Oxera

Should DTe adjust expected productivity growth for catch-up effects when setting the X-factor?

Final report prepared for DTe

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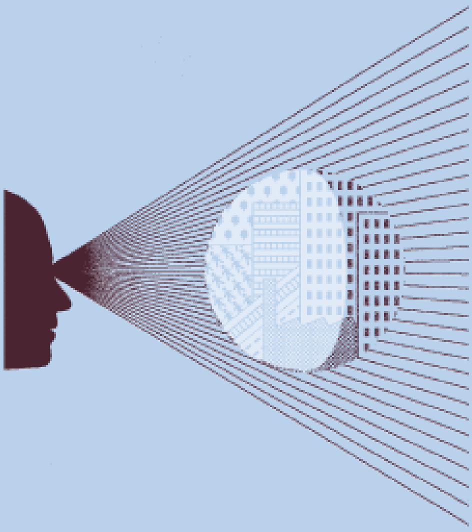

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1 Introduction

DTe regulates the tariffs for regional gas and electricity distribution system operators (DSOs) using a form of incentive regulation. It uses X-factors, representing the percentage by which DSOs' annual notional income[1] is required to change over a regulatory period, an inflation factor (the consumer price index), and a factor capturing quality (q-factor) to set the allowed income for DSOs over a regulatory period.

In the forthcoming regulatory periods (NG3R and NE4R) and future periods, DTe proposes to set an allowed income level at the end of the regulatory period equal to the sector average cost level.[2] An expected productivity growth is applied to the sector average efficient cost level to determine the sector average efficient cost (and income) at the end of the regulatory period. Within the proposed system, all companies are permitted to charge tariffs consistent with the sector average cost level at the beginning of the period. DTe sets firm-specific X-factors that make each DSO's tariffs reach the sector average efficient cost level by the end of the period. Companies with actual costs lower than the sector average have an incentive to keep their costs low since they will be able to retain the proceeds from outperforming the regulatory target. Companies with costs higher than the sector average economic costs (ie, including the allowed cost of capital) have an incentive to reduce their costs in order to increase their profitability—otherwise they recover costs equal only to the sector average.[3]

Further details of DTe's regulatory framework are set out in its method decisions.[4]

DTe proposes to set the X-factor for gas and electricity DSOs based on measured historical sector average productivity growth observed in the sector over the course of the previous regulatory period.[5] In using historical average productivity as an indicator for future productivity growth, DTe does not expect to accurately predict future productivity growth levels since it does not consider that it has sufficient information to make such predictions. However, it assumes that historical productivity growth serves as an objective guide of what is likely to be achievable in the future.

DTe has asked Oxera to provide an assessment of the case for and against making an adjustment to the X-factor that it has undertaken in previous decisions. As a result of changes in its method of setting allowed income and actually observed historical performance, DTe no longer believes this to be required as part of future price control decisions.

1.1 Context of assessment and terms of reference

1.1.1 Context of assessment

In contrast with the approach proposed for the forthcoming price controls, under the previous system the X-factors and income over a price review period were based on measured

[1] Notional income is defined as the sum of tariffs charged by companies multiplied by the respective past realised volumes applicable to each tariff. For further details see www.dte.nl.

[2] Sector average income and average cost in this context are defined as average income and average cost per unit of standardised output to abstract from differences in the size of companies.

[3] If a company's costs are higher than its allowed income, its profits are lower than the sector average and hence it does not necessarily follow that a company incurs a loss.

[4] Available at www.dte.nl.

[5] For the forthcoming price review the period of measurement is 2004–06 for gas and 2002–05 for electricity.

productivity growth. Under this approach if the resulting tariff reached a point at which the income generated was lower than the economic cost of an efficient operator, there was no automatic mechanism to adjust the tariff level so that efficient DSOs were able to at least cover their economic costs. A potential cause of upwards bias in estimating future productivity may be that historical productivity may include movements towards the efficient frontier that may not be feasible in the future. To avoid setting overly harsh X-factors, DTe exercised regulatory caution and adjusted for historical catch-up effects.

For the purposes of the adjustment, DTe defined catch-up as the (relative) inefficiencies between DSOs in 2000 (electricity) and 2001 (gas)—ie, the proportion by which companies on average would need to reduce their costs in order to reach the efficient cost level observed in 2000 (electricity) and gas (2001).

There are two main reasons why such an adjustment may no longer be required.

– **Lack of relevance**. In defining catch-up for a particular year (eg, 2001), and using this to adjust for catch-up effects that may not be possible in the future (eg, 2008–10), changes in productivity that take place following the year for which catch-up is defined are ignored. Incentive regulation is aimed at providing incentives for companies to improve their efficiency. In this context, historical catch-up determined in the manner described above lacks relevance going forward since productivity differentials are likely to change from year to year. As such, there is no reason why a productivity differential calculated several years previously should be deemed to be of sufficient relevance to require an adjustment to future productivity growth. Moreover, expected productivity growth is influenced by several factors—the potential to 'catch up' to the efficient frontier being only one.

– **Change in the regulatory framework**. As discussed, DTe proposes the introduction of an approach whereby X-factors are calculated in such a way that the income level for the sector at the end of the period is the same as the expected efficient cost level for the sector. There is therefore now a mechanism that corrects for any mistakes that may have been made in estimating expected productivity based on historical expenditure. The introduction of this mechanism means that the importance of correcting for catch-up effects has declined since any misalignments are only temporary and can be corrected at the next price review.

The remainder of this report examines the need to adjust for catch-up effects under the proposed regulatory framework.

1.1.2 Terms of reference

DTe's overarching question in the terms of reference is as follows.[6]

– Is it reasonable from an economic perspective not to adjust the sector average productivity growth used in setting the X-factor for assumed catch-up effects in the case of the upcoming gas and electricity method decisions?

The brief provided by DTe states that the following considerations should be taken into account when examining this issue:[7]

– the potential impact on DSOs and network users of not correcting for catch-up effects;

[6], DTe (2008), 'Should DTe Adjust the Measured Productivity Growth for Catch-up Effects when Estimating Sector Productivity Growth', February, p. 7.

[7] As part of this review, DTe provided a memo to Oxera setting out the details of the proposed regulatory decision: DTe (2008), op. cit. As part of the memo, DTe provided data on costs and outputs. Oxera also reviewed DTe's proposed method decisions and had several conference calls with the regulator to clarify specific aspects of DTe's regulatory framework relevant to this report.

– whether, from a methodological viewpoint, a correction for catch-up effects is appropriate, taking DTe's regulation method as a given;
– by examining historical performance in the sector, whether the actual data suggests the need for a correction for catch-up effects;
– the possibilities for measuring the degree of catch-up accurately, given the limited number of DSOs and (time series and other) data limitations.

Given the similarities in the proposed regulatory methods employed in gas and electricity, in many cases similar analysis can be applied to both sectors. Where conclusions differ between the sectors, this has been highlighted.

1.2 Assumptions

The terms of reference require Oxera to focus on a specific aspect of DTe's regulatory framework—ie, an assessment of the case for and against adjusting historically calculated productivity growth for catch-up effects. Other parts of the regulatory framework are taken as given, including the methodology and the data used in estimating the X-factors for gas and electricity DSOs.

Other questions that may arise in the context of the specific issue examined are not discussed in this report, including the appropriate length of the period over which historical productivity growth rates are calculated; the appropriateness and accuracy of the approach to measuring the cost per output and productivity (including adjustments for objectifiable regional differences)—which Oxera has not been asked to review but which is an important starting assumption for the analysis; potential issues relating to the use of trends in, and levels of, cost per output in setting income allowances; and potential impacts on financeability from this approach.

1.3 Structure

The structure of this report is as follows.

– Section 2 introduces the framework of analysis used to assess the case for and against adjusting for catch-up effects.

– Section 3 assesses the case for and against adjusting for catch-up effects within DTe's regulatory framework from a theoretical viewpoint—ie, independently of the approach of adjusting for catch-up effects.

– Section 4 examines the historically observed patterns of catch-up trends and frontier shift in the electricity and gas distribution sector, and summarises the implications of this analysis for DTe's proposed method decisions.

– Section 5 summarises the key findings from examining the case for and against adjusting for catch-up effects based on the theoretical and empirical analysis presented in this report.

2 Framework of analysis

As discussed above, DTe proposes to set the level of income at the end of the regulatory period equal to the sector average cost level. To abstract from differences in company size, the assessment in this report focuses on the concept of cost per standardised output or, equivalently, output per cost.

DTe's method assumes that all companies can achieve (or outperform) a cost per output equal to the sector average cost per output. The level of cost per output that companies are allowed at the end of the period is calculated by applying an estimate of future productivity growth (along with other factors including the constraint of average costs and revenues having to be the same at the end of the period), based on historically achieved productivity growth, to the starting average cost per output at the start of the regulatory period.

Productivity levels and trends can be further decomposed into frontier and catch-up components.

A **frontier** company is the one with the highest productivity level in any given year. Within DTe's framework of productivity measurement, productivity can be measured either as cost per output, where the company with the lowest value is the frontier company, or output per cost, where the company with the highest ratio is the frontier company. The **frontier shift** is the year-on-year change in the frontier company's productivity. It represents the rate of productivity improvement that is due to general technological progress within the sector. The concept of the frontier is dynamic: the frontier is not necessarily determined by the same company in any given year and, over time, companies may leapfrog each other to become the frontier company.

Companies with lower productivity than the frontier company may change their position over time (indeed they may become the frontier company themselves at some point). The term **catch-up** is used to describe the productivity gap between an inefficient company and the frontier company in any given year. **Catch-up rate** is used to describe the average rate of productivity growth that is achieved historically by companies that are not at the efficient frontier.

The frontier shift and catch-up rate realised by individual companies can be aggregated across companies to compute changes in sector average productivity.

When using companies' historical performance as a predictor of productivity improvements, a distinction can be made between the rate of productivity growth for companies that are at or close to the frontier, and companies that are inefficient. Efficient companies can be expected to improve their productivity at the rate of the historically achieved frontier shift. In contrast, inefficient companies can be expected to achieve higher productivity improvements since they can achieve frontier shift as well as move towards to the efficient frontier. Given the discussion above about the frontier being dynamic, it is not possible to assess whether complete catch-up has occurred based on an assessment of a historic frontier—the assessment has be to undertaken with respect to the current efficiency frontier. The empirical analysis in section 4 sets out average productivity, frontier and catch-up rates, with the methodology explained in Appendix 1.

It is often assumed that firms improve their productivity by reducing their inputs (eg, costs) for a given amount of output provided (input-oriented productivity), or by increasing their output for a given amount of resource input (output-oriented productivity). DTe does not make this assumption since companies are assumed to be able to become more efficient by both increased output or decreased inputs (ie, costs). In the context of the issue examined in this report, this introduces a potential complication if companies differ in their ability to influence productivity through output changes. Moreover, using historical productivity as an assumption for future productivity changes requires an assumption about the pattern in volume growth going forward. The theoretical analysis in section 3 abstracts from the issue of volume growth and assumes that productivity changes are due to changes in cost, given the amount of output delivered. The empirical analysis in section 4 assumes that any changes in productivity that may have been driven by volume growth rather than cost reductions are also feasible going forward, since DTe's expectation of volume growth is that its level will be similar to that observed historically.[8]

Section 3 uses the concept of frontier/frontier shift and catch-up/catch-up rate to examine the case for and against adjusting for catch-up effects from a theoretical viewpoint. Section 4 examines the issue empirically and uses these concepts to assess the case for this adjustment for the forthcoming regulatory period.

[8] Electricity DSOs' outputs have grown at a faster rate than costs, suggesting that volume growth rather than cost reductions for a given amount of output are mainly responsible productivity improvements. For gas DSOs, the data is less clear, with some operators experiencing faster growth in output than in costs, while other operators experience a slower increase in output compared with costs.

3 Theoretical analysis

This section examines the theoretical case for and against adjusting expected productivity growth based on historical information for catch-up effects. The analysis considers four main scenarios of observed historical productivity change:

– no catch-up has occurred (section 3.1);
– some catch-up has occurred (section 3.2);
– full catch-up has occurred towards the end of the previous period (section 3.3);
– full catch-up has occurred and is maintained over the previous period (section 3.4).

These scenarios cover the entire range of potential outcomes and the purpose of this section is to illustrate the implications for companies' profitability under each scenario. As such, no judgement is made about which scenario is most applicable to the gas and electricity DSOs. An empirical assessment of historical productivity, and which of the scenarios is likely to apply for the forthcoming price review, provided in section 4.

For each scenario the impact on the allowed cost per output is examined (based on the sector average at the beginning of the period and the assumption that the sector average cost is equal to sector average income). The graphical analysis uses the frontier company to illustrate the impact on companies' allowed expenditure, but the analysis could be extended to all companies. The reason for choosing the frontier company is that it has the lowest assumed scope for future productivity improvements (ie, only frontier shift and no catch-up is possible going forward), and hence the implications of overestimating future productivity would be greatest for this company.[9]

To set the allowed cost per output in the following price control, DTe's proposed approach is to reset the sector average cost level and re-estimate future productivity growth based on the outturn average productivity growth over the previous price control. Section 3.5 discusses the implications of the proposed approach for future price controls. Section 3.6 summarises the findings regarding the need for correcting for catch-up effects under each of the scenarios.

3.1 Scenario 1: no catch-up has occurred

This scenario assumes that there is variation in the level of performance between companies but that no-catch up has occurred. That is, all companies have followed the same productivity trend in the last price control period and all observed improvements could be seen to reflect frontier shift improvements.

It is helpful to consider the impact on different companies. A distinction can be made between companies that are more efficient than the average, and those that are less efficient. The impact of DTe's approach on these two groups is as follows.

– **Inefficient companies**. This measure would underestimate the scope for improvement since they still have potential to catch up to the efficient companies. In addition, because tariffs are set at the average cost *level*, inefficient companies would earn less than their economic costs and would therefore face incentives to improve their performance.

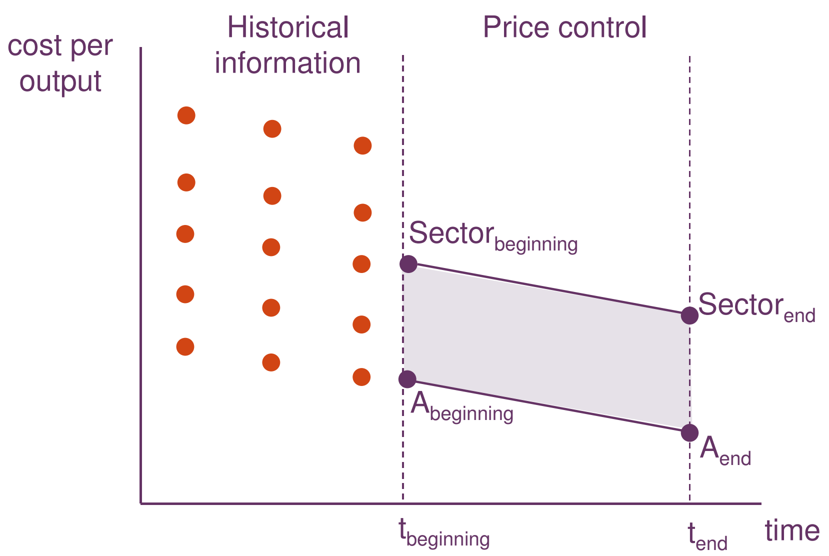
[9] The analysis abstracts from potential changes in relative efficiency over the regulatory period, including movements in the frontier company. Companies that are close to the frontier, and that are expected to remain there over the regulatory period, would be similarly affected, although to a lesser extent.

– **Efficient companies** (ie, those at the frontier). This measure would correctly estimate the scope for improvement. For companies with a lower cost per output than the sector average, the measure would underestimate the scope for improvement somewhat since there remains some scope for catch-up to the frontier. In addition, efficient companies with lower-than-average unit costs are rewarded by being able to set sector average tariffs, giving them the scope to outperform the regulatory target. Efficient companies are therefore incentivised to continue to be more efficient than the sector average.

Since there remains significant scope for catch-up, in this scenario the scope for future productivity improvements would be underestimated. Therefore, the X-factor based on the previous regulatory period's productivity improvements would be achievable by all companies.

This scenario is depicted in Figure 3.1.

Figure 3.1 Scenario 1: no catch-up has occurred



Source: Oxera.

The figure shows the following.

– The first period up to $t_{beginning}$ represents the historical period of observed performance. The second period, between $t_{beginning}$ and t_{end} represents the next price control period over which DTe has to set the allowed price levels.

– The red dots represent the companies' actual historical performance.

– $Sector_{beginning}$ is the sector average efficient unit cost level from the year prior to the start of the price control.

– $Sector_{end}$ is the expected sector average efficient cost level at the end of the price control period (and is equal to average sector income). The annual cost reduction trend, given by the line $Sector_{beginning}$:$Sector_{end}$, is equal to the productivity trend observed over the previous regulatory period, and provides the allowed expenditure level for all companies.

– $A_{beginning}$ is the cost level of the frontier company, A, at the beginning of the regulatory period. For illustrative purposes it is assumed that A retains its position at the frontier over the price control. The conclusions of the analysis are not affected by this assumption.

– A_{end} is the frontier company's expected cost level at the end of the regulatory period, with the company having reduced its costs in accordance with its productivity trend from the previous period.

– The shaded area shows company A's outperformance relative to the allowed cost level. Although not shown, inefficient companies would, on average, experience a similar negative penalty unless they manage to catch up over the regulatory period.

A special case of scenario 1 arises if some companies experience an *increase* in the cost level, resulting in productivity growth estimates that are lower than the actually realised frontier shift. In this scenario, the scope for outperforming cost reduction targets will be underestimated for all companies.

Box 3.1 Scenario 1: is there a requirement to adjust for catch-up effects?

Since there remains significant scope for companies to catch up to the efficient frontier, in this scenario the scope for average future productivity improvements based on historical performance would be underestimated.

– Companies that are less efficient than the sector average have the scope to improve their performance at a faster rate than the frontier shift (abstracting from potential operational barriers to improve performance).

– Companies that are more efficient than the sector average can be expected to increase their productivity at a faster rate than the frontier shift. For companies at the efficient frontier the historical measure would correctly estimate the scope for future improvement.

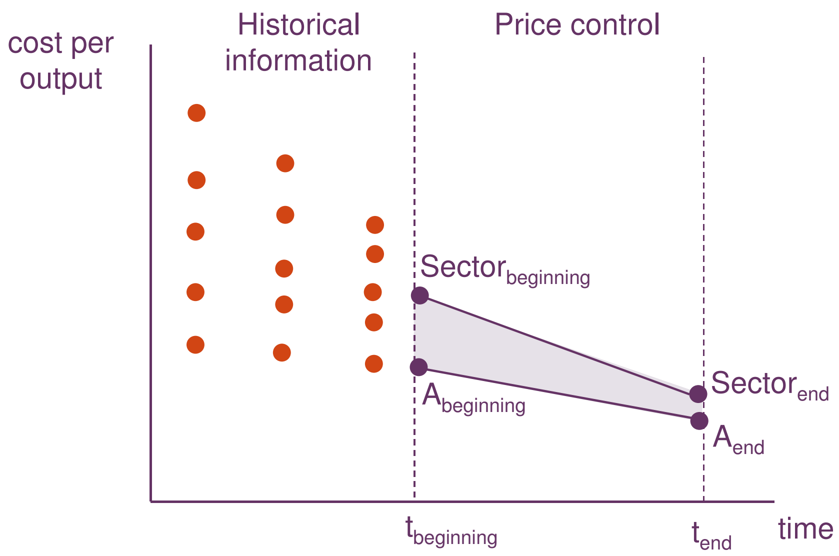
Therefore, in this case, the X-factor based on the previous regulatory period's productivity improvements would be achievable by all companies, so there is no need to adjust for catch-up effects.

If in this scenario an adjustment for catch-up effects were made, distribution network users would pay too much as the resulting tariffs would be higher than those of the average efficient company.

3.2 Scenario 2: some catch-up has occurred (partial convergence)

This scenario considers the case where partial convergence has occurred. That is, some catch-up has taken place historically, but there is still variation in performance. This scenario is illustrated in Figure 3.2. The labelling is as per Figure 3.1.

Figure 3.2 Scenario 2a: some catch-up has occurred (partial convergence)

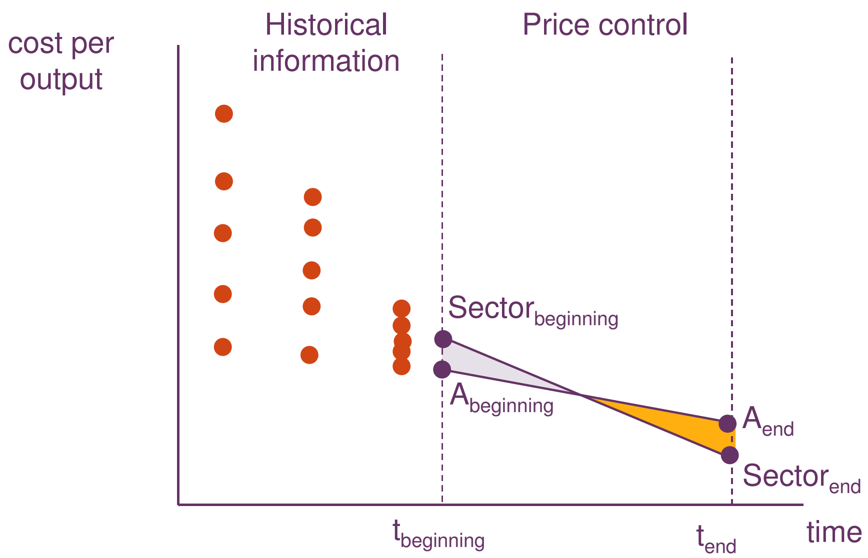


Source: Oxera.

The shaded area shows frontier company A's outperformance relative to the allowed cost level. In this scenario, the allowed expenditure line, $Sector_{beginning}$:$Sector_{end}$, converges towards A's actual performance as A can only achieve frontier shift, while the allowed line includes an element of catch-up. Although not shown, inefficient companies would, on average, experience a penalty unless they manage to catch up over the regulatory period.

If convergence were more significant (but still partial) in the previous period, this scenario would be illustrated by the figure below, with the labelling again as per Figure 3.1.

Figure 3.3 Scenario 2b: some catch-up has occurred (partial, but more complete, convergence)



Source: Oxera.

The shaded area shows company A's outperformance (grey)/underperformance (orange) relative to the allowed cost level. In this scenario, the allowed expenditure line, $Sector_{beginning}$:$Sector_{end}$, crosses A's actual performance during the next price control period since A can achieve only frontier shift, while the allowed line includes an element of catch-up (and in this scenario, a higher rate of catch-up than 2a, such that the allowed expenditure level eventually falls below what A can achieve). Although not shown, inefficient companies would, on average, experience a negative penalty unless they manage to catch up over the regulatory period.

Scenarios 2a and 2b differ in that frontier company A and, potentially, other companies (not shown in the figures) may incur economic losses over some of the years of the price review. The crossover point between the line that depicts what is achievable by A over the period ($A_{beginning}$:A_{end}) and the allowed expenditure line ($Sector_{beginning}$:$Sector_{end}$) depends on the historical sector-average catch-up rate over the previous period, as well as the rate of frontier shift. There are therefore a number of possible points at which the two lines may cross. Broadly speaking, scenario 2b may occur if companies have reduced the average distance to the frontier by more than 50%, resulting in an average catch-up rate of around 15% per annum, and if the scope for frontier shift is comparatively low.

Box 3.2 Scenario 2: is there a requirement to adjust for catch-up effects?

In a scenario where partial convergence has occurred, the scope for future performance may be under- or overestimated, depending on a company's inefficiency.

Two main scenarios may be distinguished.

- **Scenario 2a**. If some convergence occurs but there is still significant variation between companies, the more efficient companies (including the frontier company) would see their profits from outperformance gradually diminish over the price review period, and productivity may not be improved at the same rate as the sector average.

- **Scenario 2b**. If significant convergence occurs (eg, more than 50%) and the scope for frontier shift is limited, efficient companies may find that, for some years of the price review, their economic costs are greater than the allowed average expenditure. Overall, so long as the crossover point for the efficient companies does not occur too early in the regulatory period, there would be no need for adjustment. Although efficient companies will not be able to reduce their costs at the same rate as assumed, they will have had the benefit of being able to charge the average tariff, which exceeds their own costs. For situations with an early crossover point, the allowed cost level would be reset in the next regulatory period on the basis of the performance in the current period, and the trend productivity assumption would be based on the actual performance in the current period. As a result, any underperformance would be only temporary.

There is still scope for catch-up for inefficient companies. For these companies, the average historical productivity growth that includes the catch-up effect is the relevant expected productivity growth.

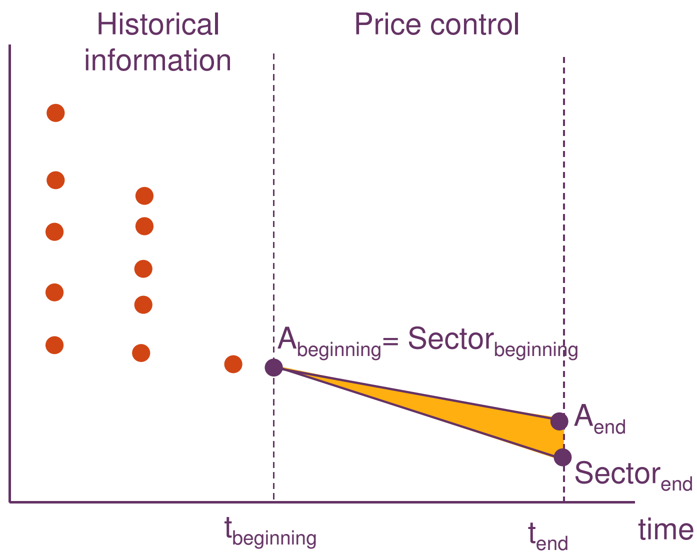
If an adjustment for catch-up effects were made under scenario 2a, distribution network users would pay too much as the resulting tariffs would be higher than those of the average efficient company.

On the other hand, under scenario 2b an adjustment for catch-up effects, if required, would ensure that distribution network users would pay a tariff that is consistent with that of the average efficient company.

3.3 Scenario 3: complete catch-up has occurred (convergence)

This scenario considers the case where full convergence has occurred historically. That is, all inefficient companies have caught up with the efficient companies, such that there is no variation in performance. This scenario is illustrated in Figure 3.4, with labelling as per Figure 3.1.

Figure 3.4 Scenario 3: complete convergence has occurred



Source: Oxera.

Since complete convergence has occurred, $A_{beginning}$ and $Sector_{beginning}$ coincide. The shaded area shows company A's (and, in fact, all companies') underperformance (orange) relative to the allowed cost level. In this scenario, the allowed expenditure line, $Sector_{beginning}$:$Sector_{end}$, is below A's actual performance for the entirety of the next price control period as A, and indeed all companies, can only achieve frontier shift, while the allowed line includes an element of catch-up.

Box 3.3 Scenario 3: is there a requirement to adjust for catch-up effects?

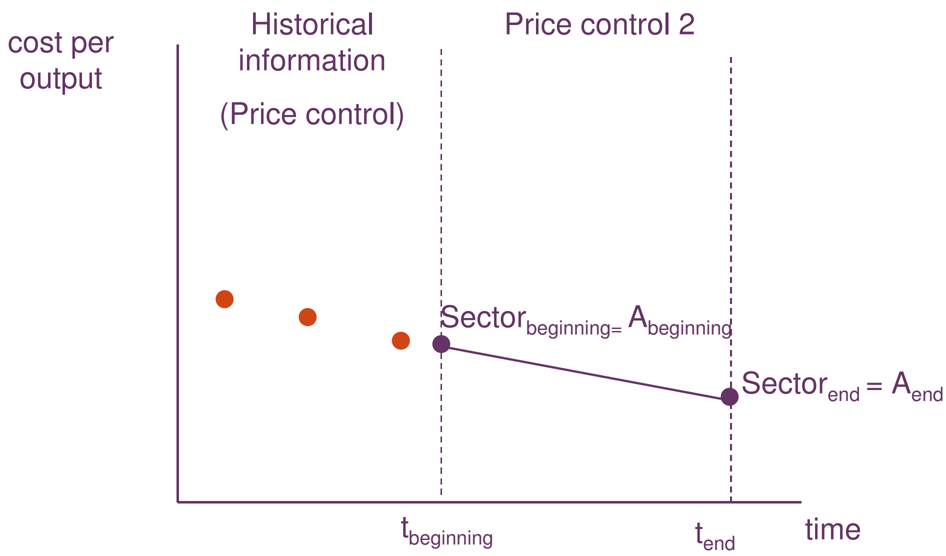
In this scenario, historical productivity would overestimate the scope for improvement over the next price review. As a result, allowed expenditure would be too low during the regulatory period for all companies, leading to underperformance. While this would be corrected in the following period, an assessment would be required to examine the extent of the potential shortfall from overestimating the scope for average cost reductions and whether this might lead companies into financial difficulties.

In this scenario an adjustment for catch-up effects would ensure that distribution network users would pay a tariff consistent with that of the average efficient company.

3.4 Scenario 4: companies have fully converged historically

This is an additional scenario where full convergence has occurred historically and is maintained during the price control period. That is, all historically inefficient companies have caught up to the frontier, such that there is no longer any variation in performance. This scenario is illustrated in Figure 3.5, with labelling is as per Figure 3.1.

Figure 3.5 Scenario 4: after convergence



As complete convergence has occurred such that $A_{beginning}$ and $Sector_{beginning}$ coincide, all the companies' positions (ie, the red dots) coincide, and $A_{beginning}$ and $Sector_{end}$ coincide.

Box 3.4 Scenario 4: is there a requirement to adjust for catch-up effects?

There would be no need for adjustment as the historical rate of improvement would capture frontier shift and would be appropriate for all companies.

Since in this scenario there would be no measurable catch-up (ie, the measured scope for catch-up would be zero), the outcome with and without adjustment would be identical and distribution network users would pay a tariff equal to that of the average efficient company.

3.5 Future price controls

In the price review period following the forthcoming review period, the sector average level of expenditure would be reset, and future productivity would be re-estimated, based on productivity over the previous price review period. Scenarios 1–4 and their respective conclusions also apply at the future price review.

However, even if full convergence over the next period occurs (scenario 4), the outturn during the subsequent price control period is unlikely to be maintained. Given the incentives within the regime, it is more likely that some leapfrogging will occur, and that some divergence will occur during the course of the subsequent period. Depending on the outturn, it is therefore likely that some companies will be rewarded and some penalised during the subsequent period.

Overall, adjusting for catch-up effects may need to be considered only under scenarios 2b and 3, both at the forthcoming and subsequent price reviews.

3.6 Summary of theoretical scenarios

Table 3.1 summarises the findings from the theoretical analysis regarding the need for adjusting for catch-up effects when setting the X-factor.

Table 3.1 Summary of theoretical analysis

Scenario	Range of catch-up	Requirement to adjust?
Scenario 1: no catch up/divergence	Catch-up >or equal to 0%	No
Scenario 2a: partial convergence	0%<catch-up< approx 50%	No
Scenario 2b: partial convergence	Approx50%<catch-up<100%	Potentially
Scenario 3: full convergence towards the end of previous period	Catch-up=100%	Yes
Scenario 4: full convergence maintained over previous period	Catch-up=100%	No

Source: Oxera.

4 Empirical analysis: DSOs’ historical performance

This section examines the evidence on historically observed levels and trends in electricity and gas DSOs’ productivity to assess the need to adjust for catch-up effects when setting the X-factor for the next price review. The analysis decomposes the levels of, and changes in, productivity into catch-up and frontier components. Definitions of these concepts are set out in the analytical framework in section 2.

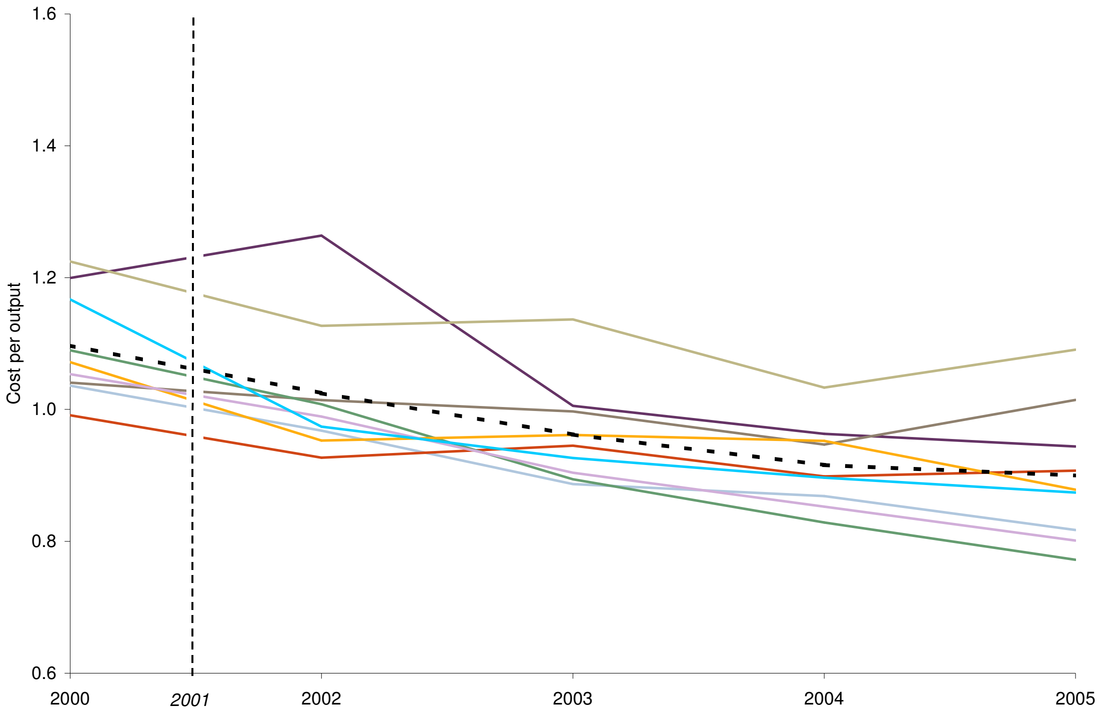
4.1 Cost per output

Figures 4.1 and 4.2 plot the costs per output for electricity and gas DSOs over time periods for which consistent data is available. While these figures do not distinguish between catch-up effects and frontier shift, they are nonetheless indicative of broad trends within the sectors.

Trends in cost per output of electricity DSOs

The trends in cost per output for electricity operators are depicted in Figure 4.1.

Figure 4.1 Trends in cost per output for electricity DSOs



Note: Data for 2001 is not available.
Source: Oxera using data provided by DTe.

The figure highlights two main patterns.

– There is some movement in the relative performance of companies over time. However, overall, there remains a significant gap between the most inefficient DSOs and most efficient.

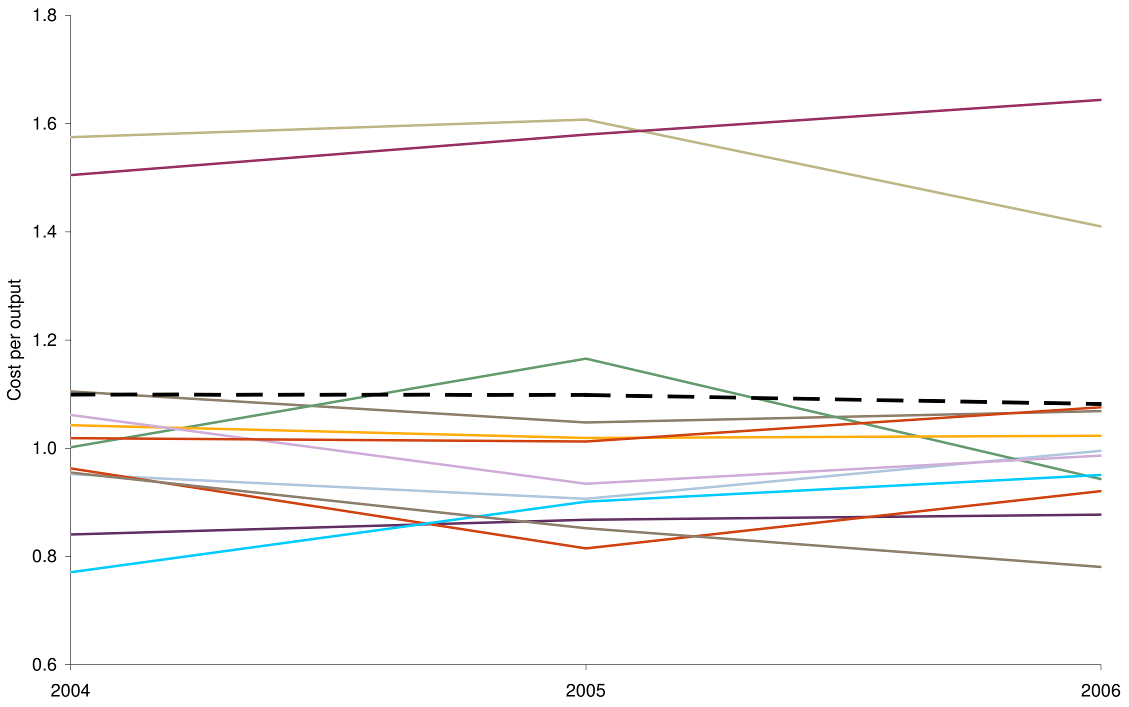
– All operators have seen a reduction in cost per output since 2000. Sector-average unit costs, depicted by the black dotted line, show a declining trend.

The examination of broad trends suggests that, for electricity DSOs, scenario 2a or, potentially, even a variant of scenario 1 may apply—ie, there has been some, although limited, convergence, but significant scope for further reductions in cost per output remains.

Trends in cost per output for gas DSOs

The trends in cost per output for gas DSOs are presented in Figure 4.2. Only three years of data are available for the gas sector, so less clear-cut conclusions can be drawn about longer-term trends.

Figure 4.2 Trends in cost per output for gas DSOs



Source: Oxera using data provided by DTe.

Two marked patterns emerge from Figure 4.2.

– There is relatively limited movement in cost per output within the sector, and the gap between the costs of the most inefficient operators and most efficient remains stable over the three years examined.

– Sector-average unit costs, depicted by the black dotted line, have remained broadly constant over the period.

The examination of broad trends suggests that, for gas DSOs, scenario 2a or, potentially, even a variant of scenario 1 may apply—ie, there has been little evidence of convergence over the time period considered and hence significant scope for further reductions in cost per output remains.

4.2 Productivity analysis

The analysis thus far has examined broad trends in productivity. This section examines the productivity levels and trends in detail in order to establish which of the theoretical scenarios discussed in section 3 can be deemed to apply to gas and electricity DSOs, and hence, whether there is a need to correct for historical catch-up effects in setting the X-factor.

In line with the convention that is often used in the academic literature, the level of average productivity is measured as output per cost. Therefore an increase in productivity leads to an upwards movement in the productivity measure—eg, starting from a productivity level of 1, a 5% increase in productivity results in a productivity growth figure of 1.05. Analogously, a reduction in productivity results in a reduction in the productivity metric—eg, starting from a productivity level of 1, a 5% decrease in productivity results in a productivity growth figure of 0.95.

Catch-up, on the other hand, is defined as efficiency (cost per output). Under this definition cost per output takes values of between 0 (ie, very low efficiency relative to the frontier) and a maximum efficiency value of 100 (ie, the efficiency value at the frontier). An efficiency figure of 80% therefore implies that a company would need to reduce its cost per output by 20% to become fully efficient. When examining catch-up rates (ie, changes in efficiency), a company moving closer to the frontier will have positive growth rates, whereas a deterioration in a company's position relative to the frontier results in a negative growth rate.

4.2.1 Electricity DSOs

Table 4.1 shows maximum productivity, the average productivity level, and the average efficiency—ie, the scope for catch-up across the industry—for each of the years. The figures for catch-up are shown on an unweighted and a weighted basis to examine whether conclusions change when taking company scale into account.

The table provides a broad indication of the average scope for catch-up over time. Columns 1 and 2 show the productivity level at the frontier and the sector average productivity level. Both the frontier and the average productivity levels have increased over time. However, while average efficiency (ie, the scope for catch-up to the average efficient cost level) exhibits a year-on-year variation of between 87% and 93%, there is little evidence that, on average, companies have moved significantly closer to the efficient frontier. In 2000 average efficiency was 91/90% (figures unweighted/weighted by system output)—ie, companies would have been able to reduce their costs per output by 9%/10% on average to reach the frontier. By 2005 average efficiency was 87%/91% respectively, showing that a similar gap to the efficient frontier remained after five years.

Table 4.1 Electricity DSOs: maximum and average productivity and the scope for catch-up

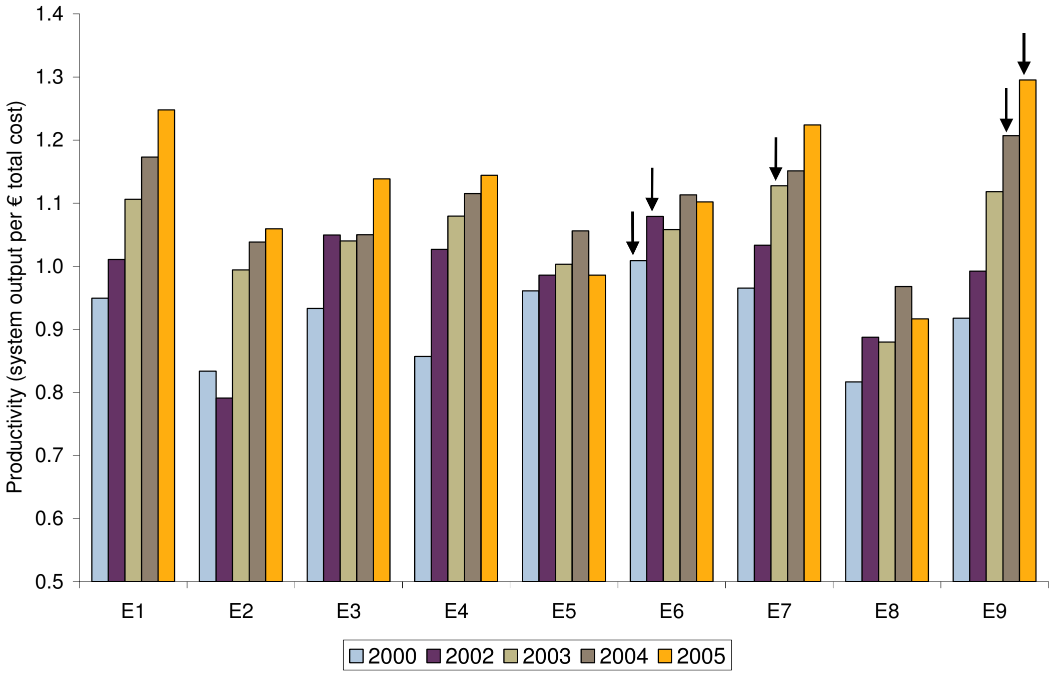
Year	Maximum productivity level (frontier) (system output per € total cost)	Sector average productivity level, (system output per € total cost)	Sector average efficiency (unweighted) (%)	Sector average efficiency (weighted by system output) (%)
2000	1.01	0.92	91	90
2001	n/a	n/a	n/a	n/a
2002	1.08	0.98	91	94
2003	1.13	1.05	93	95
2004	1.21	1.10	91	93
2005	1.30	1.12	87	91

Note: Data for 2001 not available.
Source: Oxera calculations using data provided by DTe.

The table also highlights a clear upwards trend in maximum productivity and average productivity over time, implying that some frontier shift is taking place. (The finding also confirms the declining trend in average cost per output highlighted in Figure 4.1). Maximum and average productivity are highest in 2005, the last year for which data is available.

Figure 4.3 shows the productivity level for each of the companies over time. The arrows mark the efficient frontier in each of the years.[10]

Figure 4.3 Developments in electricity DSOs' productivity



Source: Oxera calculations using data provided by DTe.

The figure shows that all companies increased productivity between 2000 and 2005, although some exhibit year-on-year fluctuations against this trend.

Table 4.2 decomposes the average change in productivity into a catch-up rate (ie, a change in efficiency) and frontier shift.[11] The changes in performance are computed relative to the frontier in 2000, the first year for which data is available, in order to obtain an overall measure of performance improvements achieved over the period.

[10] Productivity is calculated under the assumption of constant returns to scale technology, whereby a 1% increase in system output leads to a proportional increase in cost. Examination of the data revealed that, while the frontier companies in each year were relatively small, larger companies tended to be closer to the frontier on average, suggesting that the assumption of a constant returns to scale technology is valid.

[11] The methodology used to obtain these figures is described in Appendix 1.

Table 4.2 Electricity DSOs' average productivity change, catch-up rate and frontier shift (% growth relative to 2000 base year)

Year	Average productivity change (unweighted)	Average productivity change (weighted by system output)	Catch-up rate (unweighted)	Catch-up rate (weighted by system output)	Frontier shift
2000/01[1]	3.7	6.0	0.2	2.5	3.4
2000/02	7.4	12.3	0.5	5.0	6.9
2000/03	14.3	18.6	2.3	6.1	11.7
2000/04	20.0	23.2	0.3	3.0	19.6
2000/05	22.9	29.4	-4.3	0.8	28.4

Note: [1] Data for 2001 is not available and the sector average growth rate for 2000/01 was computed as the square root of the 2000–02 growth rate.
Source: Oxera calculations using data provided by DTe.

The table shows that average productivity and frontier shift have been continually improving over time, with an increase in average efficiency of around 20% and a frontier shift of close to 30% over the period considered. In comparison, the average catch-up rate to the efficient frontier has been low over the period, with average efficiency in 2005 similar to that in 2000 (see Table 4.1). Therefore, the average productivity growth across the sector of around 22.9% (29.4% weighted by system output) between 2000 and 2005 is almost exclusively driven by frontier shift. This therefore confirms the finding from above that scenarios 1 or 2a apply to the electricity DSOs, and hence the need to adjust for catch-up effects does not arise.

Box 4.1 Does the empirical analysis suggest a correction for catch-up effects for electricity DSOs?

Overall, given that very little catch-up has occurred over the period, there would not appear to be any risks to companies from not adjusting for catch-up effects as significant improvements are likely to be available going forward. In terms of the scenarios considered in section 3, scenarios 1 or 2a are most applicable in considering setting the X-factor for electricity DSOs at the next price review. There would therefore be no need to adjust expected productivity growth for catch-up effects at the next price review.

Therefore, if, under this scenario, an adjustment for catch-up effects were made, distribution network users would pay too much as the resulting tariffs would be higher than those of the average efficient company.

4.2.2 Gas DSOs

Table 4.3 shows maximum productivity, the average productivity level, and the average efficiency—ie, the scope for catch-up across the industry—for each year. The figures for catch-up are shown on an unweighted and a weighted basis to examine whether conclusions are altered when taking company scale into account.

As data for only three years is available, it is more difficult to spot longer-terms trends in performance than in the electricity sector, for which data is available over a longer time period. However, over the three years examined, while the average scope for catch-up varies on a year-on-year basis, there is little evidence of a significant tendency for companies to catch up to the efficient frontier. In 2004 average efficiency was 75%—ie, companies would have been able to reduce their costs per output by 25% on average to reach the frontier. In 2006 average efficiency was somewhat higher at 77/82% (unweighted/weighted by systems output).

Table 4.3 Gas DSOs: maximum and average productivity and the scope for catch-up

Year	Maximum productivity level (frontier) (system output per € total cost)	Sector average productivity level, (system output per € total cost)	Sector average efficiency (unweighted) (%)	Sector average efficiency (weighted by system output) (%)
2004	1.30	0.98	75	75
2005	1.23	0.99	81	83
2006	1.28	0.98	77	82

Source: Oxera calculations using data provided by DTe.

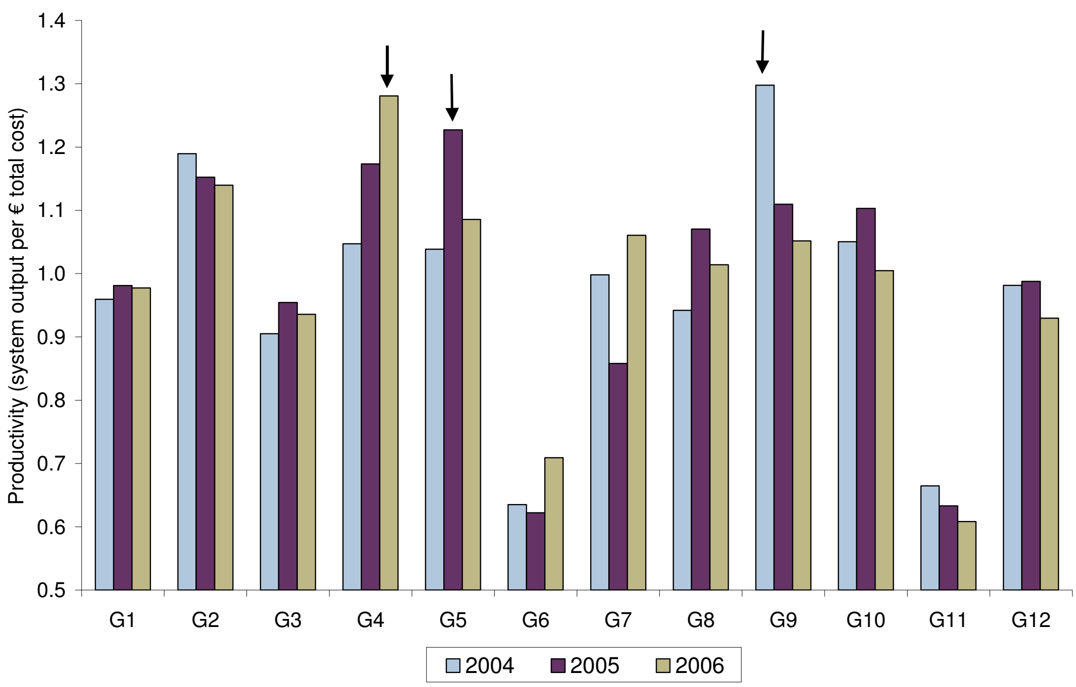
The table also shows that maximum productivity is very similar over the three years, indicating that there was not much movement at the frontier. (The finding also confirms the constant trend in average cost per output highlighted in Figure 4.2.)

Using the sector-average efficiency weighted by output suggests a somewhat more consistent, yet limited, catch-up rate, indicating that larger companies have had a greater tendency to catch up than smaller companies.

The examination of broad trends suggests that, for gas DSOs, theoretical scenarios 1 or 2a may apply—ie, there has been zero or only very limited convergence, but significant scope for further cost reductions remains.

Figure 4.4 plots the productivity for each of the companies over time. The arrows mark the efficient frontier in each of the years.

Figure 4.4 Developments in gas DSOs' productivity



Source: Oxera calculations using data provided by DTe.

The figure shows that some companies increased their productivity between 2004 and 2006, while others have reduced productivity. The fact that that some companies exhibit significant year-on-year fluctuations suggests that productivity would need to be examined over a longer period to obtain more conclusive insights regarding a trend (or lack thereof) in catch-up and frontier shifts over time.

Table 4.4 decomposes the average change in productivity into a catch-up rate and frontier shift.[12] The changes in performance are calculated relative to the frontier in 2004, the first year for which data is available, in order to obtain an overall measure of performance improvements achieved over the period examined.

Table 4.4 Gas DSOs' average productivity change, catch-up rate and frontier shift (% growth relative to 2004 base year)

Year	Average productivity change (unweighted)	Average productivity change (weighted by system output)	Catch-up rate (unweighted)	Catch-up rate (weighted by system output)	Frontier shift
2004/05	1.6	5.4	7.4	11.5	–5.4
2004/06	1.4	2.2	2.7	–2.1	–1.3

Source: Oxera calculations using data provided by DTe.

The table shows that frontier shift from 2004 to 2006 is negative, indicating technological regress. Given the maximum productivity in 2004 and 2006 (1.30 and 1.28 respectively)—see Table 4.4—and the relatively short period considered with significant fluctuations observed, it may be concluded that the frontier shift over the period was close to zero, and that any limited productivity change that occurred over the period was mostly catch-up.

However, even under this assumption historical productivity changes are low since the rate of productivity growth from 2004 to 2006 is only 1.4%—ie, less than 1% per annum. As shown in Figure 4.4 some companies succeeded in increasing their productivity over the three-year period, but only company G4 managed to achieve this consistently. Overall, the analysis confirms the finding above that scenarios 1 or 2a apply to the gas DSOs, and hence the need to adjust for catch-up effects does not arise.

Box 4.2 Does the empirical analysis suggest a correction for catch-up effects for gas DSOs?

Overall, given that very little catch-up or frontier shift has occurred over the period, there is still significant scope for catch-up and, as such, significant improvements are likely to be available going forward.

In terms of the scenarios considered in section 3, scenarios 1 or 2a are likely to be the most applicable ones to consider in setting the X-factor for electricity DSOs at the next price review. There would therefore not be any need to adjust for catch-up effects.

If, under this scenario, an adjustment for catch-up effects were undertaken, distribution network users would pay too much as the resulting tariffs would be higher than those of the average efficient company.

4.3 Robustness of methodology used

The approach employed in this report and described in Appendix 1 is one of a number approaches that may be used to assess historical average productivity growth, catch-up rate and frontier shift. The main alternative approaches would involve econometric techniques—however, implementing such approaches is beyond the scope of this report. Moreover, the robustness of the econometric analysis may be constrained by the limited number of datapoints available for analysis. However, if alternative approaches were applied to the gas

[12] The methodology used to obtain these figures is described in Appendix 1.

and electricity DSO datasets, and given the assumptions in this report as set out in section 1.2, it may be concluded that such analysis would not suggest materially different conclusions than those set out above regarding the need to adjust for catch-up effects.

5 Summary of findings

This report has examined the potential need to adjust expected productivity growth based on historical expendititure for catch-up effects when setting the X-factor. The analysis has been conducted from a theoretical and empirical perspective.

Theoretical analysis

Table 5.1 summarises the findings from the theoretical analysis regarding the need for catch-up effects when using historical expenditure to estimate future expenditure improvements for use in setting the X-factor. This analysis is applicable within DTe's framework to both gas and electricity DSOs and at current and future price reviews.

Table 5.1 Summary of theoretical analysis

Scenario	Range of catch-up	Requirement to adjust?
Scenario 1: no catch up/divergence	Catch-up >or equal to 0%	No
Scenario 2a: partial convergence	0%<catch-up< approx 50%	No
Scenario 2b: partial convergence	Approx 50%<catch-up<100%	Potentially
Scenario 3: full convergence towards the end of previous period	Catch-up=100%	Yes
Scenario 4: full convergence maintained over previous period	Catch-up=100%	No

Source: Oxera.

Overall, from a methodological perspective, and taking DTe's regulation method as given, the need to adjust for catch-up effects may need to be considered only under scenarios 2b (partial, but more complete convergence) and 3 (full convergence). Where these scenarios do not arise, and an adjustment for catch-up is made, distribution network users would pay too much as the resulting tariffs would be higher than those of the average efficient company. It should be emphasised, however, that even if full convergence were to occur in a given period, this outcome is unlikely to be maintained. Given the incentives within the regime, it is more likely that some leapfrogging would take place, and that there would be some divergence during the course of the subsequent period. As such, even if the need to adjust for catch-up were to arise in one period, it would not automatically arise at future reviews.

Empirical analysis

The empirical analysis of **electricity DSOs** shows that only very limited convergence has occurred over the period examined. In terms of the theoretical scenarios considered, scenarios 1 or 2a are the most relevant in setting the X-factor for electricity DSOs at the next price review. Therefore, there would be no need to adjust for catch-up at the next price review.

As such, and under the assumptions made in this report, there would not appear to be any risks to companies from not adjusting for catch-up effects since significant performance improvements are likely to be available going forward.

Therefore, if an adjustment for catch-up effects to electricity DSOs were made, distribution network users would pay too much as the resulting tariffs would be higher than those of the average efficient company.

The empirical analysis of **gas DSOs** shows that only very limited convergence or frontier shift has occurred over the period examined and, as such, that significant improvements are likely to be available going forward. While the time period over which productivity developments were examined was shorter than for electricity DSOs, in terms of the theoretical scenarios considered, scenarios 1 or 2a are the most applicable in setting the X-factor for gas DSOs at the next price review. As with electricity DSOs, there would be no need to adjust for catch-up at the next price review.

Under the assumptions made in this report, therefore, there would not appear to be any risks to companies from not adjusting for catch-up since significant performance improvements are likely to be available going forward.

Therefore, if an adjustment for catch-up to gas DSOs were made, distribution network users would pay too much since the resulting tariffs would be higher than those of the average efficient company.

DTe may wish to monitor developments in electricity DSOs' cost per output. While incentive regulation results in a dynamic process (eg, leapfrogging may occur), this monitoring could determine whether the need to undertake an adjustment for catch-up effects might arise at future price controls.

While this report employs a single methodology to assess the issue of average productivity growth, catch-up rate and frontier shift, it is unlikely that alternative approaches would suggest materially different conclusions regarding the need to adjust for catch-up effects.

A1 Measuring historical productivity growth

Section 4 presents historical average productivity growth measures decomposed into frontier-shift and catch-up trends. The methodology to achieve this decomposition is based on a non-parametric (ie, no assumptions about the production function are made) Malmquist productivity indexes. However, contrary to models that are often employed in the academic literature on performance assessments, in the present context with a single input (cost) and output (system output), the productivity can be measured without recourse to mathematical optimisation routines, which are required for more complex problems with multiple inputs and outputs.

Productivity is defined in each period as P = output/input, and the maximum productivity in each period as max P, allowing us to define the location of the efficient frontier in each period.[13] The following formula can then be used to measure productivity change between time t and time t+1 and its decomposition into catch-up trend and frontier-shift components:

$$\text{Productivity change} = \frac{P_{t+1}}{P_t} = \frac{\max P_{t+1}}{\max P_t} \times \frac{P_{t+1} / \max P_{t+1}}{P_t / \max P_t} = \text{(frontier shift)} \times \text{(catch-up trend)}$$

Although in the present context there are relatively few data points used to measure productivity, information on all DSOs in each sector is used to calculate productivity. Moreover, the method itself does not require a large number of data points to be workable—in theory two data points would be sufficient to compute the index. Therefore, the analysis can be regarded as robustly calculating average productivity growth, catch-up and frontier shift, under the assumptions set out in section 1.2.

However, other questions, which may be relevant in the present context, have not been considered as part of this project. These include the appropriate length of the period over which historical productivity growth rates are calculated; the appropriateness of the approach to, and the data used in, measuring the cost per output and productivity; and any potential impacts on productivity measures owing to adjustments for objectifiable regional differences.

[13] The productivity indexes are computed under the assumption of constant returns to scale.

www.oxera.com

Park Central
40/41 Park End Street
Oxford OX1 1JD
United Kingdom
Tel: +44 (0) 1865 253 000
Fax: +44 (0) 1865 251 172

Stephanie Square Centre
Avenue Louise 65, Box 11
1050 Brussels
Belgium
Tel: +32 (0) 2 535 7878
Fax: +32 (0) 2 535 7770