railtrack dataset

Series	Time period available	Notes
Input variables		
CC operating costs, £m	1995/6 – 2001/2	
CC net assets, £m	1994/5 – 2001/2	
Output variables		
Passenger train km	1994/5 – 2001/2	
Freight train km	1994/5 – 2001/2	
Other		
Revenue, £m	1994/5 – 2001/2	

7.5.2 Summary results

The trend in productivity indices for Railtrack is illustrated in Figure 27, and our estimates of productivity growth are set out in Figure 25 and Figure 26. The tables show estimates from 1995/6, and from 2000/1, because of the break in the series following the Hatfield accident.

Figure 25: Productivity growth estimates for Railtrack, 1997/8-2001/2

1995/6 – 2001/2	CRS		Volume adjusted	
	CAGR	Trend	CAGR	Trend
TFP	3.0%	3.3%	2.6%	2.9%
PFP, opex only	5.9%	6.3%	5.5%	5.9%
PFP, assets only	-1.5%	-1.1%	-1.9%	-1.5%

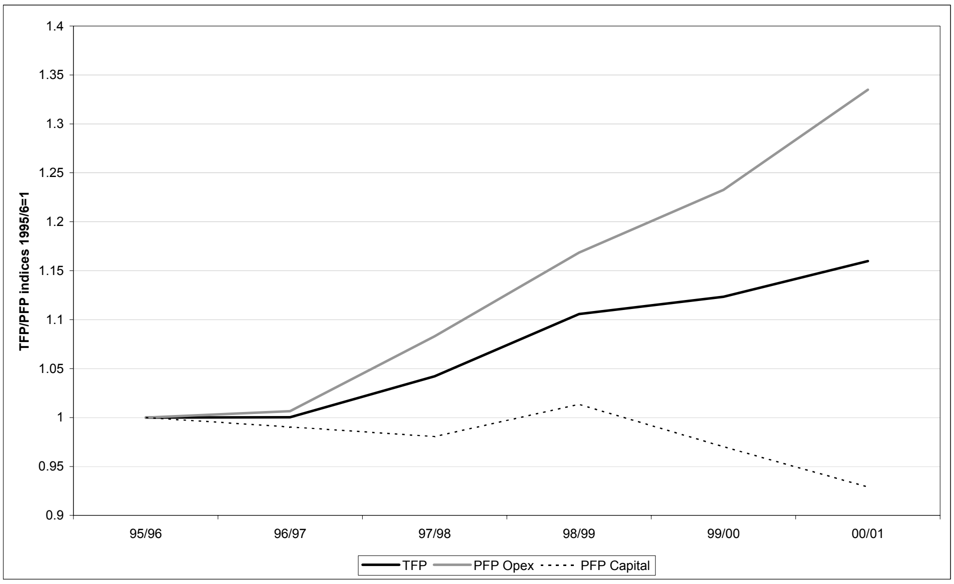
Source: CEPA calculations

Figure 26: Productivity growth estimates for Railtrack, 2000/1-2001/2

2000/1 – 2001/2	CRS
	CAGR
TFP	3.2%
PFP, opex only	8.3%
PFP, CCA only	-4.3%

Source: CEPA

Figure 27 Productivity indices for Railtrack



Source: CEPA calculations

7.5.3 Assessment

Over the period assessed, Railtrack did cut reported operating costs, and operating efficiency rose substantially with the large increase in output (passenger train km increased from 372,000 to over 427,000 over the period under consideration, an average increase of 2.7%pa). Capital efficiency declined, resulting in an overall growth in TFP of 2.9%.

In the year following Hatfield, this trend continued with a reduction of operating expenditure, and a further decline in capital efficiency, following a large increase in capital spending. These effects increased the contribution of capital.

We think that the recent history of the rail industry makes it very different from electricity distribution. There has been a history of chronic under-investment, and following a series of high profile fatal accidents a massive investment programme has begun, with continued sector restructuring. We therefore think little weight should be placed on these results in determining potential TFP growth of distribution companies.

8. TREND PRODUCTIVITY GROWTH FOR INTERNATIONAL COMPARATORS

There are companies involved in electricity distribution in all developed countries, and this would appear to provide a potentially rich source of data to assess potential efficiency. However, electricity industries are by no means homogenous:

- the way in which the sector is organised is different in each country, with different degrees of vertical integration;
- the definition of distribution activities is different. Distribution can cover operation of systems of different voltages to those in the UK;
- different styles of regulation can place different incentives on companies to those in the UK; and
- the environment may make the cost structure very different.

All these factors make comparison of UK distribution with other countries difficult. Ideally, in making comparisons with international companies, one would attempt to identify the "efficiency frontier", which reflected the different characteristics of the industry. Using Malmquist indices, one would split out "catch up" from "frontier shift" components. While this is clearly possible, it is beyond the scope of this study. However, even if differences between individuals firms are too difficult to determine, the technological and other factors driving costs in the UK are likely to be similar to those in other countries. Thus, general trends in productivity might converge internationally, and TFP trends might also converge.

For this reason, we have collected data from two countries, to provide guidance on TFP growth.

We believe that assessing the performance of electricity distribution companies internationally is a key component of the analysis. Including international distribution firms in the analysis increases the chances of capturing best practice and is particularly relevant given the increasing internationalisation of the industry. However, international comparisons must be undertaken with care to ensure that comparator companies display similar characteristics, for example in terms of size and structure. We therefore selected a number of distribution companies that we believe to be appropriate comparators from Norway, Netherlands and US, for which high quality data are available.

The resulting TFP trend for these companies would then provide guidance as to the likely rate of improvement in the international efficiency frontier for the sector. Of the countries selected, data was readily available for the US, and Norway.

For the US, detailed data on all companies undertaking electricity distribution is provided to FERC in the annual FERC form 1 submissions, and this data is published. Detailed accounting and operating data is provided separately for distribution activities. Because of the large number of companies, not all of which are representative of conditions that might be faced by UK DNOs, we focused our attention on the largest 50 companies. All data, however, is historic cost, rather than current cost, and our TFP calculation therefore required an estimate of the CCA asset value.

The estimate of CCA asset value was derived using the following steps:

- first, estimate the ratio of CCA asset value to HCA asset value in the starting year for which we are using FERC Form 1 data (1990). Construct an estimate of ratio of real CCA depreciation to asset value;
- use these ratios to estimate the start year CCA asset value, and first year real CCA depreciation;
- estimate a CCA depreciation series, assuming that $\text{depreciation}_t = \text{depreciation}_{t-1} + \text{investment}_t/\text{asset life}$. We have assumed that asset life =40; and.
- use the starting asset value, the depreciation and investment series to estimate CCA asset values, that can be used in the TFP calculation.

The first step in this estimation requires additional assumptions, and the steps to make this estimate are:

- obtain a time series of asset value data for the electricity industry from the EIA in the US[22], and use this to obtain a time series of nominal investments made, with 1977 as the first year;
- convert the series for capital investment into 2001 prices;
- derive an estimate of HCA assets for 1997 to a CCA estimate, by multiplying by the price index;
- derive a depreciation series, again assuming that $\text{depreciation}_t = \text{depreciation}_{t-1} + \text{investment}_t/\text{asset life}$. We have assumed that asset life =40.
- derive the CCA asset series using the CCA asset starting value, investment and depreciation series; and
- these series can be used to calculate the ratio of CCA to HCA asset values, and CCA depreciation / CCA asset value.

[22] Obtainable from eia.gov.us.

The data set for Norwegian companies was provided to us by the Norwegian regulator via Ofgem. Again, we focused on the largest companies, using data on the largest 25 companies. As with the US, no CCA asset series was provided, but a similar adjustment was used to obtain an estimate of capital inputs.

A summary of the data series used, and the outputs are set out in the tables below.

Figure 28. US distribution company data.

Series	Time period available	Notes
Input variables		
Distribution operating costs, $m	1992-2001	Calculated as distribution expenses plus distribution share of general admin and overhead prices.
Adjusted assets, $m	1992-2001	HCA assets provided. CCA assets estimated based on profile of capital expenditure
Output variables		
Units distributed, MWh	1992-2001	
Customer numbers,	1992-2001	

The results of the estimates for the US companies are set out below.

Figure 29. TFP results for US distribution

1992-2001	**CRS**		**Volume adjusted**	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	2.4%	2.6%	2.0%	2.2%
PFP, opex only	0.5%	0.9%	0.2%	0.5%
PFP, assets only	4.3%	4.4%	3.9%	4.0%

Source: CEPA

Figure 30. Norwegian distribution company data

Series	Time period available	Notes
Input variables		
Distribution operating costs, NOKm	1996-2001	
Adjusted assets, NOKm	1996-2001	HCA assets provided. CCA assets estimated based on profile of capital expenditure
Output variables		
Units distributed, MWh	1996-2001	
Customer numbers,	1996-2001	

Figure 31. TFP Estimates, Norwegian distribution companies

1996-2001	**CRS**		**Volume adjusted**	
	CAGR	**Trend**	**CAGR**	**Trend**
TFP	0.5%	0.4%	0.3%	0.2%
PFP, opex only	2.0%	1.8%	1.8%	1.6%
PFP, assets only	-0.9%	-0.9%	-1.1%	-1.1%

Source: CEPA

The US shows a trend volume adjusted TFP growth of 2.2%. It is interesting to note that this is comprised of a relatively low growth in operating efficiency (0.5%), and a larger growth in capital efficiency (4.0%). Indeed, the growth in capital efficiency is in part a result of falling real capital values in distribution. This is consistent with studies of US capital expenditure in network infrastructure, which has been declining for a number of years.

Norway shows a higher trend in operating efficiency, with PFP opex of around 1.6%, and a lower trend TFP growth rate of 0.2%, with operating efficiency offsetting what appears to be worsening capital efficiency. It could, however, be the result of capital expenditure designed to improve quality, for which we have made no adjustment in this analysis.

9. SECTORAL AND COMPOSITE SECTORAL ESTIMATES

The National Institute of Economic and Social Research (NIESR) dataset described in chapter 6, and used there to estimate trend growth in productivity for the UK economy also contains sectoral estimates of productivity and some of the underlying series. This dataset has been used by O'Mahony & Boer (2002) to assess the productivity performance of the UK economy. We use this data set in two further ways:

- to make an estimate of trend total productivity growth for the utilities sector;
- to construct an estimate of trend growth using trend growth in other sectors, or a "composite sector" estimate.[23]

9.1 Sectoral estimates

Estimates of TFP growth and labour productivity for utilities companies in four different countries over different time periods are set out in the tables below.[24] From this analysis, the following observations can be made:

- in the UK, trend TFP growth was relatively stable until 1990, but has risen by around three quarters of a percentage point since then;
- trend TFP growth in other countries has been lower than in the UK since 1974, but slowed further relative to the UK in the 1990s;
- similar trends for TFP can be observed for labour productivity; the UK showed a sharp increase in labour productivity in the 1990s, while labour productivity in other countries declined; and
- the trend growth in TFP for US electricity at around 1.9% is consistent with the 2.2% estimate made by analysis of company data, although labour productivity estimated from the NIESR data set is higher than from the company data analysis.

Figure 32 Estimates of utilities TFP growth from NIESR productivity dataset

Country	Sector	1950-99	1974-99	1990-99
UK	Electricity, gas & water	2.9%	3.0%	3.7%
France	Electricity, gas & water	4.8%	2.4%	1.8%
Germany	Electricity, gas & water			1.4%
US	Electricity	2.3%	0.7%	1.9%
US	Gas	1.9%	-0.2%	0.3%
US	Electricity, gas & water	1.9%	-0.2%	0.3%

Source: CEPA calculations based on NIESR data

[23] Other studies, e.g. Europe Economics (2003) refer to this as a "Nature of work" assessment.

[24] The data for Germany is only included following reunification.

Figure 33 Estimates of utilities TFP growth from NIESR productivity dataset – volume adjusted

Country	Sector	1950-99	1974-99	1990-99
UK	Electricity, gas & water	2.5%	2.8%	3.4%
France	Electricity, gas & water	4.4%	2.1%	1.5%
Germany	Electricity, gas & water			1.2%
US	Electricity	1.8%	0.5%	1.7%
US	Gas	1.7%	0.0%	0.4%
US	Electricity, gas & water	1.4%	-0.4%	0.2%

Source: CEPA calculations based on NIESR data

Figure 34 Estimates of utilities labour productivity growth from NIESR productivity dataset

Country	Sector	1950-99	1974-99	1990-99
UK	Electricity, gas & water	5.8%	5.7%	9.0%
France	Electricity, gas & water	6.9%	4.2%	2.9%
Germany	Electricity, gas & water			4.7%
US	Electricity, gas & water	3.2%	1.0%	2.0%

Source: CEPA calculations based on NIESR data

9.2 Composite sector analysis

A number of regulators have commissioned composite sector or "Nature of Work" studies to provide estimates of the trend in factor productivity. Two examples of these were work done for Ofwat[25] and Transco[26]. Essentially what this type of analysis does is to:

- estimate sectoral TFP estimates from economy-wide datasets;
- using expert judgement, assess the proportion of the regulated industry being examined represented by activities of each sector; and
- weight the sectoral TFP growth estimates with these proportions to arrive at an overall growth forecast.

We have undertaken this analysis here. Using the NIESR data set, we have estimated the trend in TFP growth for sub-sectors of the economy. These are set out in Figure 35 below.

[25] *Europe Economics, 'Scope for Efficiency Improvement in the Water and Sewerage Industries - Final Report', commissioned by Ofwat, March 2003*

[26] *Mazars Neville Russell, 'Transco Price Control Review 2002-2007', commissioned by Ofgem, September 2001*

Figure 35. Sectoral TFP trend growth estimates

Trend volume-adjusted TFP growth	1950-99	1974-99	1990-99
Coal & petroleum products	0.7%	1.7%	3.3%
Chemicals & allied products	1.2%	1.9%	1.3%
Basic metals & fabricated metal products	1.1%	2.1%	0.7%
Total machinery equipment	1.4%	2.0%	1.8%
Textiles, clothing & leather	1.7%	1.8%	1.0%
Food, drink & tobacco	0.7%	1.0%	0.5%
Other manufacturing	0.9%	1.8%	-0.2%
Agriculture, forestry & fishing	1.3%	1.9%	0.7%
Mining & extraction	-1.5%	0.3%	4.6%
Electricity, gas & water	1.2%	2.0%	3.2%
Manufacturing	1.4%	2.1%	1.3%
Construction	0.9%	1.7%	1.2%
Transport & communications	1.2%	2.1%	3.8%
Distributive trades	0.1%	0.4%	0.6%
Financial & business services	-0.4%	0.2%	0.9%
Miscellaneous	-0.7%	0.1%	0.5%
Non-market services	0.0%	0.6%	2.3%
Total economy[27]	0.8%	1.1%	1.2%

Source: NIESR data and CEPA calculations

The next step is to assess the proportion of each sector to use in the sectoral estimates. Ofgem have provided us with an analysis of the costs of DNOs, based on submission by 6 of the UK DNOs. This is set out in Figure 36 below.

[27] Trend growth. These differ slightly from the CAGR rates reported in Figure 11.

Figure 36. Analysis of DNO controllable operating costs

Activity	% of costs	% of controllable costs
Network Asset Ownership	38%	48%
New Connections	4%	5%
Network O&M	16%	20%
Asset Management	3%	4%
Metering	9%	11%
Customer Services	2%	3%
Provision of Information	3%	4%
Commercial	5%	6%
Other	20%	
TOTAL	**100%**	**100%**

Source: Ofgem

We set out below an assessment of how the sectoral activities relate to the activity analysis of DNOs. Using this analysis, and combining it with the proportion of costs for these activities in DNOs, provides an assessment of the weighting of sectoral TFP estimates in the assessment of DNO TFP. This is set out in Figure 37 below.

Figure 37. Sector of DNO business activities

	Construction	Engineering	Utilities	Business services	Communications
Network Asset Ownership	✓	✓	✓		
New Connections	✓	✓			
Network O&M		✓	✓		
Asset Management		✓	✓		
Metering		✓			✓
Customer Services				✓	✓
Provision of Information				✓	✓
Commercial				✓	

Source: CEPA

Figure 38. Composite sectoral analysis: TFP estimates

	Construction	Engineering	Utilities	Business services	Communications	Estimated TFP growth
% contribution to activities[28]	18.3%	35.8%	27.7%	9.4%	8.8%	
contribution to TFP estimate	1.20%	1.30%	3.20%	0.90%	3.80%	2.0%

Source CEPA.

Our overall assessment of the TFP growth trend for DNOs based on this composite sectoral analysis is 2.0%. The result is not particularly sensitive to changing estimates of the contribution of the different activities, and so is relatively robust to changes in the estimates of their contribution to the distribution business.

This estimate does not appear particularly convincing. Given limited data, it is difficult to be extremely scientific about estimating the contribution of the different sectors to a utility business. Moreover, the sector estimate for the utilities which is provided by the underlying dataset would appear to be more robust, and there is circularity in using the estimate for the utilities sector to estimate the TFP growth trend for a utility business.

So while the composite sectoral analysis indicates a trend growth of 2%, the historic trend of 3.1% would appear to be a more accurate estimate of historic trends. It could, however, be argued that the lower estimates are a more appropriate indicator of the future trend for DNOs, as companies other competitive sectors of the economy might be expected to operate closer to their efficiency frontier.

[28] % contribution to activities is calculated as $\Sigma_j c_i s_{ij}$ where the c_i are the cost percentages of Figure 36, and s_{ij} is the percentage of costs for an activity i deemed to be related to the costs of sector j, based on the activity analysis of Figure 37.

10. SURVEY EVIDENCE OF PRODUCTIVITY GROWTH

The estimates of trend TFP reported in the previous sections have been of historic data. In order to obtain forward looking assessments, we have conducted two surveys:

- an analyst survey. In this survey, we ask utility investment analysts their views about likely productivity trends over the next five years. Analysts have access to utility company management, and thus their expectations should reflect those of the industry.
- a company survey. This was to obtain views of companies on trends in TFP in other capital intensive sectors.

10.1 Analyst Survey

For the analyst survey, utilities analysts at 19 investment banks were approached, initially by email with a follow up by telephone. The analysts were asked to indicate their expectations of per annum percentage increase in output (units distributed and network length) and inputs (operating costs and regulatory asset value) over the next five years. Their responses were used to construct an implied TFP estimate. Seven analysts provided a complete response, and the maximum, minimum, and median response is set out in the table below.

The analysts' judgements about future productivity increases are based on a number of sources. All have had contact with senior management, and some had detailed discussions with operational management about potential cost savings. They had also considered the trend in sector productivity in recent years, and in particular since the last review of price controls. The issue of the impact of distributed generation had been considered by a few of the analysts.

Figure 39 DNO productivity growth expectations of city utilities sell-side analysts

Trend volume-adjusted TFP growth	Minimum	Maximum	Median
Volume growth	0.5%	1.9%	1.0%
Network length growth	0.5%	1.8%	1.0%
Real operating cost decrease	-1.0%	3.0%	2.0%
CCA asset value increase	0.8%	2.0%	1.5%
TFP increase	-0.3%	2.0%	1.5%

Source: CEPA

All but one of the analysts expected real operating costs to fall. This view was, however, very much an outlier, with most analysts expecting productivity gains above that expected from the overall economy, and the consensus view was for modest productivity improvements. Using the median estimate means that little weight is placed on this outlying estimate, which does reflect a reasonable market consensus view.

Issues highlighted by analysts in discussion included:

- the trend in volume growth is expected to remain stable, in line with the past trend growth at around 60% of GDP growth
- operating cost savings have been significant in the past, but most thought that future savings would be tough to achieve. Some analysts did, however, have significantly higher cost saving estimates than the average, of 3-4%, and the views of these analysts were well-founded. This indicates that the median estimate reported here is likely to be pessimistic, and thus at the low end of actual performance.
- a modest growth in regulatory asset value was expected by all. Additional capex was thought likely to be a result of recent concerns about quality, but the need for this was thought to be overdone.
- some analysts mentioned the need for investment in response to the growth in distributed generation and renewables, noting that this would mean that asset growth would be far higher than indicated.

The main result of the analyst survey was that median growth rates in productivity were 1.4% (TFP) and 2% (PFP opex).

10.2 Company survey

Companies make public statements about expected productivity improvements, and their expectations can be found in presentations made to investment analysts that follow them, as well as other published statements made by senior executives. In addition, companies give guidance to analysts on future expectations of performance.

In order to obtain another forward-looking assessment of productivity improvements, we assessed trend productivity for a range of companies, by a combination of a review of published information, supplemented by discussions with company executives initiated through investor relations contacts. These results were supplemented with discussions with sector analysts to assess the plausibility of our estimates.

No sector has exactly the same characteristics as DNOs, but capital intensive industries are likely to have similar productivity growth trends. The industries we selected for analysis were: chemicals, energy (oil & gas), metals, engineering, and construction. Given the nature of the relationship of companies with their regulators, we did not approach any regulated infrastructure companies for their views.

A summary of our assessment of the expected productivity improvements are set out below.

Figure 40 Company productivity growth expectations - summary

Sector	Companies surveyed	Average productivity growth
Chemicals	BASF, Bayer, Degussa	3.1%
Oil	BP, Shell, Total	1.1%
Metals	Norsk Hydro, Alcan	2.8%
Engineering	Schneider, Siemens, Areva, ABB	2.1%
Average		**2.3%**

Source: CEPA

It is interesting to compare the tone of presentations for companies operating in competitive parts of the economy. Many face severe competitive pressure, and their productivity growth is seen as essential to maintaining profitability. This is the case, for example, with BASF, which has a major cost cutting programme, intended to reduce costs by €900m, from a base of €5.46bn. The engineering companies have seen very tough pricing in their markets, leading them to initiate company restructurings. They are, however, more optimistic now with spending on transmission and distribution equipment expected to rise worldwide following recent supply interruptions.

This survey can by no means be considered to be representative. However, it does give an indication of the size of productivity improvements that companies operating in competitive segments of the market expect (or need) to deliver.

PART III – FORECASTING PRODUCTIVITY GROWTH

11. FORECASTING PRODUCTIVITY GROWTH FOR THE UK DNOs

A forecast trend growth rate needs to be sustainable. This means that in drawing conclusions from historic trend growth, less weight should be placed on any periods where there are special factors leading to enhanced productivity, such as the initial period following privatisation. In the discussion below, we place more weight on more recent periods.

Consideration also needs to be given to the use of the forecasts. Trend growth rates will include some 'catch up' and 'frontier shift'. A trend growth rate, therefore, can be used as an indicator of future performance of the average firm, but might be too harsh on a frontier firm.

11.1 Summary of evidence

The table below provides a summary of our estimates of trend productivity growth, using a variety of sources of evidence. Where a range of estimates have been made, the table provides what we consider to be the most appropriate estimate. In all cases, estimates are volume adjusted.

Figure 41 Summary of estimates of productivity growth

Estimate	TFP	PFP opex	Comments
UK economy	1.3%		Trend growth rate over 1974-99, and over different business cycles calculated on NIESR data.
DNOs	4.2%	7.7 %	Trend growth for last ten years, based on data from regulated accounts.
England & Wales Water & Sewerage	2.6%	5.0%	Quality adjusted figure for TFP using capex weighting, based on range of estimates for 1995/6-2001/2
England & Wales Transmission (NGC)	2.4%	4.9%	Trend growth for last eleven years, based on data from regulated accounts.
US Distribution	2.2%	0.5%	Trend growth based on ten years of data from FERC
Norwegian Distribution	0.2%	1.6%	Trend growth based on six years of data from Norwegian regulator..
Composite sector	2.0%		Weighted average of growth from related sectors based on trend growth derived from NIESR dataset
UK Utilities sector (NIESR data)	3.4%	9.0%*	Utilities sector growth derived from NIESR data set, last ten years' data
French Utilities (NIESR data)	1.8%	2.9%*	NIESR data set, last ten years' data

Estimate	TFP	PFP opex	Comments
German Utilities (NIESR data)	1.2%	4.7%*	NIESR data set, last ten years' data
US Electric Utilities (NIESR data)	1.9%	2.0%*	NIESR data set, last ten years' data
Analyst survey	1.5%	2.0%	Median expectations of city analysts from a CEPA conducted survey
Company expectations in related sectors	2.3%		Average productivity improvements expected by related companies based on survey e.g. BP

**labour productivity growth, not operating costs*
Source: CEPA

11.2 Forecasting TFP growth for the UK economy

In Section 6 we presented evidence on trend growth in TFP for the UK economy. Trend TFP growth has not varied significantly since 1974, with the exception of the last five years for which TFP data is available (1995-9). In this last period, however, there was a slow down in GDP growth. Given that growth expectations for the period 2005-10 are in line with historic trend GDP growth, it is reasonable to expect that TFP growth will continue on its long term trend rate of 1.3%.

If TFP growth were to be used directly to set X factors, then X should reflect the difference between expected industry TFP growth, and expected economy TFP growth. This 1.3% rate should therefore be deducted from expected DNO growth.

11.3 Forecasting productivity growth for the DNOs

The analysis of this report has shown that historically, DNOs have achieved substantial productivity gains. The trend rate of TFP growth has been 4.2% (last ten years, volume and quality adjusted), and operating efficiency (the PFP measure) has increased by 7.7%. The average improvement in productivity has been higher in the last five years than the previous five, with a substantial fall in operating costs following the last price review. So to what extent are these trends sustainable?

Clearly, there have been a number of special factors that have meant that DNO productivity was particularly high. There was enormous potential to cut costs in the early years following privatisation, and the DNOs' response to the last price review in 1999 appears to have significantly increased the rate of productivity growth. As a result, DNO productivity growth has been above the trend rate of growth for utilities as a whole (as calculated by

NIESR), as well as National Grid. It has also been slightly higher than the recent trend in water and sewerage productivity (with capex weighted quality).

A particular issue in interpreting the trend in DNO productivity is the substantial improvement in productivity achieved between 1999/00 and 2000/01. This exceptional reduction in productivity was probably in response to the revised price controls. While exceptional, our discussions with Ofgem indicate that the overall cost reductions were achieved, and should therefore be included in the long term trend. However, this large reduction means that productivity improvements for DNOs over the last five years were higher than in the previous five.

Given these factors, and in particular the circumstances surrounding the DNO cost reductions in 2000/01, it is unlikely that trend rates for the next price control period will continue to be as high as the historical trend would suggest. This conclusion is supported by other evidence, and in particular:

- the forward looking estimates of DNO productivity based on analyst views indicate that both TFP and operating efficiency will be far lower than was historically the case,
- the forward looking estimate of productivity in other related industries, while above trend growth for the economy, is expected to be lower than historic DNO performance, and
- the trend productivity in other countries' distribution network operators, which have not had the same pressure on productivity, has been slower.

We draw the following conclusions from this analysis for TFP growth:

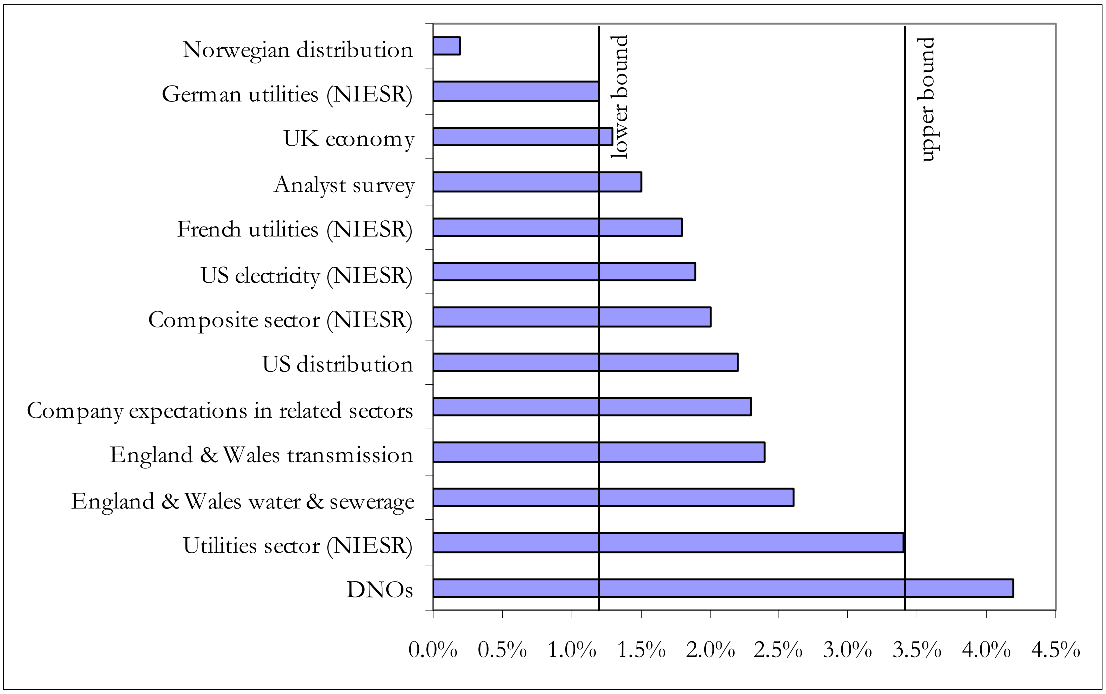
- from the discussion above, the trend rate of growth in DNOs, and in the utility sector provided by the NIESR data set provide an upper bound for future trend growth by the DNOs. The NIESR estimated rate of growth is the lowest of these, and therefore our estimate of the upper bound of future TFP growth is 3.4%. This upper bound is consistent with the longer term trend in DNO performance excluding a portion of the exceptional gains achieved in 1999/00-2000/01; and

- trend TFP growth in the sector from most other sources was above that expected for the UK economy. This included median analyst expectations, the trend for utilities in other countries[29], and expected productivity gains in other industries. The lower bound of these is provided by the German utilities aggregate industry TFP trend at 1.2%.

[29] Excluding the outlier of the case of Norwegian distribution companies.

We therefore expect total factor productivity over the next five years to lie in the range 1.2-3.4%, with a central case expectation in the middle of this range of 2.4%, or just over 1% above the rate of growth for the economy.

Figure 42 TFP growth estimates

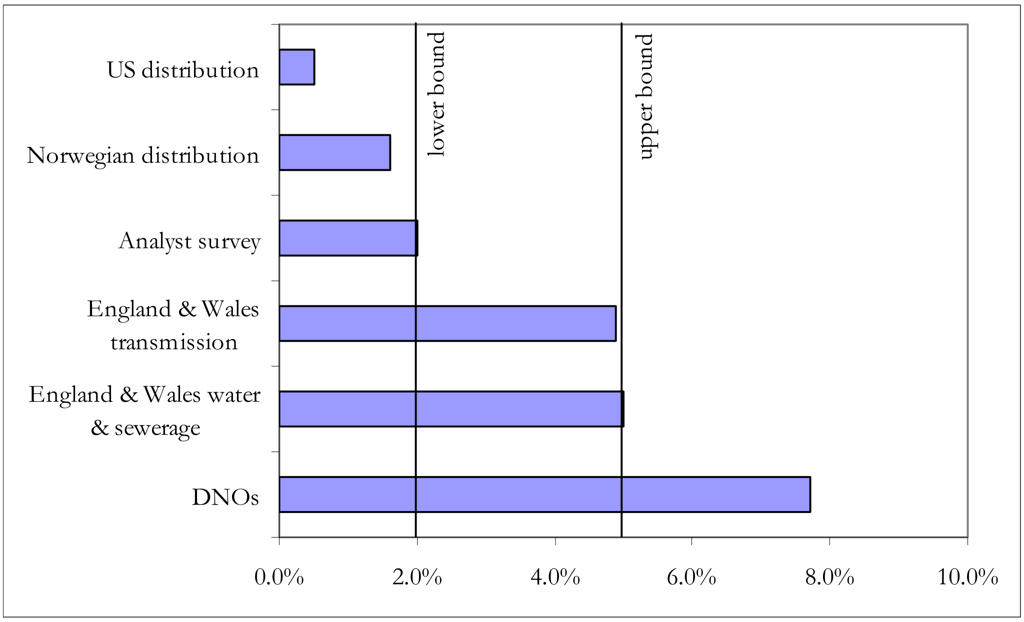


Source CEPA

As discussed in the body of the report, the estimates of trend growth are subject to a number of assumptions, and users of these estimates need to be aware of the extent to which they can vary depending on the assumptions made. Assessments of the weights on inputs to the Tornqvist indices, of the elasticity of scale, and of the extent to which quality is valued all can have significant effects on the estimates. However, the analysis has shown that despite the qualifications, there is a good degree of convergence between the estimates, giving us confidence about our estimated range of 1.2-3.4%.

The partial productivity (operating efficiency) growth estimates are set out in the figure below.

Figure 43 Estimates of PFP operating expenditure growth



Source: CEPA

As with TFP, the reasons behind the fast growth in productivity for DNOs means that the historic trend rate of growth in PFP is likely to be unsustainable. NGC has made substantial progress in operating efficiency. The trend in its performance has been steadier than that seen for DNOs, and lower than they have achieved over the last ten years. Given the DNOs historical trend over the last eleven years an upper bound based around the rate of growth of England and Wales transmission can be regarded as conservative. It is consistent with the recent trend in water performance, as well as the long term trend in DNO performance excluding the exceptional performance in 1999/00-2000/01.

Trend PFP in the Norwegian and US distribution companies has been lower than the other estimates of trend PFP growth. The median analyst expectations of growth are relatively pessimistic about prospects for PFP growth, and the historic trend for other countries. The analyst survey, therefore, provides a more reasonable lower bound to expected PFP growth of 2.0%.

This means that we expect partial productivity to improve by between 2-5% over the next five years, with a mid point of this range of 3.5% as the central estimate.

In addition to the assumptions about quality and scale, actual productivity improvements in DNOs will depend on other environmental factors. In particular, it is uncertain what the increasing role for distributed generation, including renewables, is likely to be on the DNOs.

11.4 Catch up and frontier shift

How will these productivity improvements be split between frontier shift and catch up elements? In our earlier report for Ofgem on benchmarking[30] we analysed productivity for DNOs using Malmquist indices. These allow efficiency gains to be analysed into these two elements, based on a definition of the production function (or frontier). This analysis was done for both data on operating expenditure and a measure of total expenditure, including capex. The results showed:

- for opex, all but one of the DNOs fell further behind the frontier, compared to the most efficient firm, with the extent of underperformance varying between firms;
- for total expenditure, it appears that the relative performance of firms was less dispersed than for opex, and that most of the gains were a result of a change in the frontier.

Further work outside the scope of this study would be needed fully to interpret these results, but they suggest that future total factor productivity would be determined by frontier shift, while operating efficiency is likely to be the result of a combination of catch up and frontier shift.

[30] CEPA (2003) *Background to Work on Assessing Efficiency for the 2005 Distribution Price Control Review.*

11.5 Conclusions

Our productivity improvement estimates discussed in this chapter are summarized in the table below.

Figure 44 Summary of productivity improvement estimates

	Range	Central estimate
Expected TFP growth for UK economy		1.3%
Expected TFP growth for UK DNOs	1.4% - 3.4%	2.4%
DNO TFP growth – UK economy TFP growth		1.1%
Expected growth in operating efficiency for UK DNOs	2.0%-5.0%	3.5%
DNO operating efficiency growth – UK economy TFP growth		2.2%

Source: CEPA

PART IV - ANNEXES

ANNEX 1: TERMS OF REFERENCE

Consultancy Terms of Reference: Productivity Improvements in Distribution Network Operators

Background

Ofgem is the regulator for the gas and electricity industries in England, Scotland and Wales. Ofgem's principal objective is to protect the interests of consumers. Ofgem uses price controls to protect consumers against the abuse of monopoly power by network companies. The current price controls for the fourteen companies engaged in electricity distribution in Great Britain (known as Distribution Network Operators, or DNOs) expire in April 2005, and new price controls will take effect from this date.

Ofgem is currently working on the Distribution Price Control Review (DPCR) that will put in place the price controls for DNOs for the next control period. Ofgem will make use of a number of pieces of analysis during the DPCR to set the appropriate price controls, including a review of the expenditure required by DNOs to provide distribution services. An important part of this will involve making an assessment of the level of costs that an efficient company is likely to incur in the future.

Aim of study

The aim of the study is to estimate the overall scope for Total Factor Productivity improvements for the monopoly electricity distribution activities of DNOs as a whole for the period of the next distribution price control. This study will be one of a number of assessments of the efficient level of costs that Ofgem will undertake, including benchmark comparisons of costs. Taken together, the results of these pieces of work will be used to set the price controls. Ofgem intends that the results of the various studies will be taken together to produce a robust set of price control proposals.

Scope

The scope of this study will be to estimate the overall scope for Total Factor Productivity improvements in DNOs over the five year period from 2005 to 2010, i.e. the next price control period. The estimate will be for the companies taken together in aggregate, i.e. the overall scope for productivity improvements in the electricity distribution sector. Separate estimates are required for operating expenditure, and total (i.e. operating and capital) expenditure. The estimates of productivity improvements will be divided into those which are expected to arise in the economy as a whole, and those which are specific to DNOs. The study will identify reasons why DNOs might be expected to achieve productivity improvements that are different to those that are expected in the rest of the economy.

The study will set out any assumptions that are made in the consultant's analysis. These might include the base level of productivity that is assumed, growth of distributed generation, and changes in the quality of supply.

In addition, Ofgem may, at its discretion, require the consultant to attend an industry workshop and present the results of the study, and to provide a summary response to comments received from interested parties.

Approach
The study will be a self-standing piece of analysis which estimates the scope for Total Factor Productivity improvements in DNOs. The study should concentrate on numerical analysis to estimate the scope for productivity improvements. The consultant will be expected to provide the most appropriate methodology for obtaining robust results which will be used in the overall assessment of productivity used in the DPCR. This methodology should be clearly set out in the consultant's report. It will be important to ensure that the results are of an appropriately high quality to be published as part of the DPCR. Consultants should expect their work to be challenged by DNOs and other parties.

Ofgem does not require detailed analysis of, for example, the determinants of productivity, or a review of the relevant literature.[31]

Project Management & Reporting
Ofgem will provide a project manager for the study. The project manager will facilitate initial contact with the relevant parties. A small steering group of Ofgem staff involved in the DPCR will oversee the study. The consultant will provide weekly progress updates to the project manager.

The output of the study will be a written report to Ofgem setting out the findings of the study, the basis for the conclusions reached and details of the evidence examined.
The consultant should produce a draft report by 8 September 2003 and a final report by 26 September 2003. The consultant will be required to present the findings of the draft and final reports. Ofgem will require 6 printed copies of the written reports and an electronic version. Ofgem expects that it will publish the final report.

Proposal details
Consultants who are interested in carrying out this study should provide 3 copies of a proposal to Ofgem by 12 pm on 25 July 2003. The proposal should include the following:

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[31] A similar study was recently undertaken by Europe Economics for Ofwat. The report "Scope for Efficiency Improvement in the Water and Sewerage Industries" is available from Ofwat on their website at www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/Content/efficiency_report. However, this kind of study has not previously been undertaken for electricity distribution.

- a description of the proposed approach, including as much detail as necessary to show that the proposed approach is able to deliver the requirements of the study;
- any assumptions and dependencies that the approach contains;
- a timetable and work plan showing project milestones;
- details of the consultant's company and of similar work previously undertaken; these references should, as far as possible, be examples of work undertaken by the consultant which relate closely to the requirements of this study;
- details of the key staff involved, including CVs;
- a fixed price for the study which is inclusive of all professional fees and expenses and VAT, and which is broken down to show the fee rates and workload of staff; and
- separate prices for:
    - attending an industry workshop and presenting the results of the study; and
    - providing a summary response to comments received from interested parties.

  Both of these pieces of work will be options. It will be at Ofgem's discretion whether to take up one or both of these.

The study should be completed within 2 months of receiving authority to proceed, except for the optional work to attend and present at an industry workshop, and to provide a response to comments received. The exact timing of this work will be announced separately.

Consultants may be required to give a presentation in support of their proposal.

Evaluation

Ofgem will evaluate received proposals against the following criteria:

- Understanding of Ofgem's requirements;
- Quality and clarity of the proposed approach;
- Quality of the proposed team;
- Previous experience; and
- Proposed cost of study.

Consultants are responsible for informing themselves of Ofgem's requirements. Ofgem will not be liable for any costs arising from the consultant's failure to understand Ofgem's requirements.

Ofgem is not obliged to accept any proposal.

Timetable

The timetable for this study is as follows:

Event	Date
Issue Terms of Reference	11 July 2003
Submit proposals	25 July 2003

Event	Date
Award contract	1 August 2003
Issue draft report	8 September 2003
Present results of draft report	Week commencing 15 September 2003
Issue final report	26 September 2003
Attend industry workshop and present results of study	October/November 2003
Provide summary response to comments received	October/November 2003

Confidentiality

The consultants will keep all information obtained for the purposes of the study and all information given by Ofgem strictly confidential. The consultants shall ensure that all such information is not subject to unauthorised copying or use.

Copyright

All reports, information, applications, programmes and other intellectual property created as a result of this project will remain the property of Ofgem.

Questions relating to the Terms of Reference

Any questions relating to this Terms of Reference must be addressed to the contact point below. Ofgem may circulate its response to such questions to all consultants to whom the Terms of Reference have been sent.

Haren Thillainathan
Office of Gas & Electricity Markets
9 Millbank
London
SW1P 3GE

Tel: 020 7901 7055
Fax: 020 7901 7478
Email: haren.thillainathan@ofgem.gov.uk

ANNEX 2: INDEX DEFINITIONS

Figure 45: The Tornqvist index

Total factor productivity at time t can be expressed as:

$$TFP_t = \frac{\prod_i^m \left(Y_t^i\right)^{\beta_i}}{\prod_i^n \left(F_t^i\right)^{\alpha_i}}$$

where F_t^i is the input of factor i at time t, Y_t^i are the output measures, α_i are the weights for factor inputs, and β_i are the weights for the outputs. In a two factor model, the outputs might be capital and labour, or in a three factor model, capital, labour and other operating costs. This can be expressed as:

$$\ln TFP_t = \sum_i^m \beta_i \ln Y_t^i - \sum_i^n \alpha_i \ln F_t^i$$

so differentiating with respect to t gives:

$$\frac{\left(\frac{\partial TFP_t}{\partial t}\right)}{TFP_t} = \sum_i^m \frac{\beta_i}{Y_t^i}\frac{\partial Y_t^i}{\partial t} - \sum_i^n \frac{\alpha_i}{F_t^i}\frac{\partial F_t^i}{\partial t}$$

This definition of index therefore gives an intuitive formula for the rate of change of TFP: the percentage change in the index is the weighted average of the percentage change in the outputs and inputs, where the weights are the index weights. It can be readily seen that the above expression for the rate of change of TFP can also be expressed as weighted average of rate of change in partial productivity measures, if the weights are chosen to sum to 1:

$$\frac{\left(\frac{\partial TFP_t}{\partial t}\right)}{TFP_t} = \sum_i^m \beta_i \left[\frac{1}{Y_t^i}\frac{\partial Y_t^i}{\partial t} - \sum_i^n \frac{\alpha_i}{F_t^i}\frac{\partial F_t^i}{\partial t}\right]$$

Malmquist index of productivity

Malmquist indices are one way in which productivity can be tracked over time. In contrast to other index methodologies, the Malmquist index does this with reference to a particular production technology. In principle, this can be specified in any of the ways described under the other benchmarking methodologies.

Under this approach, a production function is defined, which gives a relationship between the inputs and outputs. Each set of inputs can be used to produce a range of outputs, i.e. there is a trade off between output variables.

A distance function is defined, which states how far away a given set of inputs and outputs is from the production frontier. This is expressed as $d_0^s(y_t, x_t)$, which is the distance between the input and outputs observed in period t against the technology used in period s.

Given the above, the Malmquist index is defined as follows:

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} \times \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s} \right]^{\frac{1}{2}}$$

The first of the fractions in the square brackets represents the ratio of the distance at time t compared to technology s, to the distance at time s compared to technology s, so it increases if the distance from the technology increases. The second fraction does the same for technology at time t. The Malmquist index is the geometric average of these two.

ANNEX 3: PRODUCTIVITY AND PRICE CAPS

This Annex sets out the relationship between productivity measures and price indices, elaborating the discussion in Chapter 2.

For an industry regulated with a price control, one appropriate way to set prices is to index them to the expected change in total costs. This can be expressed as:

(Δ industry costs) = (Δ input prices) - (Δ industry TFP)

which can also be expressed as:

(Δ industry costs) = (Δ input prices) - (Δ economy TFP)
- [(Δ industry TFP) – (Δ economy TFP)]

If the economy as a whole is assumed to be competitive, then

(Δ retail prices) = (Δ input prices) – (Δ economy TFP)

This means that the expression for the change in industry costs can be expressed as:

(Δ industry costs) = Δ RPI – [(Δ industry TFP) – (Δ economy TFP)]

provided that the change in input prices for the industry is the same as for the economy as a whole (an obvious amendment to this formula can be made to reflect this if required). In Annex 2, it was shown that the rate of change in TFP can be expressed as the sum of the rate of change in partial productivity measures. This means that in a two factor model, the above expression can be decomposed further into:

(Δ industry costs) =Δ RPI
- [β^o(Δ industry opex PFP) + β^c(Δ industry capital PFP)
- (Δ economy TFP)]

=Δ RPI
- β^o [(Δ industry opex PFP) – (Δ economy opex PFP)]
- β^c [(Δ industry capital PFP) – (Δ economy capital PFP)]

where the βs are the weights on opex and capex in the TFP index respectively.

As discussed in Chapter 2, this means that if TFP growth expectations are used to set price caps, whole economy TFP growth needs to be deducted from the industry TFP growth expectation. It also needs to be deducted when partial productivity estimates are used, and separate partial productivity estimates for the economy can also be used where appropriate.

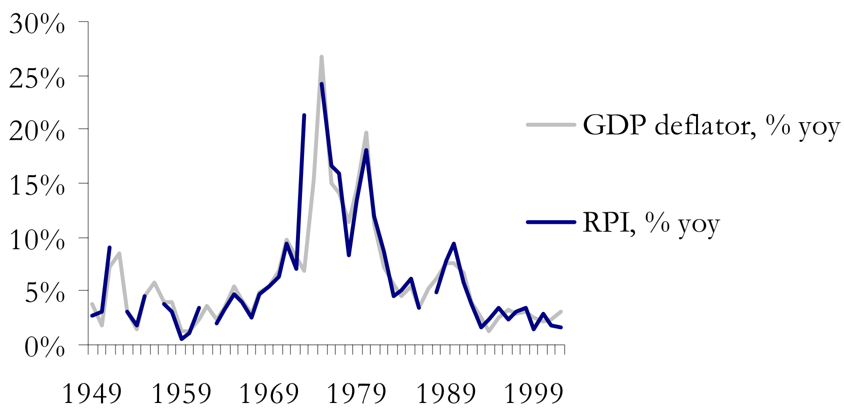
ANNEX 4 : INFLATION MEASURES

The GDP deflator, which takes into account the prices of all goods and services produced and/or purchased in the UK, provides the broadest measure of general inflation. However, the RPI, which reflects only changes in the prices of consumer goods purchased in the UK (and so excludes all non-consumer goods and exports) is far more widely used and understood. Indeed, price limits for regulated utilities are set in relation to the RPI and so the analysis contained in this report also uses the RPI as the relevant price deflator. However, ideally a GDP deflator should be used in the context of discussions about TFP improvements.

The importance of this distinction depends on the correlation between the two price indices. This annex therefore briefly examines the relationship between the GDP deflator and the RPI.

Figure 46 shows the movements in the GDP deflator and RPI over the period. As can be seen from the chart, the two series have tracked one another extremely closely. Indeed, the average growth rate and CAGR have differed by less than 0.1 percentage points over the period 1949-2002. Consequently, the use of the RPI as opposed to the theoretically superior GDP deflator in the analysis can be considered inconsequential.

Figure 46: UK price indices, 1949-2002



Source: ONS

ANNEX 5: SCALE

The relationship between cost and scale, and its importance in determining estimates of productivity growth were discussed in Chapter 4. In particular, the elasticity of costs with respect to scale are used to adjust productivity growth estimates. This elasticity may be estimated as the coefficient on ln(scale) in a regression of ln(cost) against ln(scale). A crude estimate may be obtained using cross-section observations in a single year.

For UK DNOs, we have used revenues as a proxy for total costs. For scale, Ofgem has used a variable that is a weighted average of customer numbers, units distributed and network length. In our earlier work for Ofgem on benchmarking,[32] we demonstrated that it is sufficient to use two variables, units distributed and network length. A regression of ln(revenue) against ln(scale) gives the following results.

Figure 47 Estimation of scale elasticity for DNOs (1)

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.0105	0.713177	-0.01473	0.988491
Revenue (Total cost proxy)	0.686402	0.088245	7.778326	5.01E-06

Source: CEPA

Figure 48 Estimation of scale elasticity for DNOs (2)

Multiple R	0.913503
R Square	0.834488
Adjusted R Square	0.820695
Standard Error	0.106179
Observations	14

Source: CEPA

[32] CEPA (2003). Background to work on assessing efficiency for the 2005 Distribution Price Control Review, Scoping Study, Final Report, September 2003.

Figure 49 Estimation of scale elasticity for Water industry (1)

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.548386	0.413165	1.32728	0.221043
Revenue (total cost proxy)	0.774535	0.055497	13.9563	6.73E-07

Source: CEPA

Figure 50 Estimation of scale elasticity for Water industry (2)

Multiple R	0.980076
R Square	0.960548
Adjusted R Square	0.955617
Standard Error	0.107628
Observations	10

Source: CEPA

Figure 51 Estimation of scale elasticity – US distribution (1)

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	4.449668	0.626393	7.103636	5.63E-11
ln Scale	0.816929	0.039295	20.78986	1.22E-44

Source: CEPA

Figure 52 Estimation of scale elasticity – US distribution (2)

Multiple R	0.869102
R Square	0.755338
Adjusted R Square	0.753591
Standard Error	0.825099
Observations	142

Source: CEPA

ANNEX 6: SURVEY INFORMATION

Investment banks contacted to participate in the analyst survey

ABNAmro
BNP Paribas
Cazenove
CDC Ixis
Citigroup SSB
Commerzbank
Credit Lyonnais
CSFB
Deutsche Bank
Dresdner Kleinwort Wasserstein
Goldman Sachs
HSBC
ING
JP Morgan Chase
Merrill Lynch
Morgan Stanley
SG Securities
UBS Warburg
Williams de Broe

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