The necessity and magnitude of frontier shift for the Flemish electricity and gas distribution operators over 2021–24

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Vlaamse Regulator van de Elektriciteits- en Gasmarkt

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Executive summary

Vlaamse Regulator van de Elektriciteits- en Gasmarkt (VREG) has commissioned Oxera to advise on the necessity and potential magnitude of an incremental efficiency challenge by way of a frontier shift parameter[1] for Flemish gas and electricity distribution system operators (DSOs) for the upcoming regulatory period (2021–24). As a result of a merger between operating companies Infrax and Eandis in July 2018, there is now a single operating company, Fluvius. VREG is concerned that there is now a greater risk of weakened incentives for DSOs to reveal the full potential for efficiency improvements, and thus there may be a need for an additional efficiency challenge.[2]

Necessity of the incremental challenge

VREG's current approach to estimating the efficiency challenge in a given regulatory period is based on the extrapolation of cost trend (i.e. rate of change in cost) observed under a revenue cap in a historical reference period. In an industry with multiple companies, this provides relatively consistent incentives for cost reduction, as any individual company can have only a limited impact on the estimated efficiency challenge, so there is always an incentive to outperform the revenue cap and reduce expenditure, the savings from which are shared with consumers.

However, the incentive for cost reduction is limited if the industry contains only one (or a limited number of) company(ies). A reduction in costs in the current regulatory period will feed into the efficiency challenge in the next regulatory period. As such, a company may be able to charge higher prices in the long run if it limits the extent to which (and the pace with which) it reduces expenditure. For this reason, there is a conceptual need to review and consider supplementing the current framework to mitigate this incentive risk.

VREG has imposed an additional efficiency challenge to pass on the merger-related efficiency savings to consumers more quickly than would otherwise have been the case. However, this adjustment relates to the potential for cost reduction resulting from an increase in the scale of the operating company (e.g. eliminating redundancies and enhancing efficiencies through scale) and may not address the incentive issues highlighted above. Moreover, as this is scale related, they should not directly account for frontier shift improvements.

The proposed incremental efficiency challenge is based on the potential for frontier shift productivity improvements (net of any expected change in input prices). Frontier shift relates to the ability of the most efficient companies in an industry to improve productivity (and by construction, the less efficient companies may also have additional scope for improvement). It is therefore an estimate of the *minimum* productivity improvement that a regulated company is expected to deliver. To that end, the question of assessing the need and magnitude of frontier shift is a common issue regardless of the industry structure. The assessment of this in the current regulatory framework is the focus of this report.

[1] Frontier shift is the increase in productivity through improvements in best practice (e.g. better management practices, technological change).
[2] Even with two operating companies, the incentive for cost reduction may not be as strong in Flanders as it is in other jurisdictions that have more operating companies. An additional efficiency challenge may have also been appropriate in this context.

The incremental challenge requires (i) a robust estimate of the scope for frontier shift productivity improvements in the next regulatory period; and (ii) an assessment of the extent to which frontier shift productivity improvements are already accounted for in the current regulatory framework.

Assessing the scope of frontier shift

The feasible rate of frontier shift is estimated by observing the rate of productivity growth in competitive sectors of the Belgian economy that undertake similar activities to the electricity and gas DSOs that are being assessed. In particular, we focus on measures of total factor productivity (TFP) that can account for the contribution of multiple inputs to overall productivity growth in comparable sectors. TFP analysis is well established in the economics literature[3] and is widely used in regulatory contexts.[4]

Using the most recent release of EU KLEMS data (dated 2019), we are able to estimate the productivity growth of comparable comparators over the period 2000–17.

A robust application of the method requires careful selection of:

- **the TFP measure**—TFP can be defined with respect to two output measures: gross output (GO) and value added (VA). Both measures have been used to inform frontier shift efficiency targets;
- **appropriate comparators**—only sectors that are comparable to electricity and gas DSOs *and* are sufficiently competitive should be included in the comparator set;
- **the time period of analysis**—an arbitrary selection of the analysis period could overestimate or underestimate the scope for frontier shift productivity improvements, depending on the position of the Belgian economy and the comparator sectors in the macroeconomic business cycle;
- **the aggregation approach**—the ability to derive a robust (range of) frontier shift estimate(s) is dependent on how the frontier shift achieved in the comparator industries is aggregated. Ideally, industries that are more comparable to electricity and gas DSOs should be given more weight.

Our analysis is informed by regulatory precedent, empirical evidence and the scientific literature. However, as with any empirical investigation, TFP analysis requires an element of value judgement. We therefore use extensive sensitivities to ensure that our recommended range of estimates is robust.

TFP measure

TFP is a measure of productivity growth and is estimated as the difference between output growth and weighted input growth, where inputs are typically labour, capital and intermediate inputs,[5] and the weight on each input is the share of that input in the production process. The TFP measure depends on how ‘output’ is defined: GO represents the total output of a firm, industry or economy, while VA represents the incremental value that a firm, industry or

[3] For a review, see OECD (2001), ‘Measuring productivity. OECD Manual. Measurement of aggregate and industry level productivity growth’, July, section 3.1.2.
[4] Examples include the energy and water regulators in the UK (see Ofgem (2012), ‘RIIO-T1/GD1: Real price effects and ongoing efficiency appendix’, December; and Ofwat (2019), ‘Securing cost efficiency technical appendix’, December, pp. 170–71, respectively); and ACM, the Dutch regulator (see Oxera (2016), ‘Study on ongoing efficiency for Dutch gas and electricity TSOs’, January).
[5] Intermediate inputs are inputs that are consumed in the production process, such as materials, energy, and services procured from external organisations.

economy has added in the production process (i.e. GO less any intermediate inputs consumed in the production process).

GO has a conceptual advantage in that it is the more natural measure of output in a competitive industry, as it accounts for all inputs (including intermediate inputs). Furthermore, the GO measure is considered to be more reflective of the managerial decisions made by companies, as it assumes that all inputs are controllable.

However, GO is susceptible to data uncertainty. Intermediate inputs are typically harder to measure than labour or capital at an industry level, and thus the robustness of the GO measure depends on the quality of data. As the VA measure does not account for intermediate inputs, it will be more stable in cases where there is significant volatility in the intermediate input data. For this reason, both GO and VA measures of output are used to estimate TFP and inform the potential for frontier shift.

Given the conceptual superiority of the GO measure, we place greater emphasis on the GO-based TFP estimates, while also taking the VA-based TFP estimates into account.

Accounting for input prices

The scope for cost savings in the next regulatory period may be compounded or offset by changes in input prices. In estimating the extent to which input prices are likely to change in the next regulatory period, we estimate the evolution of input prices in sectors of the Belgian economy. In so doing, we use the same EU KLEMS data, comparator industries, time period of analysis and aggregation approach as used to calculated the TFP estimate. This ensures that input price pressure and TFP are calculated on a consistent basis (i.e. in terms of dataset and methodology).

The VREG tariff methodology already accounts for general price inflation through its indexation of costs to CPI. We therefore estimate input price pressure in real terms relative to the CPI (known as real price effects, RPEs).

In combining the results from the TFP and RPE analysis, we derive an estimate of frontier shift net of real input prices, or ‘net frontier shift’.

Comparator selection

We select the comparator sectors to be used in the TFP analysis based on regulatory precedent and our expert view. This is also informed by discussions with VREG and Fluvius. The comparator sectors used in the analysis are presented in the table below. As the selection of comparators involves making certain value judgements, we present results from alternative comparator sets to demonstrate the robustness of the results.

Selection of comparators

Comparator industry	Base case	Telecoms sensitivity	EGSA sensitivity
Other manufacturing; repair and installation of machinery and equipment	✓	✓	✓
Construction	✓	✓	✓
IT and other information services	✓	✓	✓
Professional, scientific, technical, administrative and support service activities	✓	✓	✓
Telecommunications		✓	
Electricity, gas, steam and air conditioning supply			✓

Source: Oxera analysis.

‘Other manufacturing; repair and installation of machinery and equipment’ and ‘Construction’ are relevant to the maintenance and construction activities of the DSOs. The construction sector in particular has been used as the sole or key comparator industry for the assessment of capital expenditure in regulatory applications.

Productivity improvements in the data handling and processing activities of DSOs can be captured by developments in the ‘IT and other information services’ and ‘Telecommunications’ sectors. The telecommunications sector may also be loosely related to the construction and maintenance of network assets, given the inclusion of ‘wired communication’ in this sector.

‘Professional, scientific, technical, administrative and support activities’ is a relevant comparator for the DSOs’ indirect expenditure, such as human resources, research and development and legal and accounting activities.

The telecommunications sector has experienced rapid productivity growth in the analysis period, significantly higher than the second best performing industry. For this reason, it is not part of the core set and treated as a sensitivity (the ‘Telecoms sensitivity’).

‘Electricity, gas, steam and air conditioning supply’ (EGSA) is operationally comparable to Flemish DSOs in terms of the activities undertaken within the sector. However, the sector contains the DSOs being assessed (and can therefore be influenced by the DSOs); is not sufficient competitive and characterised by natural monopolies. For these reasons we treat it similar to the Telecommunications sector under the ‘EGSA sensitivity’.

Regulators also consider ‘Chemicals and chemical products’ and ‘Electrical equipment’ as comparator sectors for gas and electricity networks,[6] respectively. These sectors are not as related to the activities of gas and electricity DSOs as the core sectors. However, we still consider these as (less relevant) sensitivities to cross-check the conclusions of the report. Furthermore, Fluvius provided its view on the relevant comparator sectors and respective weights (i.e. importance) on each sector, which we have considered as well.

[6] That is, distribution and transmission system operators.

Time period of analysis

Productivity growth is typically 'pro-cyclical'. That is, productivity growth is larger in times of macroeconomic growth and smaller (sometimes negative) in times of macroeconomic decline. To avoid biasing the frontier shift estimate based on Belgium's current position in the macroeconomic cycle, we estimate productivity growth over complete business cycles.

Based on the EU KLEMS dataset, we have identified two business cycles[7] that we use for our core analysis: 2003–10 and 2010–17. As a sensitivity, we also consider two alternative business cycles: 2001–08 and 2008–12. In deriving a final estimate for the scope of productivity improvements, we attach more weight to more recent business cycles on the assumption that more recent data may better reflect the scope for productivity growth in the near future (i.e. in the next regulatory period).

Aggregation approach

As we have identified multiple comparator sectors that undertake comparable activities to the gas and electricity DSOs, the TFP estimates over the identified time periods need to be aggregated to an overall productivity measure. There are typically two approaches to aggregating frontier shift estimates across comparator industries: a simple (unweighted) average, and a weighted average. The weights in the latter approach should represent how similar each comparator industry is to the DSOs being assessed, while the former approach gives equal weight to each sector. The weighted approach involves a detailed mapping of comparator industries to specific DSOs' activities. For example, construction could be a relevant comparator for the building and maintenance of infrastructure, but may be less relevant for the indirect expenditure (e.g. human resources, research and development) of DSOs. In this case, the weight on the construction industry would be determined by the share of building and maintenance expenditure in the total expenditure of DSOs.

If the weights can be robustly estimated, the weighted average TFP across industries may match the DSOs' activities more closely than a simple average. However, such an approach requires:

- the current mix of activities undertaken by DSOs to be efficient—if the weights are determined on an inefficient cost structure, the use of internal data could perpetuate inefficiencies and may not reflect the true potential for productivity savings;
- an accurate breakdown of DSOs' expenditure by activity, and a robust mapping exercise of comparator sectors to each activity.

The comparator sectors defined in the EU KLEMS database and identified in our core set undertake a number of activities with potentially common functions. For example, all the comparator sectors (and companies classified within these) can be expected to undertake back-office tasks that rely on IT services to varying degrees. Given the overlap of activities among the comparator sectors, some amount of value judgment and reliance on simple average is inevitable even when detailed mapping information is available.

We have focused on a simple average approach to aggregation in this study, as activity-level expenditure data was not available for the Flemish DSOs. In

[7] The business cycles are identified based on a growth cycle definition. According to this definition, a business cycle is defined as a period between two points with zero output gap including both a peak and a trough.

the absence of evidence that the historical expenditure of the DSOs was efficient, we consider the simple average approach to aggregation to be robust. Even where activity-level expenditure data is available to generate weights, for the reasons highlighted above, a simple average of the sector productivity growth rates is bound to provide useful information. Nevertheless, as sensitivities to the core analysis, we have calculated weighted average productivity growth estimates where the weights have been derived from regulatory precedent in British gas distribution networks[8] and Dutch gas and electricity transmission networks[9], as well as the weights proposed by Fluvius for their comparator sectors.

Net frontier shift productivity results

The table below shows the range of estimated TFP, RPEs and net frontier shift for the base case comparators and the Telecoms and EGSA sensitivities over two complete business cycles. Analysis of the base case comparators indicates that a net frontier shift of 0.1–0.4% p.a. is feasible. That is, we expect Flemish DSOs to reduce their expenditure by up to 0.4% p.a. as a result of frontier shift productivity improvements and changes in real input prices.

Summary of net frontier shift results

	Base case	Sensitivities
Frontier shift[1] (% p.a.)	0–0.2%	-0.1–1.2%
RPEs[2] (% p.a.)	-0.4–0.1%	-0.6–0.1%
Net frontier shift[3] (% p.a.)	**0.1–0.4%**	**0–1.4%**

Note: [1] A positive number indicates there is scope for cost reduction as a result of frontier shift productivity improvements. [2] A positive number indicates that real input prices (and therefore expenditure) are rising. [3] A positive number indicates there is scope for cost reduction as a result of the combined effect of frontier shift productivity growth and real input price changes.

Source: Oxera analysis.

Sensitivities to the base case comparator set indicate that a net frontier shift towards the upper end of (or in excess of) the range estimated by the base case is feasible. In particular:

- estimated net frontier shift is typically higher in the most recent business cycle (2010–17) in both the base case and the Telecoms and EGSA sensitivities;
- the Telecoms sensitivity suggests that the true scope for frontier shift could greatly exceed that in the base case. The midpoint of the range estimated by the Telecoms and EGSA sensitivities (0.7% p.a.) is still larger than the upper bound estimated by the base case comparator set (0.4% p.a.);
- alternative sensitivities regarding comparator set, aggregation approach and international comparisons typically support a number towards the upper end (or in excess of the upper end) of the range in the base case.

Overall, we estimate the **feasible rate of net frontier shift that Flemish DSOs are likely to face in the next regulatory period to be 0.4% p.a.** In other words, we expect the Flemish DSOs to be able to reduce their expenditure at a rate of 0.4% p.a. as a result of frontier shift productivity improvements and changes in real input prices.

[8] Europe Economics (2007), 'Top down benchmarking of UK Gas Distribution Network Operators', April, section 4.
[9] Ecorys (2019), 'Wegingsfactoren voor frontier shift TSO's', January.

Decomposing the current efficiency challenge

The current efficiency challenge in VREG's tariff methodology is based on historical cost trends that may already account for all sources of productivity improvement including frontier shift.

As such, it is essential that the current efficiency challenge in the tariff methodology is decomposed into its components to ensure that there is no double-counting or neglect of the impact of frontier shift in the determination of revenues over the next regulatory period.

Using cost and output data provided by Fluvius, we assessed the extent to which the current cost trends account for frontier shift. We followed two approaches: examining the trends in unit costs of the efficient DSOs, and mathematically decomposing the cost trend using data envelopment analysis (DEA).[10]

Our analyses indicate that the most efficient electricity DSOs are reducing their unit costs in the period in which the efficiency challenge is estimated in the current regulatory framework. This indicates that frontier shift may already be accounted for in the efficiency challenge using the current framework. The reverse is true for gas DSOs—unit costs of the most efficient DSOs are rising in the analysis period, indicating that the current framework is unlikely to account for frontier shift.

The observations from unit cost trends are supported by DEA, where the frontier shift in electricity distribution is positive (i.e. efficient costs are improving indicating that an additional frontier shift challenge may double-count the scope for frontier shift efficiency improvements) and the frontier shift in gas distribution is negative (i.e. efficient costs are worsening indicating that frontier shift is not accounted for in the regulatory framework).

Both approaches (unit cost trends and DEA) are based on assumptions that may limit the robustness of any precise estimate of frontier shift in the analysis period. However, given the consistency in outcome across multiple sensitivities and the simplicity of the conclusion (i.e. frontier shift either is or is not accounted for) we consider the conclusions from the analysis to be reasonably robust.

The incremental efficiency factor through frontier shift

In setting the incremental efficiency factor, we combine our estimate of the net frontier shift applicable to the Flemish DSOs with an adjustment to account for the extent to which frontier shift is already accounted for in the regulatory framework. This is summarised in the table below.

Overall, we consider that **no incremental efficiency challenge is needed for electricity DSOs**, as the current regulatory framework already accounts for the impact of net frontier shift within the general efficiency challenge. However, an **incremental efficiency challenge of 0.4% can be applied to gas DSOs**, given the lack of frontier shift improvement observed in the period in which the general efficiency challenge is assessed.

[10] DEA is a mathematical approach to efficiency assessment that is widely used in regulatory applications. In this report, we use DEA-based Malmquist productivity indices (MPIs) to decompose the cost trends into their components. For a detailed discussion of DEA and its applications, see Thanassoulis, E. (2001), *Introduction to the Theory and Application of Data Envelopment Analysis: A Foundation Text with Integrated Software*, Springer.

Proposed incremental efficiency challenge

	Electricity	Gas
Feasible rate of net frontier shift (% p.a.)	0.4%	0.4%
Extent to which the current framework already accounts for net frontier shift (%)	100%	0%
Proposed incremental efficiency challenge (% p.a.)	**0%**	**0.4%**

Source: Oxera analysis.

1 Introduction

1.1 Remit and objectives of the study

The Flemish energy regulator, Vlaamse Regulator van de Elektriciteits- en Gasmarkt (VREG), has commissioned Oxera to conduct a study on the necessity and magnitude of a frontier shift target for the Flemish gas and electricity distribution system operators (DSOs). The objective of the study is to assess whether an additional efficiency challenge is required for the next regulatory period (2021–24) given the current regulatory framework, and, if an additional efficiency challenge is applicable, to estimate its magnitude.

1.2 Background to the regulatory framework and industry structure

VREG currently uses a CPI - X approach to set allowed revenues for the gas and electricity DSOs. Specifically, revenues are allowed to increase with the economy-wide inflation rate (CPI), less an efficiency factor, 'X'. VREG derives its efficiency factor typically using the industry's historical evolution in real 'endogenous costs' and refers to the specific factor as x. As a result of the merger between the operating companies Eandis and Infrax in 2018, VREG has applied an additional efficiency factor, x', for the last two years of the current regulatory period so that the merger synergies can be passed on to consumers more quickly than would otherwise be the case. VREG will continue to apply this additional efficiency factor in the forthcoming regulatory period until all the perceived synergies have been passed on to consumers. In other words, X in the CPI – X formula equals $(x + x')$ in the current regulatory framework.

Specifically, within a regulatory period, the allowed income of the DSOs evolves annually by a factor of $1 + CPI - x - x'$,[11] where:

- x is equal to the trend in historical costs across all DSOs over previous years. For example, for the 2017–20 regulatory period, the x factor is derived using cost information for 2011–15, and for the forthcoming regulatory period, 2021–24 (the focus of this assignment), information over 2015–19 will be used;
- x' is the anticipated saving due to the merger of the operating companies Eandis and Infrax. In essence, a sustained spread in total net cost savings of about €109m is expected by 2024. By 2020 (the current regulatory period), a total cost saving of €25.5m is anticipated. Hence, over the next regulatory period (2021–24), a total cost saving of €83.5m is expected.

VREG's current approach to setting the general efficiency challenge, x, provides relatively consistent incentives for operators to reduce costs if the industry comprises multiple owners or operators. As allowed costs are driven by past cost reductions in the industry, any one individual operator may have minimal control over the X-factor. This separation between an operator's observed expenditure and its allowed revenues, combined with a revenue cap, creates incentives for individual operators to reduce costs, which helps to set the future X-factor for all operators while passing on the savings to consumers.

As the number of independent companies in the industry reduces, individual companies will have more impact on the X-factor. As a result of the merger between the last two operating companies, Eandis and Infrax, VREG is

[11] In the price-setting formula, there is also an adjustment factor, q, used to incentivise quality of service. This factor was set to zero in the regulatory period 2017–20 (and is therefore omitted from the formula) but will be different from 0 in the regulatory period 2021–24.

seeking to reassess its approach (for example, by way of a correction factor) to setting the efficiency challenge, X, as the industry will consist of only the merged operating company, Fluvius. Under the current approach, the incentive for Fluvius's DSOs to cut costs may be reduced, as a higher cost reduction in the current regulatory period will lead to a higher efficiency challenge for themselves in the following period (creating a 'ratchet effect'). There is therefore a risk of inefficiencies arising or remaining hidden if the tariff methodology continues to rely on the endogenous cost reductions made historically, without further modifications.[12]

VREG is therefore considering imposing a third efficiency challenge, x'', to account for frontier shift[13] efficiency improvements, which is the *minimum* of what one can expect regulated companies to achieve in a given regulatory period. To that end, the question of assessing the need and magnitude of frontier shift is a common issue *regardless* of the industry structure. The assessment of this in the current regulatory framework is the focus of this report. As discussed, there appears to be a conceptual need to adjust the tariff methodology due to the change in incentives caused by the merger. However, the extent of the adjustment, x'',[14] is an empirical question and depends on the extent to which the current approach already accounts for frontier shift.

1.3 Building blocks of our assessment

As part of our assessment, we have:

- conceptually assessed the need for an incremental efficiency challenge in the next regulatory period;
- collated academic sources and regulatory precedence on the issue of frontier shift estimation to derive best practice;
- compiled a set of comparator industries to capture productivity trends in activities relevant to electricity and gas DSOs;
- identified the most appropriate productivity measure, time period of analysis and method of aggregating the sectoral productivities to inform the potential for frontier shift for the electricity and gas DSOs;
- used the same data, comparator set and analysis period to assess the potential evolution of input price inflation;
- decomposed the existing efficiency challenges into their constituents to assess the extent to which frontier shift potential is already accounted for in the current regulatory framework;
- performed extensive sensitivity analysis to test the robustness of the core analysis and help to refine the feasible range of frontier shift targets.

1.4 Structure of the report

This report is structured as follows:

[12] The merger between Eandis and Infrax makes this incentive issue more pressing. However, even with two operating companies, the incentive for cost reduction may not be as strong in Flanders as it is in other jurisdictions that have more operating companies. An additional efficiency challenge may also have been appropriate in this context.
[13] Productivity growth and its components are discussed in section 2.
[14] This report focusses on quantifying the scope for additional productivity improvements beyond what is accounted for in the current tariff methodology, but does not discuss how the adjustment for frontier shift (if necessary) is to be applied in the tariff formula.

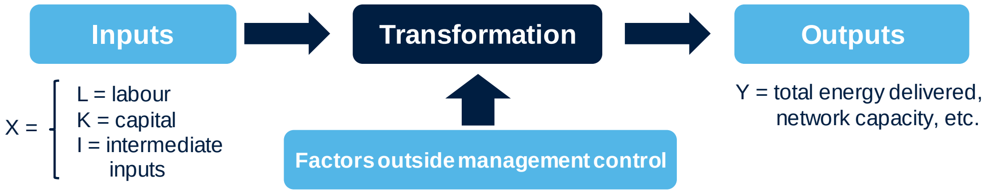
- section 2 outlines the dataset and methodology used to derive a robust estimate of frontier shift (net of input price pressure);
- section 3 presents the results from our total factor productivity (TFP) analysis and sets out the feasible range of net frontier shift;
- section 4 examines the evidence of the frontier shift already achieved by the Flemish gas and electricity DSOs in the reference regulatory period;
- section 5 presents our recommendation for the incremental net frontier shift challenge in gas and electricity distribution.

2 Net frontier shift methodology

2.1 Productivity as a concept

In production economics theory, the concept of production is defined as the transformation of factors of production (inputs) into a set of outputs. The exact process through which inputs are transformed into outputs is generally not examined in economics applications through top-down approaches[15]—rather, it is considered as a 'black box' technology where inputs enter the black box and outputs leave, as shown in Figure 2.1.

Figure 2.1 Production process



Note: Inputs used in the production process fall broadly into three categories: (i) labour (i.e. the number of hours worked); (ii) capital (e.g. the network of pipes used to deliver gas); and (iii) intermediate inputs (inputs that are consumed in the production process, such as fuel for transport vehicles).

Source: Oxera.

In this context, productivity is defined as the ratio of output to input, Y/X. Productivity can therefore be improved by increasing the level of output(s) with input(s) being held constant; decreasing the level of input(s) with output(s) being held constant; or a combination of the two. This calculation is relatively simple in a stylised example with a single input and a single output. However, empirical challenges arise when companies produce multiple goods or services by utilising a number of inputs.[16]

The *value* of all outputs can be aggregated and compared across competitive industries, as in competitive industries the price of final outputs conveys economic meaning in terms of its value to consumers. Economists typically use the total value of outputs as the numerator of the productivity ratio.

The aggregation of inputs requires the relative importance of each input in the production process to be estimated. Although this can be achieved using several techniques, in this report we use the growth accounting (GA) approach, as is common in regulatory settings,[17] whereby inputs are weighted by the share of their contribution to total output. In this approach, productivity is calculated as output divided by the weighted sum of inputs; and productivity growth is calculated as the difference between output growth and weighted average input growth (otherwise known as the 'residual method').

Productivity growth itself can be driven by different types of efficiency improvement, as shown in the equation below.

$$\Delta\, productivity = \quad h(\Delta\, catchup\ efficiency,$$
$$\Delta\, technology\ (frontier\ shift), \Delta\, scale\ efficiency)$$

[15] Instead, this is considered in bottom-up approaches such as process benchmarking and reference models.
[16] For example, a phone manufacturer will use multiple inputs (e.g. labour, machinery, silicon, power) to produce multiple phones (of different sizes and specifications).
[17] For example, the Bundesnetzagentur uses a GA approach to assess frontier shift in its Törnqvist analysis of German electricity and gas DSOs. See Bundesnetzagentur (2018), 'BK4-18-056 Beschlusskammer 4', November.

Where:

- $\Delta\, catchup\ efficiency$ measures the improvements in productivity relative to the current best practice in the industry, which is defined with reference to a set of comparators and technology;
- $\Delta\, scale\ efficiency$ measures the improvements in productivity associated with operating at a more optimal scale;
- $\Delta\, technology\ (frontier\ shift)$ measures the extent to which best practice has improved over time;
- h is the function describing the mathematical relationship between the components of productivity growth and overall productivity growth.

In competitive markets, it is expected that relative inefficiency cannot exist in the long run.[18] Therefore, if productivity growth is assessed over an extended time period, catch-up efficiency improvements should account for a small amount of overall productivity growth. Furthermore, under neoclassical assumptions, firms should operate under constant returns to scale.[19] That is, firms become neither more nor less productive as the scale of operations changes. As such, scale efficiency improvements should also account for a small amount of overall productivity growth. It is therefore often assumed that most (or all) of the productivity growth in competitive markets is attributed to frontier shift.

However, in practice, most industries do not fulfil the theoretical expectations of perfect competition. Inefficiencies can arise and be sustained if competitive pressures are not strong enough. Furthermore, economies of scale may exist at the firm or industry level. For these reasons, observed productivity growth in real-world applications may be due to all sources of efficiency improvements.

In a regulatory context, the components of productivity growth should account for price movements. This is because productivity as a concept is ‘price-agnostic’—it relates to the production technology used and concerns only input and output *quantities*. Regulators are interested in costs, and specifically changes in costs over time. Changes in costs are typically described as a function of three main components:

- outputs—an increase in output typically requires an increase in expenditure;
- productivity—increases in productivity mean that the same outputs can be produced at a lower cost (or more outputs can be produced for the same cost);
- input prices—increases in input prices (e.g. increases in wages, assets) typically lead to higher costs.

Combining the estimated frontier shift target with an estimate of input price change leads to an estimate of ‘net’ frontier shift’.[20]

[18] If an individual firm is operating with relative inefficiency, it will not be able to charge as low a price as its efficient competitors. Consumers will therefore be drawn to the lower-priced competitors and the inefficient firm will have to either reduce its inefficiency or leave the market. Frictions in the market (such as imperfect consumer knowledge) may allow inefficiency to persist in the short run.
[19] For example, see Varian H. (2006), *Intermediate Microeconomics*, Norton, Fifth Edition, pp. 322–324 and 335–336.
[20] An alternative approach is to jointly estimate the scope for frontier shift productivity improvements and changes in input prices to assess the level of efficient expenditure in the forthcoming regulatory period, by

Regulators often assess the components of productivity growth separately in setting efficiency targets.[21] However, in setting the efficiency adjustment using the historical trend in total expenditure (x), VREG does not currently distinguish between the above three sources of efficiency improvement, and clearly, historical trends in expenditure can in theory include all of the above factors

The incremental efficiency challenge for the next regulatory period, x'', is envisaged in the form of a frontier shift productivity target. Frontier shift can be achieved by all companies in an industry. As such, a frontier shift target is the *minimum* of what one can expect regulated companies to achieve in any given regulatory period.

2.2 Estimating frontier shift

Regulators typically assess the scope for frontier shift productivity improvements using 'top-down' methods. These methods do not examine the details of the production process and the scope for technological progress at each stage of the process. Rather, they use high-level productivity metrics to assess the extent of long-run frontier shift in the past, and extrapolate that performance into the future (calibrating them appropriately for future uncertainties). The 'top-down' methods can be broadly split into two categories.

- **Indirect comparisons.** The feasible rate of frontier shift is based on the estimated productivity growth of competitive[22] sectors of the Belgian economy that undertake similar activities to those undertaken by the Flemish electricity and gas DSOs. If the past rate of productivity growth is a good indicator of the scope for productivity improvements in the future, this approach can provide useful evidence to estimate the scope for frontier shift improvements. Examples of indirect comparisons being used to set frontier shift targets include the following.
    - Ofgem (UK):[23] in its determination of an ongoing efficiency challenge (frontier shift) for the gas distribution networks on total expenditure (TOTEX), Ofgem considered a range of total and partial factor productivity measures estimated using EU KLEMS data. In the case of electricity distribution, Ofgem applied a further efficiency challenge, as it felt that there was higher scope for productivity improvements through

examining the evolution of output prices in comparable competitive sectors of the economy. Under certain neoclassical assumptions, output price movements represent the combined impact of frontier shift and changes in input prices. Output price analysis has been used by the Dutch regulator, ACM. See ACM (2013), 'Methodebesluit GTS 2014-2016', October; ACM (2013), 'Methodebesluit Transporttaken Tennet 2014-2016', October.

[21] For example, the energy regulator for Great Britain, Ofgem, assesses the scope for catch-up efficiency improvements in its comparative assessment, and the scope for frontier shift net of input price pressure in its ongoing efficiency assessment. See Ofgem (2012), 'RIIO-GD1: Final Proposals – Overview', December, section 4. Similarly, the German energy regulatory, the Bundesnetzagentur, sets individual efficiency targets for DSOs based on a comparative assessment and an industry-wide target to capture frontier shift and input price pressure. See Ordinance on incentive regulation of energy networks (ARegV) §9, §12–16 and appendix 3, http://www.gesetze-im-internet.de/aregv/.

[22] As noted previously, on the assumption that the comparator sectors are broadly competitive, all of the estimated productivity growth can theoretically be attributed to frontier shift. Relative inefficiency cannot exist in the long run in a competitive market, suggesting that productivity growth cannot be driven by catch-up efficiency improvements. Furthermore, perfect competition requires that firms operate under constant returns to scale, and therefore productivity growth cannot be attributed to scale efficiency improvements. Productivity growth in industries that are not competitive (e.g. because they are characterised by natural monopolies) cannot be used to estimate frontier shift with simple applications of this method. As noted, most sectors may not meet the criteria of perfect competition, so some adjustment to the estimated productivity may be required to avoid conflating different sources of efficiency improvements.

[23] Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July, Section 3.

incremental benefits from smart grids and smart meter technologies.[24] It is intending to perform similar analysis in the next price control (RIIO2).[25]

- ACM (Netherlands):[26] ACM used a combination of TFP estimates and output price indices to set ongoing efficiency targets for the Dutch electricity and gas transmission sectors.

- **Direct comparisons.** The feasible rate of frontier shift is based on evidence of the frontier shift achieved by the regulated companies themselves. Examples of direct comparisons being used to set frontier shift targets include the following.
  - Council of European Energy Regulators (CEER):[27] in 2012, a pan-European benchmarking study of electricity transmission system operators (TSOs) used data envelopment analysis (DEA)[28] to estimate the rate of frontier shift achieved by the industry.[29] The results from this analysis have been used by some regulators (e.g. ACM).
  - Bundesnetzagentur (Germany):[30] the regulator uses direct evidence of the efficiency gains that the industry has achieved historically to set an ‘X-gen’ (frontier shift net of input prices) for the forthcoming regulatory period. For the upcoming period, it has used frontier-based methods such as Törnqvist, DEA and stochastic frontier analysis (SFA) models to estimate frontier shift.

Given that all of the Flemish DSOs are managed on the operational level by the same entity, there is a potential absence of sufficient managerial independence to perform robust direct comparisons.[31] Furthermore, using the historical performance of the DSOs to set forward-looking frontier shift targets leads to the same incentive issues highlighted with the general efficiency target (x) in section 1—i.e. the incentive for cost reduction is limited as the number of independent operators reduces.

In this report, we therefore focus on indirect comparisons to assess the feasible rate of net frontier shift in the next regulatory period. This has the advantage over direct comparisons in that it is independent of what the Flemish DSOs have achieved in the past. We also use, at a high-level, direct evidence to inform the magnitude of frontier shift productivity improvements in the past, and therefore the extent to which the current approach to estimating the X-factor already accounts for frontier shift. This is explained further in section 2.6.

Indirect comparisons involve assessing the productivity gains made by competitive sectors of the economy that undertake comparable activities to

[24] Ofgem (2014), ‘RIIO-ED1: Final determinations for the slowtrack electricity distribution companies’, November, Section 4.
[25] Ofgem (2018), ‘RIIO-2 Sector Specific Methodology’, December.
[26] ACM (2017), ‘Incentive regulation of the gas and electricity networks in the Netherlands’, May.
[27] Frontier Economics, Consentec and Sumicsid (2013), ‘E3GRID2012 – European TSO Benchmarking Study: A report for European Regulators’, July.
[28] DEA is a mathematical non-parametric approach that is widely used internationally when benchmarking regulated companies. For a more detailed discussion on DEA, see Thanassoulis, E. (2001), *Introduction to the Theory and Application of Data Envelopment Analysis: A Foundation Text with Integrated Software*, Springer.
[29] A similar study was conducted in 2019 (see Sumicsid (2019), ‘Pan-European cost-efficiency benchmark for electricity transmission system operators’, July) but no frontier shift analysis was published. Oxera understands that frontier shift results were discussed with the TSOs participating in the project.
[30] Bundesnetzagentur (2018), ‘BK4-18-056 Beschlusskammer 4’, November.
[31] In some cases, it is possible to use direct evidence from international comparators to assess frontier shift. However, this requires sufficiently strict comparability data and operational environments. Such analysis was not deemed practical in the current assignment.

those undertaken by the Flemish gas and electricity DSOs. This typically requires methodological decisions regarding:

- the appropriate measure of productivity;
- the appropriate comparator sectors;
- the period over which productivity growth is to be estimated;
- ways of aggregating the comparator sectors' productivity measure into a consolidated measure;
- the adjustments required to decompose the estimated productivity growth into frontier shift and other sources of efficiency gains.

Our decisions relating to the above concepts will be based on scientific best practice, regulatory precedent and our expert view. However, as with most empirical applications, there is a degree of value judgement in estimating frontier shift. As such, we undertake extensive sensitivity analysis to support our core choices.

To ensure comparability with the frontier shift estimates, we will use the same assumptions (e.g. in terms of the comparator sectors, time period and ways of aggregating them) in estimating the input price pressure that Fluvius's DSOs are likely to face in the next regulatory period.

2.3 The dataset

Productivity analysis requires detailed data on input and output volumes for competitive industries that are comparable to the electricity and gas activities that DSOs in Flanders undertake. The EU KLEMS[32] database provides data on key macroeconomic variables (such as economic growth, labour employment, capital formation and productivity growth) at the industry level[33] for all EU member states, as well as some non-EU countries such as Japan and the USA.

The most recent version of the EU KLEMS dataset for Belgium (the 2019 release) contains data for most variables from 1996 to 2017. However, data for labour and capital volumes begins only in 1999, so the analysis period is limited to 2000–17. As a sensitivity, we have conducted a similar analysis for the Dutch economy and associated sectors, as the Netherlands is a relevant comparator economy for Belgium. The core results for this are presented in appendix A1.

2.4 Total factor productivity

Several productivity metrics exist and can be appropriate in different contexts. These can be broadly split into two categories.[34]

- **Partial factor productivity (PFP) measures.** These include high-level metrics such as output per worker or labour productivity at constant capital. Such measures are sometimes used to set efficiency targets, especially if

[32] Stehrer, R., Bykova, A., Jäger, K., Reiter, O. and Schwarzhappel, M. (2019), 'Industry Level Growth and Productivity Data with Special Focus on Intangible Assets', October. Data is available at https://euklems.eu/.
[33] Specifically, the dataset disaggregates data according to the NACE Rev. 2 (ISIC Rev. 4) industry classifications.
[34] For a detailed discussion of different productivity measures, see OECD (2001), 'Measuring productivity. OECD Manual. Measurement of aggregate and industry level productivity growth', July, section 2.

these are set on a subset of total expenditure.[35] However, PFP measures are not comprehensive measures of productivity. In particular, the productivity of any one input depends on the utilisation of other inputs, which implies that partial measures are not likely to truly reflect the productivity potential of an input set.

- **TFP measures.** TFP estimates are calculated using data on all inputs, and therefore represent the productivity of the entire production process. TFP is therefore seen as a more relevant productivity measure for a broad cost base, such as TOTEX.

Given the completeness of the TFP measure and the focus on determining the efficient level of TOTEX in the regulatory framework, we consider it to be the most appropriate measure in this context.

The exact method of calculating TFP differs depending on the measure of output used. Typically, practitioners consider either gross output (GO) or value added (VA) measures of output. GO represents the total output of a firm, industry or economy and can be considered as the 'end-product'. VA, on the other hand, represents only the incremental value that a firm, industry or economy has added in the production process. In other words, VA is GO less any intermediate input consumed in the production process (such as materials, services procured from external organisations, and energy consumed in the production process).

The GO-based TFP growth measure is estimated as the residual from subtracting the weighted average growth of labour (L), capital (K) and intermediate inputs (I) from the growth of gross output (GO) according to the equation below.

$$gTFP(GO) = gGO - w_L \times gL - w_K \times gK - w_I \times gI$$

Where:

- gGO represents the growth in gross output volume;
- gL represents the growth in labour volume, weighted by the labour share of GO, w_L;
- gK represents the growth in capital volume, weighted by the capital share of GO, w_K;
- gI represents the growth in intermediate input volume, weighted by the intermediate input share of GO, w_I.[36]

VA-based productivity measures are calculated similarly, but with intermediate inputs removed from the equation and the weights calculated as the share of input in VA rather than in GO.

Under neoclassical assumptions regarding the production technology, VA- and GO-based TFP measures are related. In particular, it can be demonstrated that a scaling factor can be applied to TFP(GO) to derive TFP(VA). As this scaling

[35] For example, Ofgem used labour productivity at constant capital to set a 1% p.a. frontier shift target on OPEX. See Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July, p. 21.
[36] GA typically utilises an endogenous capital share of output and, as such, $w_L + w_K + w_I = 1$ by construction.

factor is greater than 1 by construction,[37] TFP(VA) will be larger in absolute terms than TFP(GO) if the neoclassical assumptions are maintained.[38]

Both TFP(GO) and TFP(VA) have been used in regulatory contexts to set efficiency targets. GO has the advantage that it is the more natural measure of output in a competitive industry as it accounts for the contribution of all inputs to output, including intermediate inputs. The inclusion of all inputs can avoid biases in the VA measure when the mix of inputs used in the production process changes. Furthermore, the GO measure is closely related to the decisions made by companies, as it assumes that all inputs in the production process are controllable.

One key drawback with the GO measure of output is that it is susceptible to data uncertainty. While labour and, to a lesser extent, capital volumes can be measured with relative ease, intermediate input volumes are typically harder to estimate at an industry level. Furthermore, the GO measure is more sensitive to the change in the vertical structure of firms (and therefore a change in the role of intermediate inputs)—for example, if activities are outsourced between periods of analysis, the relative weight of intermediate inputs can change drastically between these periods. This can have a large impact on the resulting productivity estimates, essentially compounding the effect of measurement errors that are already present in the intermediate input data. VA-based productivity measures are by construction more stable in such cases, since intermediate inputs are not directly part of the estimation procedure.

On balance, we consider that both methods can be used to set frontier shift targets for the Flemish DSOs. However, given the conceptual superiority of the GO-based measure, we place greater emphasis on GO-based TFP. Some weight is also placed on the VA-based estimates.

2.5 Accounting for input prices

Any cost savings made through frontier shift productivity improvements may be compounded or offset by changes in input prices. As both productivity growth and input price pressure affect the evolution of output prices in a competitive market, VREG will also need to account for the impact of input price pressure on the DSOs' efficient level of expenditure if it is to mimic the pressures of a competitive market.

There are two approaches to assessing the impact of input price pressure on the Flemish DSOs' efficient costs:

- use a combination of specific input price indices (and forecasts where possible) and the inputs used in Flemish DSOs' production process to build a 'bottom-up' index;
- examine the historical evolution of input prices in the same comparator sectors used to set the frontier-shit target to build a 'top-down' index.

The former approach requires a detailed breakdown of the main inputs used by the Flemish DSOs and each input's share in total expenditure, as well as forecasts of relevant input price indices. This approach has an advantage over

[37] The scaling factor is the inverse of the share of VA in GO. As VA is equal to GO minus intermediate inputs, and intermediate inputs cannot be negative, GO is always greater than (or equal to) VA. The inverse of the share of VA in GO is therefore always greater than (or equal to) 1.
[38] See Balk, B.M. (2009), 'On the relation between Gross Output- and Value Added-based productivity measures: The importance of the Domar Factor', *Macroeconomic Dynamics*, **13**, pp. 241–67.

the 'top-down' method as it can be made forward-looking (if the regulatory framework requires it to be), it is based on external forecasts, and it matches the cost structure of the assessed DSO. However, one key drawback of such analysis is that it requires Fluvius's DSOs' current mix of inputs that comprise the cost base to be efficient. Furthermore, while high-level price indices are typically publicly available, more detailed indices may not be. We have therefore opted to use the second approach (i.e. top-down) as a practical solution.

The 'top-down' method is a more straightforward approach. While the approach is based on past performance (i.e. is backward-looking), it is used by regulators in the Netherlands[39] and Germany.[40] This approach uses the same EU KLEMS dataset and methodology used to estimate the frontier shift target and is therefore internally consistent in terms of dataset and methodology.

The VREG tariff methodology already accounts for the impact of general price inflation (CPI) in its price-setting formula. If DSO-specific input prices evolve at the same rate as general price inflation, then the regulatory framework already accounts for the impact of input price pressure. We therefore assess the *difference* between DSO-specific input price growth and observed CPI. In other words, we assess the impact of input prices in real terms (i.e. real price effects, RPEs).

2.6 Setting the incremental efficiency challenge

Once a robust net frontier shift estimate has been derived, it is essential that the efficiency challenge feeds into the current framework in such a way that it does not double-count or undercount the potential for efficiency savings. As discussed in section 1.2, the efficiency factor (x) in VREG's tariff methodology is estimated by extrapolating historical trends in costs. It can therefore already account (to some extent) for all sources of efficiency gains, as shown in the equation below.

$$\Delta\, expenditure = \quad g(\Delta\, \boldsymbol{productivity}, \Delta\, output, \Delta\, input\ prices)$$

$$\Delta\, \boldsymbol{productivity} = \quad h(\Delta\, catchup\ efficiency, \\ \Delta\, \boldsymbol{technology}\ (\boldsymbol{frontier\ shift}), \Delta\, scale\ efficiency)$$

Where:

- $\Delta\, expenditure$ represents the change in expenditure over the previous regulatory period;
- $\Delta\, \boldsymbol{productivity}$ is the productivity growth;
- $\Delta\, output$ is the output growth;
- $\Delta\, input\ prices$ is the change in input prices;
- $\Delta\, catchup\ efficiency$ is the amount by which inefficient DSOs have caught up to current best practice;

[39] ACM implicitly does this through its use of output price indices when assessing the rate of frontier shift for gas and electricity TSOs. See ACM (2017), 'Incentive regulation of the gas and electricity networks in the Netherlands', May.
[40] The Bundesnetzagentur constructs a backward-looking price index to assess input price pressure in its Törnqvist analysis. See, Bundesnetzagentur (2018), 'BK4-18-056 Beschlusskammer 4', November, pp. 36–42.

- $\Delta\, \boldsymbol{technology\ (frontier\ shift)}$ is the productivity improvements associated with improvements to best practice;
- $\Delta\, scale\ efficiency$ is the productivity improvements associated with operating at a more productive scale size;
- g and h are the functions describing the mathematical relationship between the variables.

If much of the historical cost reduction was driven by frontier shift productivity improvements, imposing an additional net frontier shift productivity target will overstate the case for cost reduction and may therefore be unachievable.

In theory, the efficiency factor relating to the merger (x') will feed mainly into the scale efficiency component of the equation above. The cost savings from the merger are expected to come from:

- operating cost savings related to FTEs (e.g. through redundancies or scale efficiencies);
- savings on other operational costs (e.g. through redundancies or scale efficiencies);
- savings on depreciation resulting from savings on investment;
- additional depreciation resulting from the additional ICT change process.

These cost savings are merger-specific and are made possible as a result of the increased size of the operating company. As such, they appear to be scale-related and should not directly account for frontier shift productivity improvements. During discussions with Fluvius and VREG as part of this study, Fluvius and VREG did not present evidence or conceptual counter-arguments to this view. The focus of decomposing the existing X-factors is therefore on the general efficiency factor (x).

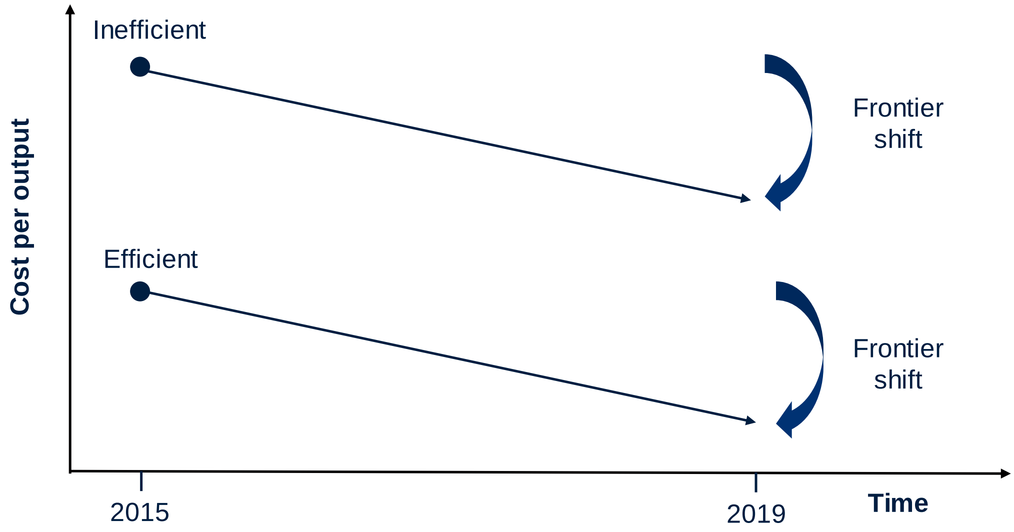
In order to assess how much x currently accounts for net frontier shift, Fluvius has provided Oxera with data on cost and output for each of the DSOs.[41] We use a combination of high-level unit cost trends and other scientific methods to assess the extent to which the recent historical cost evolution is driven by frontier shift.

In assessing unit cost trends, we considered the following two scenarios.

- **Scenario 1.** The historical cost trend is driven to a large extent by the most efficient DSOs in Flanders. The inefficient DSOs are keeping up with the rate of frontier shift but are not catching up to the frontier. In this scenario, much of the estimated X-factor will already account for frontier shift productivity improvements, and an incremental net frontier shift target may not be required. This scenario may require an adjustment on the inefficient DSOs' expenditure reflecting their catch-up potential. This is illustrated in Figure 2.2 below.

[41] Fluvius's data was forward to Oxera by VREG on 14/10/2019.

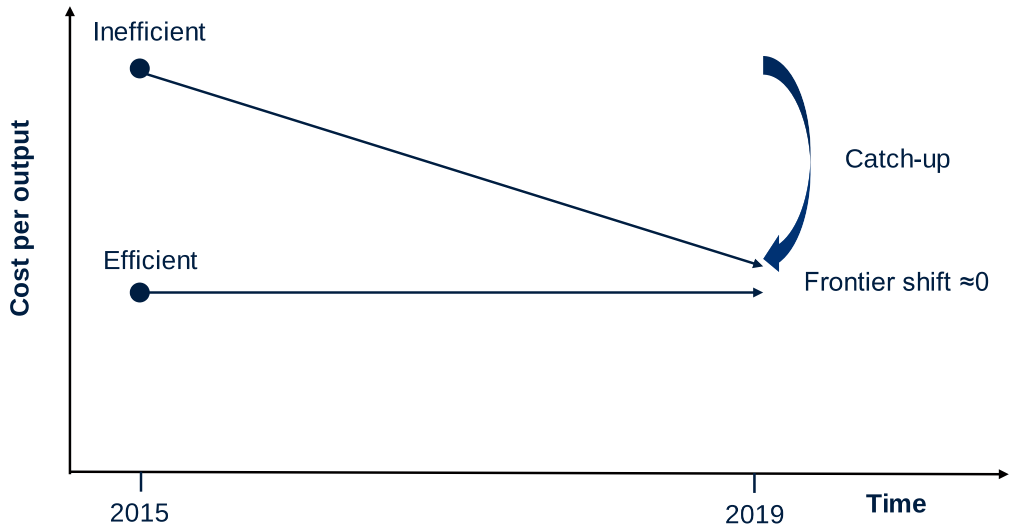
Figure 2.2 Scenario 1—high frontier shift and no catch-up improvement



Source: Oxera.

- **Scenario 2.** The historical cost trend is driven to a large extent by inefficient DSOs catching up to current (internal) best practice. The industry best practice itself is not progressing in the analysis period. In this scenario, the X-factor does not account for frontier shift productivity improvements, and the frontier shift expectations can be applied. This is illustrated in Figure 2.3 below.

Figure 2.3 Scenario 2—no frontier shift



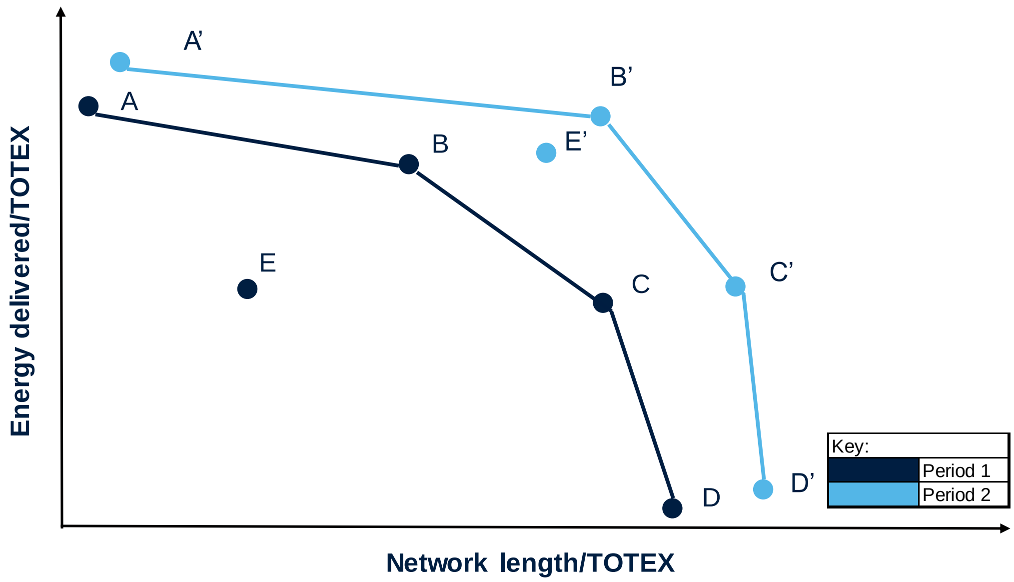
Source: Oxera.

Of course, the actual performance of the DSOs could sit in between the two scenarios, in which case an incremental net frontier shift target is required but not the full potential indicated by the TFP analysis, as the historical cost trend includes some frontier shift improvements.

Unit cost trends can account for only one output at a time. In order to account for multiple outputs simultaneously, we use a DEA-based Malmquist productivity index (MPI) as further evidence for the extent to which current cost trends already account for frontier shift.[42]

In DEA, a DSO is identified as efficient if no other DSO can produce more output at the same cost (or, equivalently, the same output at a lower cost). Figure 2.4 presents a stylised example of how DEA can be used to estimate frontier shift.

Figure 2.4 DEA Malmquist decomposition



Note: Each point on the graph represents a DSO at a particular point in time, and the lines represent the estimated efficiency frontier. The example assumes a constant returns to scale (CRS) production technology.

Source: Oxera.

In period 1, DSOs A, B, C and D are identified as efficient based on energy delivered and network length as outputs, and TOTEX as the input, as no other DSO in the sample produces more of any one output without producing less of another output (the graph is normalised for the same level of TOTEX for all the DSOs). DSO E is estimated to be inefficient, as DSO B can produce more of both outputs for the same level of input. The production frontier in period 1 is therefore defined as the line ABCD.

As a result of technological progress or a reduction in input prices, the DSOs A, B, C and D can produce more outputs in period 2 for the same level of input. The frontier has therefore shifted to the line A'B'C'D'. Although DSO E has also made significant productivity gains (it can now produce more of both outputs for the same level of input), much of this has been a result of it catching up to the frontier in period 2 relative to period 1, rather than frontier shift improvements. The extent to which the observed productivity growth is driven by frontier shift can be quantified by decomposing the MPI using DEA.[43] This analysis can be extended to accommodate any number of inputs and outputs.

[42] Alternative methods, such as SFA, can also be used to decompose the historical cost trend into its components. However, these require certain parametric assumptions unlike DEA, and additional data to test these assumptions. We have therefore focused on DEA apart from the unit cost trends to assess the historical level of the frontier shift improvement.
[43] Nishimizu, M. and Page, J. (1982), 'Total Factor Productivity Growth, Technological Progress and Technical Efficiency Change: Dimensions of Productivity Change in Yugoslavia, 1965-78', *Economic*

The approach outlined in this section can be used to estimate the advancements in internal best practice (i.e. the extent to which the efficient Flemish DSOs are improving productivity). As frontier shift relates to the ability of the most efficient companies in an industry to improve productivity, this may differ from the 'true' rate of frontier shift if the most efficient DSOs in Flanders are 'catching up' to global best practice in their industry (i.e. more efficient DSOs in other jurisdictions).[44]

Journal, **92**, pp. 920–936. Färe, R., Grosskopf, S., Lindgren, B. and Roos, P. (1989), 'Productivity Developments in Swedish Hospitals: A Malmquist Output Index Approach'.

[44] It is possible to perform such an assessment, and many examples of international benchmarking exercises exist (e.g. see Frontier Economics, Consentec and Sumicsid (2013), 'E3GRID2012 – European TSO Benchmarking Study', July). However, such exercises typically require extensive analysis to ensure that all costs and output data are comparable across jurisdictions. Furthermore, country-specific factors (such as regulatory stringency) need to be robustly accounted for. As such, we did not consider such an approach for this report.

3 Net frontier shift analysis

In this section, we present our selection of comparator industries and the time period of analysis and present the net frontier shift results.

3.1 Comparator selection

The EU KLEMS 2019 dataset identifies 49 industries and industry aggregates that could be used to set the net frontier shift target. For the net frontier shift estimate to reflect what is achievable by the Flemish DSOs, it is essential that the Flemish DSOs are compared only with sectors of the Belgian economy that undertake similar activities to the gas and electricity activities of the Flemish DSOs.

Our selection of comparator sectors is based on regulatory precedent[45] and our own expert view. As the industry definitions have undergone revisions in each iteration of the EU KLEMS dataset, it may be neither possible nor desirable to use historical precedent directly in our analysis. As part of this exercise, we also reached out to VREG and Fluvius to seek their views.

3.1.1 Comparator industries

Table 3.1 below shows the comparator industries that we have used to quantify the net frontier shift that Fluvius's gas and electricity DSOs are likely to face. Although the selection of comparators is informed by the best-practice application of this methodology, there is still a degree of value judgement. As such, we present results for a range of sensitivities regarding comparator selection.[46]

Table 3.1 Comparator selection

Comparator industry	Base case	Telecoms sensitivity	EGSA sensitivity
Other manufacturing; repair and installation of machinery and equipment	✓	✓	✓
Construction	✓	✓	✓
IT and other information services	✓	✓	✓
Professional, scientific, technical, administrative and support service activities	✓	✓	✓
Telecommunications		✓	
Electricity, gas, steam and air conditioning supply			✓

Source: Oxera.

These comparators are justified in turn below.

Other manufacturing; repair and installation of machinery and equipment

'Repair and installation of machinery and equipment' is a direct comparator for renewal, replacement and maintenance expenditure of all DSOs. However, this classification also includes 'Other manufacturing' (i.e. manufacturing activities

[45] The exact definition of industry structures and industry aggregations tends to differ across sources. For example, the EU KLEMS 2017 release aggregates 'Electricity, Gas and Water Supply' into one industry, whereas the EU KLEMS 2019 release (the dataset used in this report) separates the two into 'Electricity, gas, steam and air conditioning supply' and 'Water supply; sewerage; waste management and remediation activities'. As such, although regulatory precedent can be used to inform our view, it is generally not possible or relevant to apply regulatory precedent directly in this context.
[46] Additional sensitivities regarding the comparator selection can be found in appendix 5A2.

that cannot be neatly categorised into other manufacturing sectors). As such, it suffers from being a ‘catch-all’ classification. Given its direct relevance to a large proportion of DSOs’ expenditure, we consider it a core comparator.

Construction

The construction sector includes civil engineering, construction of buildings, and other specialised construction activities. It is often seen as the key comparator for regulated utilities’ capital expenditure.[47]

IT and other information services

IT and other information services includes activities such as computer programming and data processing. Data processing is particularly relevant for expenditure relating to monitoring and managing the network. Furthermore, the sector is a relevant comparator for the metering activities undertaken by DSOs (such as reading meter data, validating the data, and transferring the data to the suppliers).

Professional, scientific, technical, administrative and support service activities

This sector includes a range of activities, including legal and accounting activities; activities of head offices; and scientific research and development. This makes it an appropriate comparator for Fluvius’s DSOs’ indirect expenditure.

Telecommunications

Gas and electricity distribution require substantial information flows and data processing. This makes the Telecommunications sector a relevant comparator, particularly for Fluvius’s DSOs’ maintenance and monitoring expenditure. As with the ‘IT and other information services’ sector, Telecommunications can be a relevant comparator for data-intensive activities such as metering. Given that this sector also contains wired telecommunication activities, it may also be loosely relevant to the DSOs’ construction expenditure.

However, caution is required when including this sector in the comparator set, for a number of reasons. First, the sector has experienced, and continues to experience, rapid growth in output, mainly in the broadband and mobile markets. This growth in output was possible due to high investment (i.e. rapid growth in inputs) and rapid technological change (fibre technology, 3G and 4G wireless telecommunications protocols). As a result, the rate at which capital inputs become obsolete is very high and prices for capital inputs are very volatile. This is in stark contrast to the DSO sector, where output and input prices are much more stable.

For this reason, we treat it as a relevant sector for consideration in a sensitivity as it can provide useful information on the true productivity potential.

Electricity, gas, steam and air conditioning supply (EGSA)

This industry is operationally comparable to Fluvius’s DSOs in terms of the activities that it undertakes. Fluvius itself would be included in the data for this industry. However, regulators and practitioners are generally wary of including this sector in frontier shift analysis, as:

[47] For example, Ofgem uses construction as the main comparator for capital and replacement expenditure. See Ofgem (2012), ‘RIIO-T1/GD1: Real price effects and ongoing efficiency appendix’, December, p. 15.

- the sector often contains the company that is being assessed (as is the case in this context), and therefore the estimated productivity growth is endogenous. That is, Fluvius's productivity growth in the past will influence the estimated frontier shift used to set allowances in the future;
- the sector is not sufficiently competitive, and therefore the estimated productivity growth will contain elements of catch-up efficiency. Relatedly, the sector contains companies that are publicly owned, where the incentive for cost reduction (or productivity improvement) may be weaker than in competitive sectors;
- the sector is characterised by natural monopolies. The estimated productivity growth may also account for scale economies (note that the estimated productivity growth of a natural monopoly may be negative if it is experiencing declining output volumes).

For these reasons, and similar to the treatment of the Telecommunications sector, we treat it as a relevant sector for consideration in a sensitivity as it can provide useful information on the true productivity potential.

As well as the Telecoms and EGSA sensitivities provided in the main report, we consider two further sensitivities to the comparator selection: 'Chemicals and chemical products' and 'Electrical equipment'. There is regulatory precedent supporting their inclusion in the analysis, but they are only loosely related to the activities of the DSOs.

Chemicals and chemical products

This industry is loosely related to the activities of gas DSOs as it involves, to some extent, the transport of liquids and/or gases through a network of pipes. Furthermore, it has been used by regulators in the past.[48] However, this industry carries out primarily manufacturing activities and is therefore unlikely to be a direct comparator to the gas distribution sector. Comparability is even more limited when considering the electricity distribution sector. For these reasons, we consider it as a sensitivity in our analysis but do not attach a large weight to these results.

Electrical equipment

This industry involves the manufacture of electrical equipment and may therefore be a relevant comparator for electricity distribution. It does have some regulatory precedent,[49] although it is only loosely related to the activities of DSOs, for the same reasons as listed above. We therefore consider this as another sensitivity.

Fluvius's comparator set includes 'Electricity, Gas and Water Supply', 'Chemicals and chemical products' and 'Information and communication'. There is significant overlap between Fluvius's comparator selection and our own. This is discussed in more detail in appendix 5A3.

[48] For example, see Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July; and Oxera (2016), 'Study on ongoing efficiency for Dutch gas and electricity TSOs', January.
[49] It is possible to use this industry only with the more recent releases of the EU KLEMS dataset. Ofgem used a similar industry, 'Manufacture of electrical and optical equipment', in its ongoing efficiency assessment for gas distribution and electricity and gas transmission. See Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July.

3.1.2 Aggregating across industries

Each comparator industry provides valuable (and different) information regarding the extent to which the Flemish DSOs can improve productivity. For this reason, a composite measure including data from multiple industries provides a more robust estimate of the scope for frontier shift than relying on a single industry alone.[50] When aggregating the TFP estimates from different industries into a composite estimate, it is common to consider weighting the industries by how comparable they are to the Flemish DSOs.[51] In theory, a weighted average could be constructed following this procedure, as follows.

- **Cost allocation exercise.** This involves defining the key, distinct activities undertaken by DSOs and determining the contribution of each activity to providing gas and electricity distribution services. This could be undertaken using a cost allocation exercise, whereby activity cost centres of a DSO are created, and costs are allocated to the activities based on defined activity metrics (e.g. the intensity, importance or proportion of spend on each activity). The resulting estimate is a measure of the importance of each activity to the overall organisation and is typically referred to as the 'weight' of the activity.
- **Mapping exercise.** Once activities have been identified, individual sectors can be mapped directly to the most relevant activities. For example, the construction sector may be relevant to maintenance and construction activities, but not to indirect operating expenditure, such as human resources. Multiple sectors can be assigned to each activity without necessarily attaching specific weights within that activity—an industry's contribution to an activity is typically averaged equally with other relevant industries if multiple industries are deemed relevant to that activity.
- **Deriving weights.** The relative importance of each industry (i.e. the weight attached to each industry in the aggregation process) is derived by aggregating the weights of the activities to which they are mapped.

Frontier shift is based on the productivity gains that an efficient DSO is expected to achieve due to technological progress. Weighted averages should therefore be used to reflect as closely as possible the true activity structure of an efficient DSO, in terms of both technical efficiency (i.e. how good a DSO is in transforming inputs to outputs) and allocative efficiency (i.e. whether the DSO uses the correct mix of inputs to produce the correct mix of outputs).

If inefficiency is present in the DSOs being assessed, the use of internal data to estimate weights could perpetuate such technical and allocative inefficiency, as it would preserve an inefficient cost structure. Furthermore, the frontier shift derived on that basis is not likely to reflect the true potential for productivity savings. In the absence of evidence that the expenditure of Flemish DSOs is efficient, a weighted average based on this data may not provide an appropriate benchmark.

Furthermore, the practical limitation with such an approach in this context is that we did not have access to such disaggregated data on Fluvius's DSOs'

[50] It should be noted that some regulators have relied on the productivity estimates of individual sectors to determine the frontier shift target (applying value judgement and regulatory discretion in the process), rather than an aggregated one (examples include Bundesnetzagentur's use of the energy sector in the third regulatory period; Ofgem's use of the construction sector to determine the CAPEX frontier shift in RIIO and previous reviews; Ofwat's PR19 methodology).
[51] Alternative weighting systems are sometimes considered. For example, Ofgem has considered weights based on how large each sector is in the UK economy. See Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July, pp. 18–19.

expenditure. Fluvius provided us with a breakdown of expenditure by accounting costs (e.g. operating costs, depreciation, taxes) for each DSO, but not by activity (e.g. maintenance, monitoring, construction, indirect operating costs). While accounting measures can be useful when examining a company as a whole, they are not helpful in determining the activities that make up the operation of the company and their relative importance. We therefore did not consider it appropriate to use such accounting data to generate weights for the comparator industries.

It is also the case that the comparator sectors defined in the EU KLEMS database and identified in our core set undertake a number of activities with potentially common functions. For example, all the comparator sectors (and companies classified within these) can be expected to undertake back-office tasks that rely on IT services to varying degrees. Given the overlap of activities among the comparator sectors, some amount of value judgment and reliance on simple average is inevitable even when detailed mapping information is available. In the absence of evidence that the historical expenditure of the DSOs was efficient, we consider the simple average approach to aggregation (which is divorced from the internal cost data of the DSOs) to be robust. Even where activity-level expenditure data is available to generate weights, for the reasons highlighted above, a simple average of the sector productivity growth rates is bound to provide useful information.[52]

Fluvius did provide its own view of appropriate comparator sectors and their respective weights (based on qualitative operational analysis), and we discuss this in appendix A3. The analysis of Fluvius's comparator set and their respective weights supports the results of this report (see section 3.6 for the main results). Furthermore, as a sensitivity, we have used regulatory precedents in British gas distribution and Dutch electricity and gas transmission to construct weights for the aggregation process and this further supports the results presented in the main report (see appendix A4).

3.2 Time period of analysis

Economic activity varies from one period to the next, and these fluctuations can have an impact on the estimated productivity growth. As such, the choice of start point and end point of the analysis can have a significant impact on the resulting estimates. Given the sensitivity of the estimates to the time period of analysis, the chosen period must be robustly justified. In particular, the following considerations need to be made.

- **The stability of TFP growth.** If productivity growth is relatively stable over the available data, the most robust estimate of TFP would simply use all of the available data. If productivity growth is volatile over time, the selection of the most appropriate time period of analysis becomes more nuanced, as the full dataset may produce a biased estimate (upwards or downwards) of the feasible rate of productivity growth in the next regulatory period.
- **The cyclicality of TFP growth.** If productivity growth fluctuates around its long-run average growth rate, it is said to be 'cyclical'. In such cases, the data on which productivity growth is estimated should include periods of both below- and above-average TFP growth. Productivity growth is said to be 'pro-cyclical' if these cycles are broadly in line with the economic cycles of the overall economy (i.e. the business cycle). If productivity growth is

[52] This approach to aggregation has been widely used to set frontier shift targets in regulated contexts. For example, see Ofgem (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix', December, pp. 23–26.

indeed pro-cyclical then the appropriate time period of analysis can be informed by business cycles in the overall economy.

In simplified models of production, there is no clear reason why productivity growth and output growth should be related. An increase or decrease in output should be matched by a proportionate increase or decrease in input, leaving productivity unchanged.

However, microeconomic and macroeconomic evidence indicates that productivity growth is pro-cyclical in the real world. There are various hypotheses for why this is the case, including:

- **exogenous shocks**—the pro-cyclicality of productivity is a product of productivity growth and output growth being driven by the same exogenous shocks (such as war or technological innovations);
- **labour-hoarding**—labour market imperfections (such as labour regulations or trade union power) reduce the ability of firms to downsize in an economic decline. As the demand for output falls, the same number of employees produce less output and the measured productivity falls. Similarly, as the demand for output rises, the same number of employees produce more output and measured productivity rises;
- **economies of scale**—the production technology facing firms may exhibit increasing returns to scale, at least in the short term. That is, a 1% increase in outputs requires an increase in inputs of less than 1%. Similarly, a 1% decrease in outputs requires a less than 1% decrease in inputs. By construction, the measured productivity growth of such technology would be pro-cyclical.[53]

Because of this pro-cyclicality, regulators typically assess productivity growth over complete business cycles when setting frontier shift productivity targets.[54] In this section, we:

- define what a business cycle is and how it is measured;
- present evidence from other regulators regarding how time periods of analysis are selected;
- identify business cycles in the Belgian economy;
- demonstrate that TFP is indeed pro-cyclical in this context.

3.2.1 Defining the business cycle

The business cycle[55] is a macroeconomic phenomenon whereby output growth fluctuates around its long-run average growth rate and is typified by economic stages of expansion, contraction and recovery.

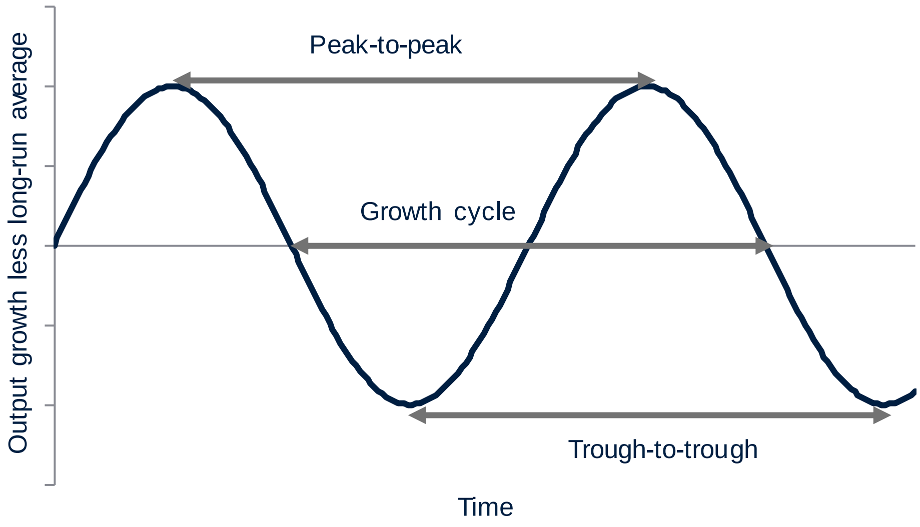
Business cycles can be measured in multiple ways, provided that they include one period of below-average and one period of above-average growth. For example, they can be defined as:

[53] These hypotheses are discussed in BIS (2011), 'Productivity and the Economic Cycle', March, section 2.
[54] For example, see CEPA (2012), 'Scope For Improvement In The Efficiency Of Network Rail's Expenditure On Support And Operations: Supplementary Analysis Of Productivity And Unit Cost Change', March.
[55] The term 'business cycle' can be misleading as it implies some form of regularity or predictability. In reality, these fluctuations in output are typically irregular and unpredictable. They do nonetheless demonstrate the same pattern of economic expansion, a crisis point followed by a recession, and then recovery.

- ‘peak-to-peak’ business cycles: the business cycle starts at the highest point in a cycle and continues through one contraction before reaching the next peak;
- ‘trough-to-trough’ business cycles: the business cycle begins at the lowest point in a cycle, continues through one period of expansion, and ends at the following lowest point in the cycle;
- ‘growth cycle’ business cycles: the cycle begins at average output growth, and then cycles through one period of expansion and contraction before ending at average output growth.

These cycles are displayed graphically in Figure 3.1 below.

Figure 3.1 Stylised example of business cycles



Source: Oxera.

All three measures of the business cycle are valid. In this report, we use the ‘growth cycle’ definition, as is consistent with regulatory precedent.[56]

3.2.2 Insight from other applications

Because productivity growth is generally pro-cyclical, regulators have to balance competing aspects when determining the appropriate time period of analysis. Based on a review of regulatory precedent,[57] regulators need to make the following considerations.

- Due to the pro-cyclicality of productivity growth, TFP must be estimated over complete business cycles. If TFP is estimated over incomplete business cycles, the impact of recessions and economic upturns may bias the estimate of long-run productivity growth and the potential for frontier shift in future regulatory periods.[58]

[56] For example, see CEPA (2012), ‘Ongoing efficiency in new method decisions for Dutch electricity and gas network operators’, November, p. 41.
[57] For a detailed literature review, see Oxera (2016), ‘Study on ongoing efficiency for Dutch gas and electricity TSOs’, January, Table 5.1.
[58] For example, see Oxera (2008), ‘What is Network Rail’s likely scope for frontier shift in enhancement expenditure over CP4?’, prepared for Office of Rail Regulation, March, section 5.2.

- More recent data *may* be more informative of the scope for productivity improvements in the upcoming regulatory period than older data.[59] This is especially true if the historical data exhibits structural breaks.[60] However, if the recent data covers a period of unusual economic activity that is not expected to continue in the next regulatory period, it may be more appropriate to give weight to older data that may better reflect the economy going forward.[61]

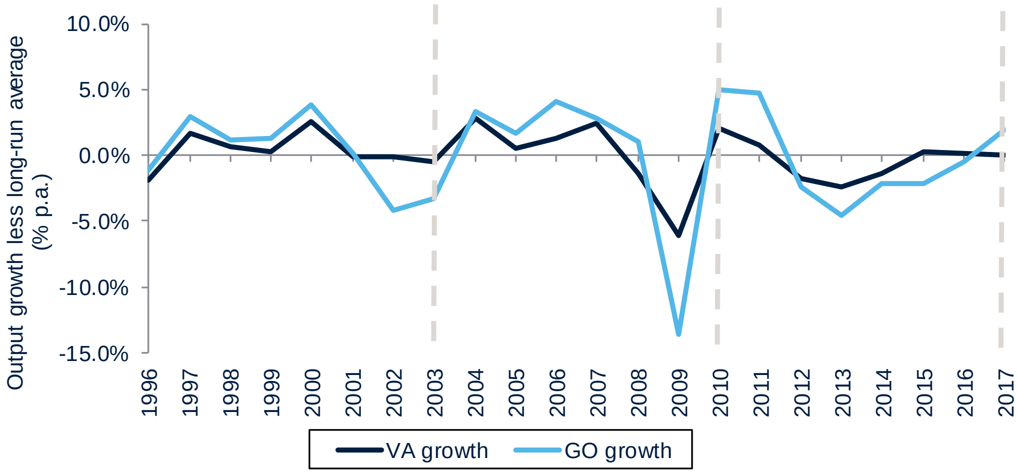
In determining the appropriate time period of analysis, we follow the same principles.

3.2.3 Identified business cycles

Figure 3.2 shows the output growth of the Belgian economy according to the EU KLEMS dataset. Starting from the most recent year of data (2017) and working backwards, there is evidence that the Belgian economy has experienced two business cycles in recent years, which are highlighted in grey: the most recent is from 2010 until 2017 (the latest year in the data), and the one preceding it is from 2003 until 2010.[62]

Growth in the two output measures (VA and GO) is highly correlated.[63] GO growth is typically larger in magnitude than VA growth, but the same business cycles are identified using both output measures. This will form our core period of analysis over which TFP is estimated.

Figure 3.2 Output growth in the Belgian economy—core



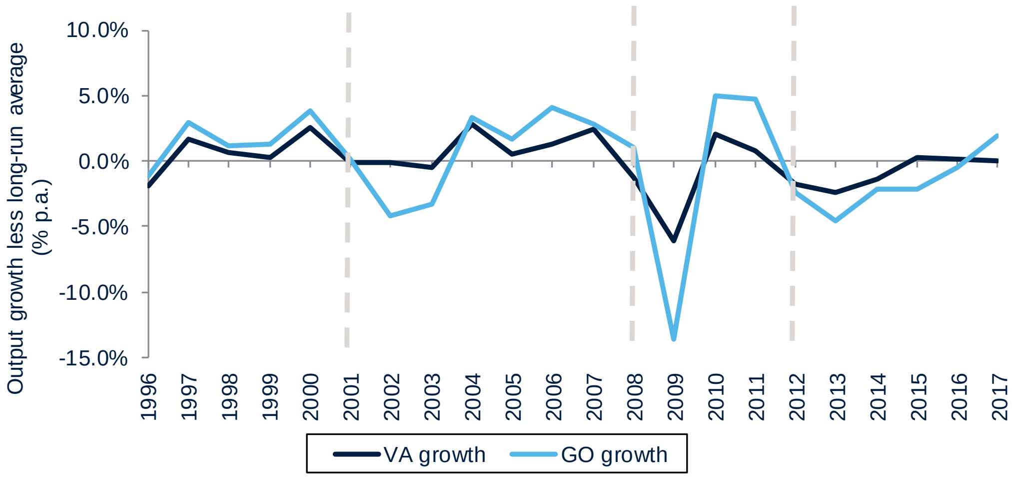
Note: The identified business cycles are marked by the grey dotted lines.

Source: Oxera analysis of EU KLEMS data.

[59] For example, First Economics used only the most recent business cycle to estimate productivity growth for the Utility Regulator in Northern Ireland, despite having access to a significantly larger dataset. See First Economics (2012), 'The Rate of Frontier Shift Affecting Water Industry Costs', December.
[60] For example, in a report for Ofgem, Europe Economics notes that the privatisation of utilities in the UK could have had an impact on the estimated productivity growth in the late 1980s and early 1990s. See Europe Economics (2007), 'Top down benchmarking of UK gas distribution network operators. A Report by Europe Economics to Ofgem', April.
[61] For example, in a report for Ofwat, Europe Economics states that its preferred time periods of analysis are 'pre-crisis' (1997–2007) and 'post-crisis' (2010–2014), thus excluding the impact of a severe recession in 2008 and 2009 in the UK. See Europe Economics (2018), 'Real Price Effects and Frontier Shift', January.
[62] An additional business cycle from 1996 until 2003 can also be identified. However, the EU KLEMS dataset has data on input volumes only from 2000 onwards. As such, TFP cannot be estimated in such a period and we exclude this from the analysis.
[63] The correlation coefficient for the analysis period is 0.88.

Figure 3.3 shows that two alternative business cycles can be identified, if the analysis starts from the least recent data and business cycles are counted moving from the past to the present. These are in the periods of 2001–08 and 2008–12. Although these also represent complete business cycles, they are treated as a sensitivity in this report as they (i) are less recent than those identified in Figure 3.2; and (ii) use a shorter period of data. As such, they may be less relevant in predicting productivity growth in the next regulatory period.

Figure 3.3 Output growth in the Belgian economy—sensitivity



Note: The identified business cycles are marked by the grey dotted lines.

Source: Oxera analysis of EU KLEMS data.

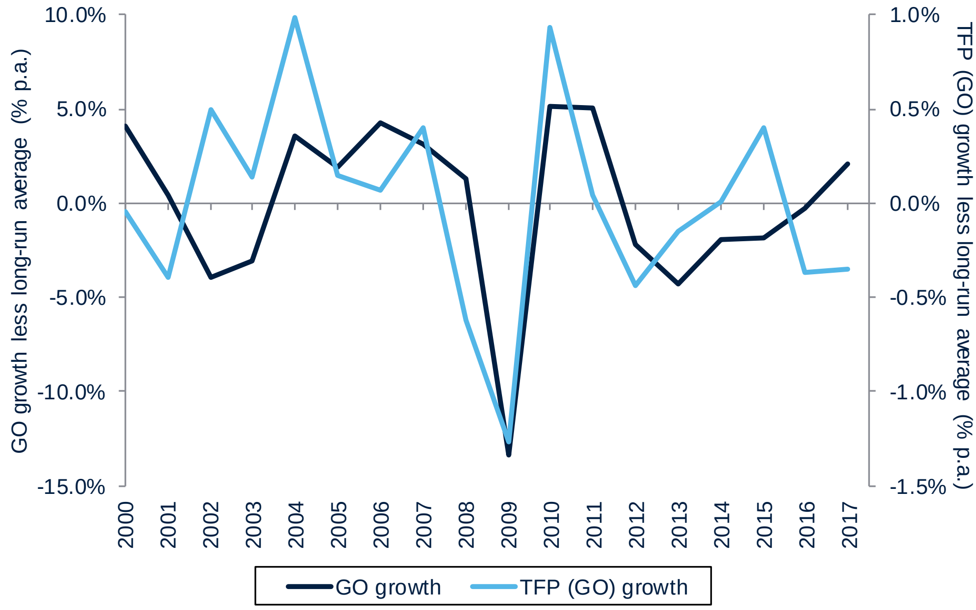
3.2.4 The pro-cyclical nature of TFP

Although extensive macroeconomic literature supports the view that productivity growth is generally pro-cyclical,[64] this is ultimately an empirical question that needs to be justified in specific contexts. Figure 3.4 below shows the relationship between GO growth (i.e. output growth) and TFP(GO) growth (i.e. productivity growth).

TFP(GO) growth is typically smaller in magnitude than output growth, and there are some time periods where TFP(GO) growth appears to be less correlated with GO growth. However, the correlation coefficients in the core time period (2003–17) and the sensitivity time period (2001–12) are 0.68 and 0.66 respectively, suggesting that the two series are positively correlated in these periods. As such, TFP(GO) can be considered pro-cyclical and the business cycles identified in Figure 3.2 and Figure 3.3 can therefore be applied to TFP.

[64] For example, see BIS (2011), 'Productivity and the Economic Cycle', March, section 2; and Boisso, D., Grosskopf, S. and Hayes, K. (2000), 'Productivity and efficiency in the US: effects of business cycles and public capital', *Regional Science and Urban Economics*, **30**, pp. 663–681.

Figure 3.4 Output growth and TFP growth—GO

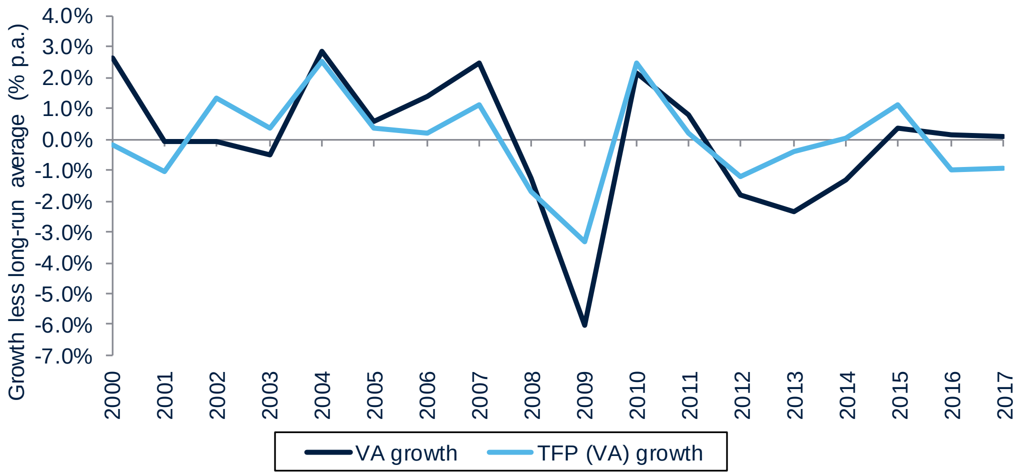


Note: The correlation coefficient between GO output growth and TFP(GO) growth is 0.57 in the full time period.

Source: Oxera analysis of EU KLEMS data.

Figure 3.5 shows that the relationship between VA growth (i.e. output growth) and TFP(VA) growth is closer. Indeed, given the larger magnitude of TFP(VA) growth, the relationship is more apparent in the graph. Furthermore, the correlation coefficients in the core and sensitivity time periods are 0.86 and 0.89, respectively, which is an even closer relationship than that observed between GO and TFP(GO).

Figure 3.5 Output growth and TFP growth—VA



Note: The correlation coefficient between VA output growth and TFP(VA) growth is 0.77 in the full time period.

Source: Oxera analysis of EU KLEMS data.

3.3 Potential adjustment to the TFP estimates

The set of comparator industries used in the analysis[65] has been carefully constructed to ensure that it is characterised by competitive firms, as far as possible. This was to ensure that the estimated TFP growth was driven by frontier shift productivity improvements rather than other sources of efficiency gains.

However, as noted in section 2.1, few industries will fulfil all of the requirements of perfect competition, and therefore some of the estimated productivity growth in these industries may be driven by catch-up and scale efficiency improvements, as well as frontier shift. If other sources of efficiency gains are present, an adjustment to the estimated TFP growth will be required to isolate the impact of frontier shift.

There is limited academic literature regarding the extent to which recent productivity growth in the Belgian economy is driven by frontier shift. In a cross-country study of private sector productivity growth, Alvarez et al. (2010)[66] showed that frontier shift (referred to as 'technical change' in the paper) was responsible for most of the productivity growth in the Belgian economy in the period 1980–2002. Although this is largely outside of the analysis period considered in this report (2001–17), this supports the view that no adjustment is necessary to isolate the impact of frontier shift on TFP growth.

In the absence of further evidence, we do not consider that an adjustment to TFP growth is necessary to derive a robust estimate of frontier shift.

3.4 TFP estimates

This section presents the results from TFP analysis of the comparator sectors outlined in section 3.1 to derive the feasible rate of frontier shift that Flemish DSOs can achieve in the next regulatory period.

Table 3.2 shows the estimated GO-based TFP in our core time period of analysis, 2003–17. Analysis of the core comparator industries (the 'base case') suggests that a frontier shift of 0.1% p.a. is feasible. That is, output per unit of input should increase at a rate of 0.1% and, assuming that output is fixed and there are no changes in input prices, cost should fall at a rate of 0.1% p.a.

Productivity growth varies across sectors and time periods of analysis, and is significantly larger in the Telecommunications sector than elsewhere. Meanwhile, productivity growth in the EGSA sector is lower on average and is more dependent on the time period of analysis than other sectors.

[65] See section 3.1.
[66] Alvarez, I., Delgado, M. and Salinas-Jimenez, M. (2010), 'Determinants of TFP growth in EU countries: a sectoral comparison with Malmquist Indices', Table 2.

Table 3.2 TFP(GO) growth, 2003–17 (% p.a.)

Comparator industry	2010–17	2003–10	Average
Other manufacturing; repair and installation of machinery and equipment	0.3%	0.5%	0.4%
Construction	-0.2%	0.2%	0.0%
IT and other information services	0.0%	-0.6%	-0.3%
Professional, scientific, technical, administrative and support service activities	0.1%	0.1%	0.1%
Telecommunications	2.4%	2.6%	2.5%
Electricity, gas, steam and air conditioning supply	-1.7%	1.1%	-0.3%
Base case	**0.1%**	**0.1%**	**0.1%**
Telecoms sensitivity	**0.5%**	**0.6%**	**0.5%**
EGSA sensitivity	**-0.3%**	**0.3%**	**0.0%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.3 shows the equivalent results for VA-based TFP. Note that the estimated productivity growth is typically larger when using the VA-based measure.[67] In this instance, the analysis of the core comparator set is 0.2% p.a. and the Telecommunications sector has a significantly higher productivity growth rate than all other comparators. As with the GO-based measure, the EGSA sector has a significantly more volatile productivity growth than other sectors.

Table 3.3 TFP (VA) growth, 2003–17 (% p.a.)

Comparator industry	2010–17	2003–10	Average
Other manufacturing; repair and installation of machinery and equipment	0.9%	1.4%	1.1%
Construction	-0.8%	0.7%	-0.1%
IT and other information services	0.1%	-1.1%	-0.5%
Professional, scientific, technical, administrative and support service activities	0.3%	0.2%	0.2%
Telecommunications	5.3%	5.2%	5.3%
Electricity, gas, steam and air conditioning supply	-3.9%	2.1%	-0.9%
Base case	**0.1%**	**0.3%**	**0.2%**
Telecoms sensitivity	**1.2%**	**1.3%**	**1.2%**
EGSA sensitivity	**-0.7%**	**0.6%**	**0.0%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.4 shows the estimated GO-based TFP in the period 2001–12, which we consider as a sensitivity. Productivity growth in this period is typically slower than in our base case—only ‘Other manufacturing; repair and installation of machinery and equipment’ experiences a faster productivity growth in this period.

[67] As outlined in section 2.4, this result is expected under standard neoclassical assumptions regarding the production technology.

Table 3.4 TFP (GO) growth, 2001–12 (% p.a.)

Comparator industry	2008–12	2001–08	Average
Other manufacturing; repair and installation of machinery and equipment	1.3%	-0.2%	0.5%
Construction	-0.3%	0.3%	0.0%
IT and other information services	0.0%	-0.2%	-0.1%
Professional, scientific, technical, administrative and support service activities	-0.8%	-0.2%	-0.5%
Telecommunications	2.0%	3.2%	2.6%
Electricity, gas, steam and air conditioning supply	-1.5%	0.6%	-0.5%
Base case	**0.1%**	**-0.1%**	**0.0%**
Telecoms sensitivity	**0.5%**	**0.6%**	**0.5%**
EGSA sensitivity	**-0.3%**	**0.1%**	**-0.1%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.5 shows the productivity growth in the alternative time period using the VA-based TFP measure. As before, the VA-based measures generally show higher levels of productivity growth than the GO-based measures, and the implied frontier shift from our core comparator set is 0.1% p.a.

Table 3.5 TFP (VA) growth, 2001–12 (% p.a.)

Comparator industry	2008–12	2001–08	Average
Other manufacturing; repair and installation of machinery and equipment	3.4%	-0.7%	1.4%
Construction	-0.8%	0.9%	0.0%
IT and other information services	0.1%	-0.3%	-0.1%
Professional, scientific, technical, administrative and support service activities	-1.6%	-0.4%	-1.0%
Telecommunications	4.3%	6.5%	5.4%
Electricity, gas, steam and air conditioning supply	-3.4%	1.1%	-1.2%
Base case	**0.3%**	**-0.1%**	**0.1%**
Telecoms sensitivity	**1.1%**	**1.2%**	**1.1%**
EGSA sensitivity	**-0.5%**	**0.1%**	**-0.2%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Observing the range of estimated frontier shift in the core comparator set (i.e. the base case) over complete business cycles, a frontier shift of -0.1–0.3% p.a. is feasible.[68] This feasible range estimated by the base case comparators can be narrowed to 0–0.2% p.a.[69] by using two most recent business cycles.

Examining the two sensitivities that we consider (the Telecoms and EGSA sensitivities), the range can be widened to -0.2–1.2% p.a.[70] This is evidence

[68] The lower bound is determined by TFP growth (under VA or GO based measures) in the period 2001–08. This represents data from the oldest business cycle. The upper bound is driven by TFP(VA) growth in the 2008–12 business cycle and the 2003–10 business cycle.
[69] The lower bound is determined by the TFP(GO) measure in the period 2001–08 and the upper bound is determined by the TFP(VA) measure in the period 2003–17.
[70] The lower bound determined by the TFP(VA) growth in the EGSA sensitivity in the period 2001–08 and the upper bound determined by the TFP(VA) growth in the Telecoms sensitivity in the period 2003–17.

that the true potential for productivity growth may be wider than that implied by the base case and may exceed the range estimated in the base case.

3.5 RPE estimates

This section estimates the RPEs that the Flemish DSOs are likely to face in the next regulatory period using the same output measures, comparator industries and time periods of analysis as are used to assess the scope for frontier shift.

Table 3.6 shows the RPEs in the core analysis period (2003–17) using the GO-based price measure. Using the base comparator set, RPEs across the analysis period indicate that real input prices are currently falling at a rate of 0.2% p.a., and have been falling at a rate of 0.4% p.a. in the most recent business cycle. This implies costs should be reducing as a result of changes in input prices.

Input prices in the Telecommunications and 'IT and other information services' industries are falling at a faster rate than among the rest of the comparators.

Table 3.6 RPEs (GO), 2003–17 (% p.a.)

Comparator industry	2010–17	2003–10	Average
Other manufacturing; repair and installation of machinery and equipment	-0.2%	0.7%	0.2%
Construction	-0.7%	0.9%	0.1%
IT and other information services	-0.5%	-1.0%	-0.7%
Professional, scientific, technical, administrative and support service activities	-0.2%	-0.3%	-0.3%
Telecommunications	-3.1%	-0.6%	-1.9%
Electricity, gas, steam and air conditioning supply	-1.5%	0.7%	-0.4%
Base case	**-0.4%**	**0.1%**	**-0.2%**
Telecoms sensitivity	**-0.9%**	**-0.1%**	**-0.5%**
EGSA sensitivity	**-0.6%**	**0.2%**	**-0.2%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.7 shows the estimated RPEs in the core analysis period when using the VA measure of output. In the base case, RPEs are marginally positive (0.1% p.a.) and, as with the GO measure, real input prices are lower in the most recent business cycle. In particular, the VA-based RPE measure indicates that real input prices are falling by 3.9% p.a. in the EGSA sector and including this industry in the comparator set significantly reduces the overall RPE from +0.1% p.a. to -0.3% p.a.

Table 3.7 RPEs (VA), 2003–17 (% p.a.)

Comparator industry	2010–17	2003–10	Average
Other manufacturing; repair and installation of machinery and equipment	0.4%	3.1%	1.7%
Construction	-1.7%	0.6%	-0.6%
IT and other information services	-0.2%	-1.3%	-0.8%
Professional, scientific, technical, administrative and support service activities	0.0%	-0.4%	-0.2%
Telecommunications	-3.1%	1.3%	-0.9%
Electricity, gas, steam and air conditioning supply	-3.9%	0.4%	-1.8%
Base case	**-0.4%**	**0.5%**	**0.1%**
Telecoms sensitivity	**-0.9%**	**0.7%**	**-0.1%**
EGSA sensitivity	**-1.1%**	**0.5%**	**-0.3%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

The estimated RPEs using GO-based measure in the alternative period of analysis is shown in Table 3.8. Real input prices in the base case comparator set have been falling at a rate of 0.4% p.a. in this period—this is faster than the 0.2% p.a. decline in input prices observed in the core period (see Table 3.6).

Table 3.8 RPEs (GO), 2001–12 (% p.a.)

Comparator industry	2008–12	2001–08	Average
Other manufacturing; repair and installation of machinery and equipment	0.6%	-0.7%	0.0%
Construction	-0.5%	0.7%	0.1%
IT and other information services	-0.6%	-1.2%	-0.9%
Professional, scientific, technical, administrative and support service activities	-0.8%	-0.7%	-0.8%
Telecommunications	-3.3%	-0.1%	-1.7%
Electricity, gas, steam and air conditioning supply	-0.2%	2.6%	1.2%
Base case	**-0.3%**	**-0.5%**	**-0.4%**
Telecoms sensitivity	**-0.9%**	**-0.4%**	**-0.6%**
EGSA sensitivity	**-0.3%**	**0.2%**	**-0.1%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.9 shows RPEs using the VA-based measure in the alternative time period of analysis. Note that, in this period, real input prices are falling with the VA measure, unlike in the base period of analysis.

Table 3.9 RPEs (VA), 2001–12 (% p.a.)

Comparator industry	2008–12	2001–08	Average
Other manufacturing; repair and installation of machinery and equipment	2.6%	0.5%	1.5%
Construction	-1.8%	0.7%	-0.5%
IT and other information services	-0.4%	-0.6%	-0.5%
Professional, scientific, technical, administrative and support service activities	-1.6%	-0.8%	-1.2%
Telecommunications	-3.9%	2.7%	-0.6%
Electricity, gas, steam and air conditioning supply	-3.1%	0.5%	-1.3%
Base case	**-0.3%**	**-0.1%**	**-0.2%**
Telecoms sensitivity	**-1.0%**	**0.5%**	**-0.3%**
EGSA sensitivity	**-0.9%**	**0.1%**	**-0.4%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Again, focusing on the estimated RPEs in complete business cycles of the base case comparator set, a feasible range for the RPEs that the Flemish DSOs are likely to face in the next regulatory period is -0.5–0.5% p.a.[71] Examining the results over two complete business cycles, the range can be narrowed to -0.4–0.1% p.a.[72]

With the exception of the RPEs presented in Table 3.7, the analysis indicates that RPEs are generally negative. That is, real input prices have generally fallen in the period of analysis and, other things being equal, this implies that costs should be reducing in the next regulatory period.

Both the Telecoms and the EGSA sensitivities indicate that the RPEs could be significantly lower (i.e. more negative) than that estimated in the base case. Again, considering our core analysis period, the range could be extended to -0.6–0.1% p.a.[73]

3.6 Net frontier shift estimates

This section combines the results from sections 3.4 and 3.5 to estimate the feasible rate net frontier shift that the Fluvius DSOs can achieve in the next regulatory period.

Table 3.10 shows that the GO-based net frontier shift estimates of the base comparator set indicate that a cost reduction of 0–0.4% p.a. is feasible. That is, as a combined effect of frontier shift productivity improvements and real input price pressure, a cost reduction of 0–0.4% p.a. relative to CPI is feasible. The net frontier shift is typically higher in the most recent business cycle (2010–17), and is significantly higher when the Telecommunications sector is included in the comparator set. The inclusion of the EGSA sector reduces the estimated net frontier shift by 0.1% in the first business cycle and increases it by 0.1% in the second business cycle, leaving no overall impact on average.

[71] The lower bound of the range represents the RPE(GO) estimated in the period 2001–08, while the upper bound of the range is determined by RPE(VA) in the period 2003–10.
[72] The lower bound determined by the RPE(VA) measure in the period 2001–12 and the upper bound determined by the RPE(VA) measure in the period 2003–17.
[73] The lower bound driven by the RPE(GO) measure in the Telecoms sensitivity in the period 2001–08 and the upper bound determined by the RPE(VA) in the base case comparator set in the period 2003–17.

Table 3.10 Net frontier shift (GO), 2003–17 (% p.a.)

Comparator industry	2010–17	2003–10	Average
Other manufacturing; repair and installation of machinery and equipment	0.5%	-0.2%	0.2%
Construction	0.4%	-0.7%	-0.1%
IT and other information services	0.5%	0.5%	0.5%
Professional, scientific, technical, administrative and support service activities	0.3%	0.4%	0.4%
Telecommunications	5.5%	3.2%	4.3%
Electricity, gas, steam and air conditioning supply	-0.2%	0.4%	0.1%
Base case	**0.4%**	**0.0%**	**0.2%**
Telecoms sensitivity	**1.5%**	**0.6%**	**1.1%**
EGSA sensitivity	**0.3%**	**0.1%**	**0.2%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

The equivalent results for the VA-based measure, shown in Table 4.11, are slightly more volatile across business cycles, with a range of -0.2–0.5% p.a. for the base comparator set. However, the high-level message is similar—the net frontier shift is higher in the most recent business cycle (2010–17) and significantly higher when including Telecommunications in the comparator set.

Table 3.11 Net frontier shift (VA), 2003–17 (% p.a.)

Comparator industry	2010–17	2003–10	Average
Other manufacturing; repair and installation of machinery and equipment	0.5%	-1.8%	-0.6%
Construction	0.9%	0.1%	0.5%
IT and other information services	0.3%	0.3%	0.3%
Professional, scientific, technical, administrative and support service activities	0.2%	0.6%	0.4%
Telecommunications	8.5%	3.9%	6.2%
Electricity, gas, steam and air conditioning supply	0.0%	1.7%	0.9%
Base case	**0.5%**	**-0.2%**	**0.1%**
Telecoms sensitivity	**2.1%**	**0.6%**	**1.3%**
EGSA sensitivity	**0.4%**	**0.2%**	**0.3%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.12 shows GO-based net frontier shift estimates in the two alternative business cycles, 2001–08 and 2008–12. The net frontier shift estimates are typically higher in these periods. In this base case, they suggest that a 0.4% p.a. reduction in expenditure is feasible.

Table 3.12 Net frontier shift (GO), 2001–12 (% p.a.)

Comparator industry	2008–12	2001–08	Average
Other manufacturing; repair and installation of machinery and equipment	0.6%	0.5%	0.6%
Construction	0.2%	-0.4%	-0.1%
IT and other information services	0.6%	1.0%	0.8%
Professional, scientific, technical, administrative and support service activities	0.0%	0.5%	0.3%
Telecommunications	5.3%	3.3%	4.3%
Electricity, gas, steam and air conditioning supply	-1.4%	-2.1%	-1.7%
Base case	**0.4%**	**0.4%**	**0.4%**
Telecoms sensitivity	**1.3%**	**1.0%**	**1.2%**
EGSA sensitivity	**0.0%**	**-0.1%**	**0.0%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

Table 3.13 shows the net frontier shift in the alternative time periods using the VA-based measure. The results are more volatile across business cycles than the GO-based measure and indicate a range of -0.1–0.5% p.a.

Table 3.13 Net frontier shift (VA), 2001–12 (% p.a.)

Comparator industry	2008–12	2001–08	Average
Other manufacturing; repair and installation of machinery and equipment	0.8%	-1.1%	-0.2%
Construction	0.9%	0.1%	0.5%
IT and other information services	0.5%	0.3%	0.4%
Professional, scientific, technical, administrative and support service activities	0.0%	0.4%	0.2%
Telecommunications	8.2%	3.8%	6.0%
Electricity, gas, steam and air conditioning supply	-0.2%	0.5%	0.1%
Base case	**0.5%**	**-0.1%**	**0.2%**
Telecoms sensitivity	**2.1%**	**0.7%**	**1.4%**
EGSA sensitivity	**0.4%**	**0.0%**	**0.2%**

Note: Figures are presented to one decimal place and may not aggregate to the composite figures due to rounding.

Source: Oxera analysis of EU KLEMS data.

3.6.1 Summarising the results

Analysis of the core comparators over individual business cycles indicates that the rate of net frontier shift that the DSOs can achieve in the next regulatory period is in the range of -0.2–0.5% p.a.[74] Examining results from two complete business cycles, the range in the base case narrows to 0.1–0.4% p.a. The Telecoms and EGSA sensitivities suggest that the true potential for net frontier shift may be in the range 0–1.4% p.a., which suggests that the true scope for cost reduction may be significantly greater than that implied by the base case results.

[74] The lower bound is determined by the TFP(VA) growth in the period 2003–10 and the upper bound is determined by the TFP(VA) growth in the period 2008–12.

The net frontier shift estimates for the base case and Telecoms and EGSA sensitivities are summarised in Table 3.14 below.

Table 3.14 Summary of net frontier shift results

	Base case	Sensitivities
Frontier shift[1] (% p.a.)	0–0.2%	-0.1–1.2%
RPEs[2] (% p.a.)	-0.4–0.1%	-0.6–0.1%
Net frontier shift[3] (% p.a.)	**0.1–0.4%**	**0–1.4%**

Note: The range presented is for two complete business cycles only. [1] Frontier shift is the scope for productivity improvements. Here, a positive number indicates a reduction in costs is possible. [2] RPEs are the impact of real price changes on expenditure. Here, a positive number indicates positive real input price growth and an increase in the level of expenditure. [3] Net frontier shift is the combined impact of frontier shift and RPEs. Here, a positive number indicates a scope for cost reduction. Productivity growth in sectors may be compounded or offset (and therefore cancelled out) by changes in real input prices. For this reason, the aggregated net frontier shift range will not be equal to the difference between the frontier shift and RPE figures in the table.

Source: Oxera analysis of EU KLEMS data.

While we consider the analysis of the base case comparators to represent the most robust estimates of the scope for net frontier shift, the true scope for net frontier shift is likely to lie towards the top end of the feasible range. The arguments are outlined below.

- The estimated net frontier shift is higher in the most recent business cycles (2010–17 and 2008–12), and lies in the range of 0.4–0.5% p.a. in the base case. As the recent past may be more indicative of the scope for net frontier shift in the near future, this would imply that a higher net frontier shift is feasible.
- The EGSA sensitivity generally supports the range provided by the base case comparator set. However, the Telecoms sensitivity suggest that the true scope for net frontier shift may be significantly higher than that estimated in the base case. The upper end of the range in the base case is still well below the midpoint of the overall range implied by the sensitivities (0–1.4% p.a.).
- Analysis of the base case comparator set in the Dutch economy suggests that a net frontier shift of 0.4–0.5% p.a. is feasible (see appendix A1). This is the upper end of the range estimated by the base case in the Belgian economy.
- The analysis of the base case comparators is broadly insensitive to the 'Chemicals and chemical products' and 'Electrical equipment' sensitivities presented in appendix A2.
- The upper end of the range is supported by Fluvius's own comparator selection and the weights that it suggests in the aggregation process (see appendix A3).
- Weighted average aggregation approaches (based on regulatory precedent in gas distribution and gas and electricity transmission) suggest that a net frontier shift of 0.4% p.a. is not only feasible but may underestimate the scope for net frontier shift (see appendix A4).

Based on the analysis presented in this section and the arguments outlined above, we consider **a net frontier shift of 0.4% p.a. to be achievable for gas and electricity DSOs**. That is, DSOs should be able to reduce their expenditure at a rate of 0.4% p.a. as a result of frontier shift productivity improvements and changes in input prices.

4 Assessing the frontier shift achieved by the Flemish DSOs in the reference period

As discussed in section 2.6, the approach to setting the efficiency target (x) in VREG's tariff methodology involves extrapolating trends in historical expenditure. As such, it may already incorporate, to some extent, all sources of productivity improvements, including frontier shift. We consider that there are only a few options available to enable the decomposition of the historical cost trend into its components. For example, we can rely on quantitative methods or expert judgement or regulatory precedence, or a combination of these. In our view, the second and third options are not practical for us to consider[75] in the current case and we focus on quantitative methods. In particular, we rely on cost and output data for each DSO provided by Fluvius to decompose the cost trends and determine how much frontier shift is already accounted for in the regulatory framework using established methods.

Frontier shift is defined as the productivity improvement achieved by the most efficient companies as a result of technological change. By examining the productivity improvements of the most efficient DSOs, it is possible to assess how much of the trend in expenditure is driven by frontier shift. As indicated earlier, we consider two methods to perform this decomposition: unit cost trends and DEA.

Both methods, unit cost trend analysis and DEA, have limitations in the current context (e.g. limited independence of individual data; relatively limited data). However, any other quantitative method used in the process will have similar limitations. Given the limitations of the methods and lack of robust alternative options, we look for *directional consistency* in the results from both methods and place less weight on the detailed results from each.

As these approaches rely exclusively on data internal to Fluvius, they can be used only to assess the improvements in internal best practice. This could differ from the 'true' rate of frontier shift if the most efficient DSOs are catching up to global best practice in their industry. For example, if the most efficient DSOs within Fluvius are catching up to more efficient DSOs in Germany or the UK (or, indeed, other areas of Belgium), even the productivity growth achieved by the efficient DSOs will contain an element of catch-up efficiency improvement.

The complete cost data that will be used to determine the general efficiency target (x) (2015–19) for the next regulatory period (2021–24) was not available for this study—the cost data for the year 2019 was provisional.

4.1 Unit cost trends

As productivity is defined as the ratio of outputs to inputs, a natural starting point in assessing the extent to which the Flemish DSOs have increased their productivity is in examining their trends in unit costs (a ratio of cost to a specific output or a composite output). In this context, the relevant metric is the extent to which the most efficient DSOs (i.e. those with the lowest unit costs) have reduced unit costs.

DSOs produce multiple outputs, and it is possible that unit costs expressed in terms of different outputs will lead to different conclusions. For this reason, the unit cost trends presented in this section are qualitative and are used to deploy

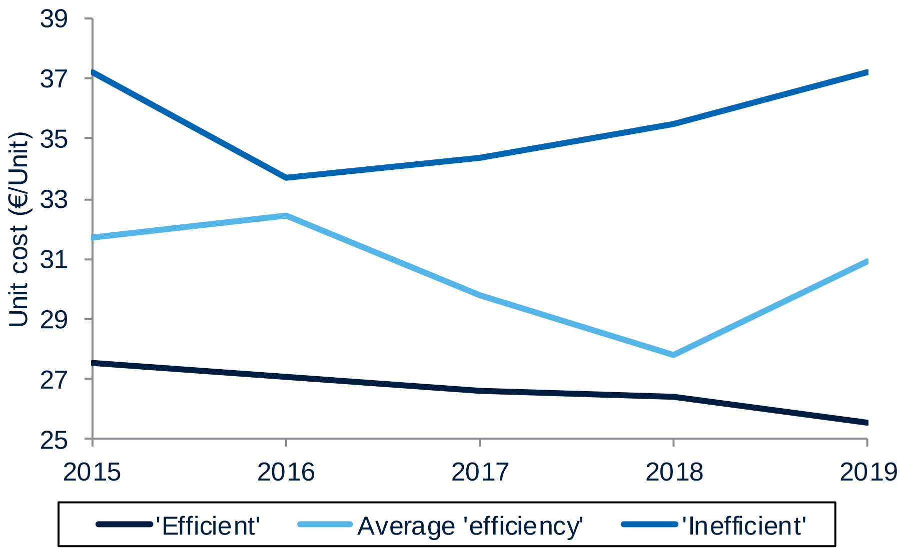
[75] In the current context, we do not have sufficient knowledge to apply expert judgement. Moreover, we have not identified any relevant regulatory precedence on the decomposition that we could rely on.

support evidence from other benchmarking methods. In this section, we also generate a composite output measure defined as the geometric mean[76] of energy delivered, network length and number of connections.[77]

Figure 4.1 shows the unit cost trends in electricity distribution for three clusters of DSOs: efficient DSOs (the three DSOs in the sample with the lowest unit costs); inefficient DSOs (the three DSOs in the sample with the highest unit costs), and averagely efficient DSOs (the remaining DSOs).

The chart shows that, although there has been some catch-up in the sample, the most efficient DSOs are reducing unit costs at a faster rate than the inefficient DSOs. As such, some of the current cost reduction in electricity distribution may be driven by frontier shift.

Figure 4.1 Unit cost trends—electricity distribution



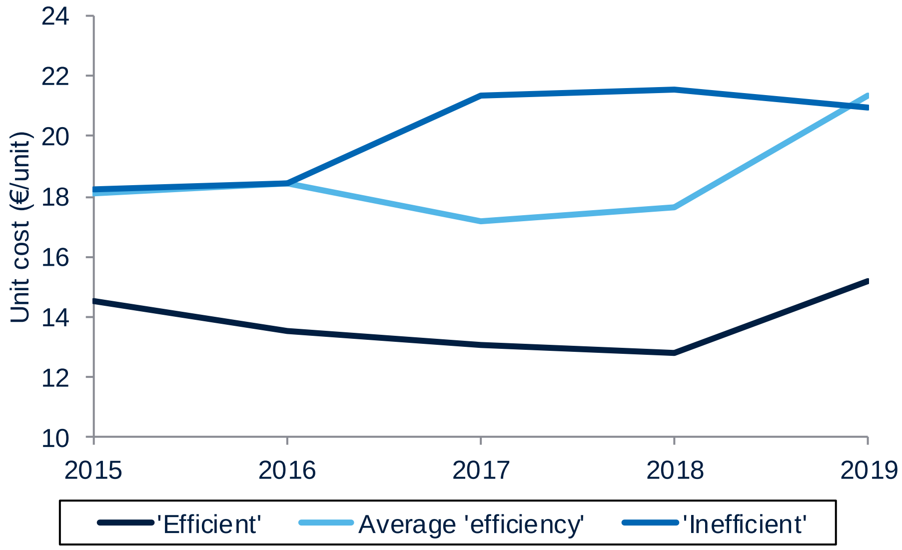
Note: The chart shows the cost per unit. The geometric mean of outputs does not have an intuitive unit, €/((km*Connection*Wh)$^{1/3}$). A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is an average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is an average of the three least efficient DSOs; and the averagely efficient unit cost is an average of the remaining DSOs.

Source: Oxera analysis of Fluvius data.

Figure 4.2 shows the equivalent unit cost trends in the gas distribution sector. In gas distribution, the most efficient DSOs have not made any material reductions in unit costs in the full analysis period. It is therefore unlikely that much, if any, frontier shift is currently accounted for in an X-factor.[78]

[76] Each output is given equal weight in the calculation. Results when outputs are treated individually can be found in appendix 5A5.
[77] These are often considered the core outputs of DSOs and have been used in regulatory applications of DEA. For example, see Ajayi, V., Anaya, K. and Pollitt, M. (2018), 'Productivity growth in electricity and gas networks since 1990', December.
[78] Part of this conclusion in dependent on the accuracy of the 2019 data, which is an important data point as it is part of data that VREG uses to determine x. We expect Fluvius's projections to be relatively close to the outturn expenditure as they were provided in October, close to the end of the year. We note that when data was limited to 2018, evidence from DEA (section 4.2) and alternative output variables (appendix 5A5) support the current conclusion that the efficiency frontier of the gas DSOs has been regressing.

Figure 4.2 Unit cost trends—gas distribution



Note: The chart shows the cost per unit. The geometric mean of outputs does not have an intuitive unit, €/((km*Connection*Wh)$^{1/3}$). A DSO’s efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is an average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is an average of the three least efficient DSOs; and the averagely efficient unit cost is an average of the remaining DSOs.

Source: Oxera analysis of Fluvius data.

Aggregating the outputs using a geometric mean imposes assumptions regarding the relative importance of each output in determining expenditure. Unit cost trends with outputs considered in isolation (e.g. cost per connection) broadly support the above two conclusions, as shown in Table 4.1 below. The table shows that there is no evidence of frontier shift in gas distribution using the unit costs that we consider in this report. In electricity distribution, the evidence is mixed when using number of customers as the key output variable (there is no clear reduction in using costs with this output).

Table 4.1 Unit cost evidence of frontier shift

Output	Gas	Electricity
Network length	X	✓
Number of customers	X	✓/X
Energy delivered	X	✓
Geometric mean	X	✓

Note: ‘X’ indicates that there is no evidence of frontier shift when the output is used as the denominator in the unit cost ratio. ‘✓’ indicates that there is evidence of frontier shift.

Source: Oxera analysis of Fluvius data.

These sensitivities are discussed in appendix A5.

4.2 Data envelopment analysis

It is possible to account for multiple outputs using advanced scientific methods of estimation, such as DEA. Indeed, these methods are used to explicitly set frontier shift efficiency targets in some jurisdictions.[79] These methods are typically used when there is a sufficiently large number of independent DSOs (although the appropriate sample size is an empirical question).

Fluvius is the operator of nine gas distribution networks and ten electricity distribution networks. This sample size is smaller than that used by other regulators that use direct methods of frontier shift estimation. Furthermore, the networks are not sufficiently independent to allow for a robust analysis. We therefore consider DEA as a method for providing qualitative (i.e. directional) evidence regarding the extent to which the current cost trends are driven by frontier shift, rather than informing an exact number.

DEA estimates a specific value of frontier shift for each DSO, depending on the mix of outputs it produces and the evolution of the efficient frontier at that point. To derive an overall estimate of the frontier shift that the industry has achieved, we take a weighted average of the estimated frontier shift across DSOs, where the weights are defined as the share of the DSO's costs in the total industry costs. This is done to improve the comparability of the estimated frontier shift and the methodology used to set cost targets.[80]

The input used in the DEA model is nominal endogenous costs, consistent with the expenditure that is assessed in VREG's methodology to determine the efficiency factor, x. The outputs used in the DEA model are network length, number of connections, and energy delivered. This is consistent with applications of this approach in the gas and electricity distribution sectors.

Table 4.2 shows the estimated frontier shift for gas and electricity distribution. In this table, a positive number indicates an improvement in best practice (indicating a reduction in expenditure). The estimated frontier shift in electricity distribution is positive and above our central estimate of the net frontier shift of 0.4% p.a. that the DSOs can achieve in the next regulatory period (although some sensitivities suggest that greater efficiency gains are feasible). For this reason, we do not consider it appropriate to impose an additional net frontier shift target in electricity distribution.

Conversely, the estimated net frontier shift is negative in gas distribution and is significantly below what we estimate from indirect analysis. For this reason, we consider that the full frontier shift estimated from the indirect analysis can be applied in gas distribution.

Table 4.2 Frontier shift—DEA

	2015–18	2015–19
Electricity distribution (% p.a.)	1.4%	0.8%
Gas distribution (% p.a.)	-0.1%	-2.4%

Note: Consistent with scientific best practice in estimating frontier shift, a CRS technology is assumed when constructing the MPI (see, for example, Thanassoulis, E. (2001), *Introduction to the Theory and Application of Data Envelopment Analysis: A foundation text with integrated software*, Kluwer Academic Publishers, pp. 177–178). Here, a positive number indicates an improvement in productivity and a decrease in efficient expenditure.

Source: Oxera analysis of Fluvius data.

[79] For example, the Bundesnetzagentur uses a combination of DEA and SFA to estimate a Malmquist index that it uses to set the ongoing efficiency target for gas and electricity DSOs in Germany. See Bundesnetzagentur (2018), 'BK4-18-056 Beschlusskammer 4', November.
[80] VREG estimates the efficiency factor by estimating the trends in total industry expenditure for gas and electricity separately. This implicitly gives more weight to the cost reduction (as measured in percent per annum) achieved by DSOs with larger expenditure. For consistency, we also give more weight to the frontier shift observed by the DSOs with larger expenditure.

4.3 Proposed adjustments

The evidence presented in this section indicates that much of the cost reduction achieved by electricity DSOs in 2015–19 is driven by frontier shift. To avoid double-counting the impact of net frontier shift on Fluvius's DSOs' expenditure, a large downward adjustment to the net frontier shift estimated in section 3 is needed to derive an incremental efficiency challenge, x''. Indeed, an adjustment may not be required at all.

Conversely, as there has been no evidence of frontier shift improvement in gas distribution, the risk of double-counting the impact of net frontier shift on Fluvius's DSOs' expenditure is limited. It may therefore be appropriate to apply the full net frontier-shift estimate to the price-setting formula in gas distribution.

As noted at the outset, both approaches used in this section to decompose the historical cost trend into frontier shift and other effects have limitations in the current context. However, given the congruency in the results (i.e. analysis consistently indicates that no frontier shift has been observed in gas distribution and some frontier shift is observed in electricity distribution) and the simplicity of the conclusion (that the full challenge should be applied to gas DSOs and no challenge should be applied to electricity DSOs), we consider that our recommendations regarding the need and magnitude of the incremental efficiency challenge are appropriate.

5 Conclusion

In this report, we have used indirect methods of frontier shift estimation to calculate the feasible rate of net frontier shift that are appropriate for the Flemish gas and electricity DSOs over the next regulatory period. The time period over which productivity was assessed was chosen in order to avoid biasing the estimates based on the position of the Belgian economy in the business cycle—productivity growth was estimated only over *complete* business cycles. Similarly, other elements of the analysis in terms of productivity measure, comparator set and aggregation approach were based on regulatory precedents, empirical evidence and our expert view, with the results cross-checked using extensive sensitivity analysis.

Analysis in the base case comparator set over two complete business cycles indicates that a net frontier shift in the range of 0.1–0.4% p.a. is feasible. While we consider the base case comparators to provide the most robust evidence for the scope for net frontier shift productivity improvements, sensitivity analysis regarding the choice of comparators, time period of analysis, aggregation approach and international comparisons typically supports the upper end of the range or higher.

We therefore consider the overall feasible rate of net frontier shift to be 0.4% p.a., which indicates that **costs should reduce by 0.4% p.a. over the next regulatory period as a result of frontier shift productivity improvements and changes in real input prices**. This estimate is informed and supported by extensive sensitivities regarding the choice of comparators, time period of analysis and measure of TFP growth.

Using cost and output data for each DSO (provided by Fluvius), we have also assessed the extent to which the current regulatory framework already accounts for frontier shift productivity improvements (net of input price pressure). Results from high-level unit cost trends and DEA support the conclusion that the current tariff-setting methodology already accounts for net frontier shift for electricity DSOs. In contrast, the current tariff-setting methodology does not account for net frontier shift for gas DSOs.

Table 5.1 summarises the results from sections 3 and 4 to estimate the incremental frontier shift efficiency target, x''.

Table 5.1 Proposed incremental efficiency challenge

	Electricity	Gas
Feasible rate of net frontier shift (% p.a.)	0.4%	0.4%
Extent to which VREG tariff methodology already accounts for net frontier shift (%)	100%	0%
Proposed x'' (% p.a.)	**0%**	**0.4%**

Source: Oxera analysis.

To conclude, our analysis indicates that **an incremental challenge of 0.4% p.a. should be applied to gas DSOs** in the upcoming regulatory period. Meanwhile, **no incremental challenge should be applied to electricity DSOs**.

A1 Sensitivity analysis—Dutch EU KLEMS data

To ensure that our analysis is not unduly influenced by the particular macroeconomic circumstances of the Belgian economy, we perform a similar analysis on a different country’s data. The Netherlands is a relevant comparator economy that can provide useful information on the frontier shift potential in a neighbouring country of a similar size.

Table A5.1 below shows the results of the core analysis when using Dutch EU KLEMS data. The overall figures in the base case are higher than what we estimate in the Belgian economy, which further supports our conclusion that a net frontier shift target towards the higher end of the estimated range should be selected.

Table A5.1 Net frontier shift growth, 2004–17 (% p.a.)

Comparator industry	GO-based	VA-based
Base case	0.4%	0.5%
Telecoms sensitivity	1.0%	1.4%
EGSA sensitivity	0.5%	0.8%

Note: Only one full business cycle was identified in the Dutch economy, from 2004 to 2017.

Source: Oxera analysis of EU KLEMS data.

A2 Sensitivity analysis—alternative comparator selection

Although we consider our ‘base case’ in the main report to be the most robust selection of comparators, there is a large degree of value judgement at this stage of the analysis. We therefore present results for sensitivities to the core empirical analysis relating to the selection of comparator industries in this appendix, specifically relating to the inclusion of ‘Chemicals and chemical products’ and ‘Electrical equipment’. In general, these industries are typically loosely related to the activities carried out by DSOs and have been used by regulators in past decisions. These industries are outlined below.

Chemicals and chemical products

This industry is loosely related to the activities of gas DSOs as it involves, to some extent, the transport of liquids and/or gases through a network of pipes. As this industry carries out primarily manufacturing activities, it is unlikely to be a direct comparator to the gas distribution sector. Comparability is even more limited when considering the electricity distribution sector.

Electrical equipment

This industry involves the manufacture of electrical equipment and may therefore be a relevant comparator for electricity distribution. As with ‘Chemicals and chemical products’, this sector is primarily a manufacturing industry and is less relevant to the activities of DSOs than the comparators considered in the main report.

The overall selection of comparators is summarised in Table A5.2.

Table A5.2 Sensitivity comparator selection

Comparator industry	Base case	Gas sensitivity	Gas + Telecoms	Electricity sensitivity	Electricity + Telecoms
Other manufacturing; repair and installation of machinery and equipment	✓	✓	✓	✓	✓
Construction	✓	✓	✓	✓	✓
IT and other information services	✓	✓	✓	✓	✓
Professional, scientific, technical, administrative and support service activities	✓	✓	✓	✓	✓
Telecommunications			✓		✓
Chemicals and chemical products		✓	✓		
Electrical equipment				✓	✓

Source: Oxera.

The net frontier shift analysis for each of the sensitivities is shown in Table A5.3.

Table A5.3 Estimated net frontier shift

TFP measure; time period	Base case	Gas sensitivity	Gas + Telecoms	Electricity sensitivity	Electricity + Telecoms
TFP(GO); 2010–17	0.4%	0.2%	1.1%	0.4%	1.2%
TFP(GO); 2003–10	0.0%	-0.3%	0.3%	0.1%	0.6%
TFP(GO); 2008–12	0.4%	0.2%	1.1%	0.3%	1.2%
TFP(GO); 2001–08	0.4%	-0.2%	0.4%	0.6%	1.1%
TFP(VA); 2010–17	0.5%	0.3%	1.6%	0.1%	1.5%
TFP(VA); 2003–10	-0.2%	0.1%	0.7%	-0.2%	0.5%
TFP(VA); 2008–12	0.5%	1.1%	2.2%	-0.1%	1.3%
TFP(VA); 2001–08	-0.1%	-0.4%	0.3%	0.4%	1.0%

Source: Oxera.

The impact of each of the sensitivities can be summarised as follows.

Gas sensitivities

The analysis of the ‘gas sensitivity’ comparators suggests a feasible net frontier shift range of -0.4–1.1% p.a. This is a wider range than in the base case presented in the main report (-0.2–0.5% p.a.) and is driven by the sensitivity of the ‘Chemicals and chemical products’ industry to the time period of analysis and the output measure. Estimating over two complete business cycles, the range can be narrowed to -0.1–0.3% p.a.

The analysis of the gas sensitivity suggests that the feasible rate of frontier shift in gas distribution may be lower than that suggested by the base case comparator set. However, when the Telecommunications sector is also included in the comparator set, the feasible rate of frontier shift in the gas sensitivity increases to 0.3–2.2% p.a. For this reason, there is insufficient evidence that the feasible rate of frontier shift in gas distribution is lower than the 0.4% determined in the main report.

Electricity sensitivities

The net frontier shift of the ‘electricity sensitivity’ comparators suggests that a net frontier shift of -0.2–0.6% p.a. is feasible. The range can be narrowed to 0–0.5% p.a. by estimating over two complete business cycles. This is broadly aligned with the refined range presented in the main report (0–0.4% p.a.) and we therefore consider the conclusions of the main report to be appropriate in electricity distribution.

A3 Fluvius's comparator selection

We sought input from Fluvius and VREG to ensure transparency, and to benefit from the insights that both the company and the regulator can provide. As part of this consultation process, we asked Fluvius for its view of the most comparable competitive sectors of the Belgian economy to its electricity and gas DSOs, and the appropriate weight for each sector. Table A5.4 below shows these sectors and their associated weights.

Table A5.4 Fluvius's proposed comparator set and weights

Sector	Weight
Electricity, Gas and Water Supply	50%
Chemicals and chemical products	20%
Information and communication	30%

Source: Fluvius. Email received from VREG 09/10/2019.

We discuss each sector in turn below.

Electricity, Gas and Water Supply

This industry is the most operationally comparable to Fluvius's DSOs in terms of the activities that it undertakes. Fluvius itself would be included in the data for this industry. However, regulators and practitioners are generally wary of including this sector in frontier shift analysis, as the sector often contains the company that is being assessed; the sector is not sufficiently competitive and the sector is characterised by natural monopolies. This is discussed in more detail in section 3.1 of the main report.

However, given the operational comparability of this sector, we use a subset of the sector as a sensitivity to our main analysis.[81]

Chemicals and chemical products

This industry is loosely related to the activities of gas DSOs as it involves, to some extent, the transport of fluids through a network of pipes. Furthermore, it has been used by regulators in the past.[82] For these reasons, we consider it as a sensitivity in our analysis but do not attach a large weight to these results.

Information and communication

We do believe that this industry aggregate can provide useful information in our assessment of frontier shift. However, the industry aggregate is composed of three industries:

- Publishing, audio-visual and broadcasting activities;
- Telecommunications;
- IT and other information services.

[81] The EU KLEMS dataset was updated during the consultation process. In the most recent release, the 'Electricity, Gas and Water Supply' sector was disaggregated into 'Electricity, gas, steam and air conditioning supply' and 'Water supply; sewerage; waste management and remediation activities'. In this analysis, we assume that Fluvius would have selected 'Electricity, gas, steam and air conditioning supply' had it been available, and would have attached the same 50% weight.
[82] For example, see Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July; and 'Oxera (2016), 'Study on ongoing efficiency for Dutch gas and electricity TSOs', January.

We do not consider 'Publishing, audio-visual and broadcasting activities' to be a comparable industry to the electricity and gas activities of the Flemish DSOs, but we use the other two industries in our analysis. Note that we use the Telecommunications sector as a sensitivity, given its exceptionally large net frontier shift in the analysis period.

Despite our reservations with Fluvius's selection of comparator industries and their associated weights, we present the results from such analysis as a sensitivity in Table A5.5. Compared with the simple average of our base case comparators, the estimated net frontier shift with these weights and comparators is highly sensitive to the choice of time period ranging from -1% p.a. to 1.6% p.a.. Despite the presence of one low estimate of net frontier shift, the analysis of Fluvius's weights and comparators shows that a target of 0.4% p.a. is feasible for Flemish DSOs.

Table A5.5 Fluvius's weights and comparators—results (% p.a.)

TFP measure; time period	Base case	Fluvius
TFP(GO); 2010–17	0.4%	0.4%
TFP(GO); 2003–10	0.0%	0.3%
TFP(GO); 2008–12	0.4%	0.0%
TFP(GO); 2001–08	0.4%	-1.0%
TFP(VA); 2010–17	0.5%	0.8%
TFP(VA); 2003–10	-0.2%	1.6%
TFP(VA); 2008–12	0.5%	1.6%
TFP(VA); 2001–08	-0.1%	0.6%

Source: Oxera analysis of EU KLEMS data.

A4 Sensitivity analysis—weighted average aggregation methods

In aggregating the productivity estimates from individual sectors into a composite measure, we considered only a simple average approach to aggregating in the main report. This was primarily driven by a lack of detailed data regarding the cost structure of an efficient Flemish DSO. In this section, we explore the use of three different weighting structures used by regulators and consultants to assess the scope for frontier shift efficiency improvements.

- **Ecorys (2019).**[83] In a report for ACM, Ecorys determined the weights that may be applied to individual sectors for gas and electricity TSOs. This is based on the cost structure of the two companies being assessed, TenneT and Gasunie Transport Services (GTS).
- **Europe Economics (2007).**[84] In a report for Ofgem, Europe Economics constructed weights for British gas DSOs. As with ECORYS, this was based on the observed cost structure of the DSOs.
- **Ofgem (2012).**[85] Ofgem constructed weights for each sector based on the size of the industry relative to the total economy.

These are discussed in turn below.

A4.1 Ecorys (2019)

The weights estimated by Ecorys are based on the cost structure of Dutch electricity and gas TSOs. No evidence is provided that this cost structure is efficient and the weights calculated under this approach are therefore subject to the same critique outlined in section 3.1.2. Furthermore, the use of these weights to set efficiency targets for Flemish DSOs further assumes there are no material differences in the cost structure between distribution and transmission activities (and between Dutch and Flemish operating environments). For these reasons, we consider these as sensitivities only and they do not inform our analysis.

Table A5.6 shows the weights used in Ecorys's analysis. The first column ('core weights') presents the weight for each comparator industry, where the weight is determined by the relevance of the sector to gas and electricity transmission. The second column ('cross-check') estimates weights based on the similarity of the comparator sector in terms of capital structure, workforce and use of materials. As the cost data used to derive the weights in Table A5.6 was not published in the report, we are unable to perform our own mapping exercise and must use the same comparators as Ecorys.

Table A5.6 Sector weights— Ecorys's approach

	Core weights	Cross-check
Telecommunications	5%	11%
IT and other information services	6%	9%
Professional, scientific, technical, administrative and support service activities	7%	14%
Construction	24%	12%

[83] Ecorys (2019), 'Wegingsfactoren voor frontier shift TSO's', January.
[84] Europe Economics (2007), 'Top down benchmarking of UK Gas Distribution Network Operators', April, section 4.
[85] Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July.

Financial and insurance activities	2%	10%
Transportation and storage	13%	12%
Other manufacturing; repair and installation of machinery and equipment	24%	10%
Electricity, gas, steam and air conditioning supply[1]	20%	23%

Note: The weights presented in the Ecorys paper did not sum to 100%. In the weights used in this analysis, we have normalised the weights to sum to 100%. [1] Ecorys used the 'Electricity, Gas and Water Supply' sector in its analysis. In the EU KLEMS 2019 release, this sector was disaggregated into 'Electricity, gas, steam and air conditioning supply' and 'Water supply; sewerage; waste management and remediation activities'.

Source: Ecorys (2019).

Table A5.7 presents the estimated net frontier shift when such weights and comparator sectors are used in our analysis. Using the 'core weights' from Ecorys, the estimated net frontier shift is in the range 0–0.9% p.a. and is typically higher than our base case (-0.2–0.5% p.a.). The increase in estimated net frontier shift is more pronounced when using the 'cross-check' weights—the estimated net frontier shift increases to 0.3–1.7% p.a..

Table A5.7 Estimated net frontier shift— Ecorys weights

TFP measure; time period	Base case	Core weights	Cross-check
TFP(GO); 2010–17	0.4%	0.5%	0.7%
TFP(GO); 2003–10	0.0%	0.0%	0.3%
TFP(GO); 2008–12	0.4%	0.3%	1.1%
TFP(GO); 2001–08	0.4%	0.2%	0.8%
TFP(VA); 2010–17	0.5%	0.9%	1.1%
TFP(VA); 2003–10	-0.2%	0.1%	0.5%
TFP(VA); 2008–12	0.5%	0.4%	1.7%
TFP(VA); 2001–08	-0.1%	0.1%	0.7%

Source: Oxera analysis of EU KLEMS data.

A4.2 Europe Economics (2007)

As part of a study of top down benchmarking of British gas DSOs, Europe Economics constructed a weighted average TFP measure that took into account the cost structure of the DSOs. The expenditure across the gas distribution industry was divided into five activities:

- capital and replacement expenditure—referred to as 'CAPEX' and 'REPEX' respectively. These activities include the investment in assets whose benefits are expected to last for a number of years, extending the life of such assets and the replacement of assets;
- work management—includes asset management; operations management; contract management; customer management; network support; health, safety and the environment; network policy; safety and engineering; and call centres;
- emergency and repairs—involves the cost of responding to and repairing faults on the network;
- support services and indirect OPEX—includes information provision; data centres; audit costs and property management; and
- maintenance and other—involves the routine maintenance and monitoring of the network.

The industry-wide share of costs associated with each activity, along with our proposed mapping of the four base comparator industries to each activity, is shown in Table A5.8 below.

Table A5.8 Activity weights—Europe Economics approach

	Activity Weight[1]	Industry 1[2]	Industry 2[2]
CAPEX and REPEX	55.9%	Construction	Other manufacturing; repair and installation of machinery and equipment
Work management	12.5%	Professional, scientific, technical, administrative and support service activities	IT and other information services
Emergency and repairs	11.6%	Construction	Other manufacturing; repair and installation of machinery and equipment
Support services and indirect	13.0%	Professional, scientific, technical, administrative and support service activities	IT and other information services
Maintenance and other	7.0%	Construction	Other manufacturing; repair and installation of machinery and equipment

Source: [1] Europe Economics (2007). [2] Oxera.

Given multiple sectors can be considered comparators of each activity, and there is no evidence to support giving one sector more weight than another *within* the activity to which it is mapped, we give equal weight to each sector within the activity. The associated weights on each sector are therefore:

- Construction: 37%;
- Other manufacturing; repair and installation of machinery and equipment: 37%;
- Professional, scientific, technical, administrative and support service activities: 13%;
- IT and other information services: 13%.

The estimated net frontier shift is shown in the table below. The overall range of estimated frontier shifts is wider with the weighted average (-0.5–0.7% p.a.) compared with the simple average (-0.2–0.5% p.a.). When looking at the most recent business cycle (2010–2017), the productivity growth is higher with the weighted average measure. Conversely, estimated productivity growth is lower in the second business cycle (2003–10) with the weighted average measure. There does not appear to be a systematic difference between the weighted and unweighted estimates (i.e. the weighted average is not systematically higher or lower than the unweighted average) and, for this reason, we conclude that this weighted average broadly supports the unweighted average estimate of the main report.

Table A5.9 Estimated net frontier shift—Europe Economics weights

TFP measure; time period	Base case	EE sensitivity
TFP(GO); 2010–17	0.4%	0.5%
TFP(GO); 2003–10	0.0%	-0.2%
TFP(GO); 2008–12	0.4%	0.4%
TFP(GO); 2001–08	0.4%	0.2%
TFP(VA); 2010–17	0.5%	0.6%
TFP(VA); 2003–10	-0.2%	-0.5%
TFP(VA); 2008–12	0.5%	0.7%
TFP(VA); 2001–08	-0.1%	-0.3%

Source: Oxera analysis of EU KLEMS data.

A4.3 Ofgem (2012)

Ofgem takes a different approach to deriving weights to that outlined in the main report. Instead of weighting the comparator sectors based on their relevance to gas and electricity distribution activities, it weights sectors based on the proportion of output (measured in VA or GO terms, depending on the measure of TFP estimated) that that sector contributes to the total economy as shown in the equation below.

$$w_i = \frac{Y_i}{\sum_j Y_j}$$

Where:

- w_i is the weight on sector i in the aggregation process;
- Y_i is the output of sector i, measured in terms of either VA or GO;
- $\sum_j Y_j$ is the total output of all the comparators considered.

This approach has the advantage that it is entirely independent of the current cost structure of DSOs. However, the weights derived from such an approach do not represent the similarity of the comparator sectors to Flemish DSOs, but the size of the comparator sector within the Belgian economy. It is not clear ex ante why such weights should be used to assess the scope for net frontier shift for gas and electricity DSOs.

Table A5.10 shows the weights on each sector of our core comparator set when such an approach is applied to the Belgian economy. Compared with the precedents outlined in sections 5A4.1 and 5A4.2, the estimated weight on ‘Professional, scientific, technical, administrative and support service activities’ appears inconsistent with operational expectations. Using this method, the weight is over 50%, whereas precedent from other methods indicates that a weight of 7–14% may be more appropriate.

Table A5.10 Sector weights—Ofgem approach

	GO weight (%)	VA weight (%)
Other manufacturing; repair and installation of machinery and equipment	4%	4%
Construction	36%	27%
IT and other information services	7%	8%
Professional, scientific, technical, administrative and support service activities	53%	62%

Source: Oxera analysis of EU KLEMS data.

We present the results from such weights in Table A5.11 below. Weighting based on industry size leads to a narrower range of estimated net frontier shift (0–0.4% p.a.) than a simple average (-0.2–0.5% p.a.).

Table A5.11 Estimated net frontier shift—Ofgem weights

TFP measure; time period	Base case	Ofgem sensitivity
TFP(GO); 2010–17	0.4%	0.4%
TFP(GO); 2003–10	0.0%	0.0%
TFP(GO); 2008–12	0.4%	0.2%
TFP(GO); 2001–08	0.4%	0.2%
TFP(VA); 2010–17	0.5%	0.4%
TFP(VA); 2003–10	-0.2%	0.4%
TFP(VA); 2008–12	0.5%	0.3%
TFP(VA); 2001–08	-0.1%	0.3%

Source: Oxera analysis of EU KLEMS data.

A5 Alternative output variables

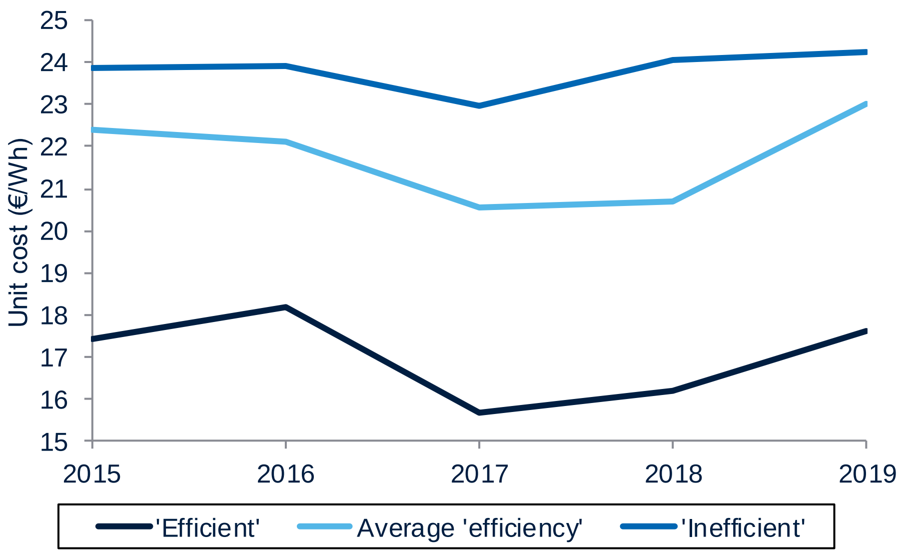
In section 2.6, we presented stylised figures showing how, at a high level, unit cost trends could provide directional evidence regarding the extent to which cost reduction has been a result of frontier shift productivity improvements. In section 4.1 we presented unit cost trends where a composite output variable was constructed. In this section we test the robustness of the conclusions presented in section 4.1 to the individual output measures.

A5.1 Unit cost trends—electricity

When using the composite output variable, the current regulatory framework was assessed to already account for frontier shift in electricity distribution. Figure A5.1 below shows the unit cost trends for efficient, averagely efficient and inefficient electricity DSOs when energy delivered is used as the measure of output.

At a high level, the results are broadly consistent with the core analysis. That is, unit costs have been falling for the most efficient DSOs[86] in the sample and frontier shift may be driving the change in expenditure. As such, the current framework may already capture the impact of frontier shift productivity improvements on expenditure.

Figure A5.1 Expenditure per unit of energy delivered—electricity distribution



Note: The chart shows the cost per unit of energy delivered. A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is an average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is an average of the three least efficient DSOs; and the averagely efficient unit cost is an average of the remaining DSOs.

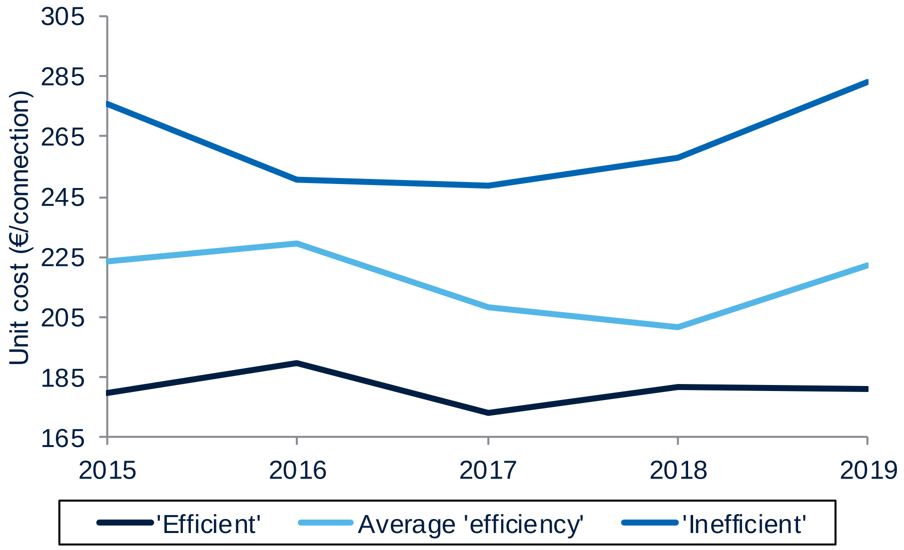
Source: Oxera analysis of Fluvius data.

Figure A5.2 shows the cost per connection for electricity DSOs. Here, the trends indicate that the most efficient DSOs are not improving their productivity at a significant rate. Similarly, the inefficient and averagely efficient DSOs are

[86] There is some evidence that efficient DSOs have increased their unit costs in recent years, particularly from 2018 to 2019. However, the data for 2019 is provisional and excluding this observation produces a clear downward trend in unit costs.

not improving their unit costs. This may weaken the extent to which the historical cost trend in electricity distribution is driven by frontier shift.

Figure A5.2 Expenditure per connection—electricity distribution

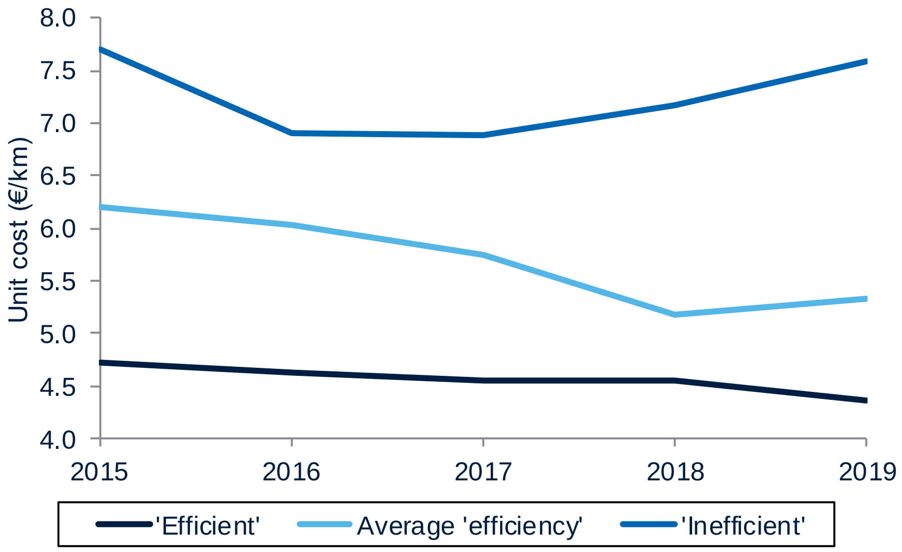


Note: The chart shows the cost per connection. A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is an average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is an average of the three least efficient DSOs; and the averagely efficient unit cost is an average of the remaining DSOs.

Source: Oxera analysis of Fluvius data.

Finally, Figure A5.3 shows the evolution of unit costs when network length is defined as the output variable. There is a clear downward trend in unit costs for the most efficient DSOs. This supports the core conclusion that much of the current methodology already accounts for frontier shift in electricity distribution.

Figure A5.3 Expenditure per kilometre of network—electricity distribution



Note: The chart shows the cost per kilometre of the network. A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is a simple average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is a simple average of the three least efficient DSOs; and the averagely efficient unit cost is a simple average of the remaining DSOs. Data regarding network length was unavailable for the year 2019, and has therefore been estimated by applying the average annual growth of the variable (in the period 2012–18) to the 2018 value for each DSO.

Source: Oxera analysis of Fluvius data.

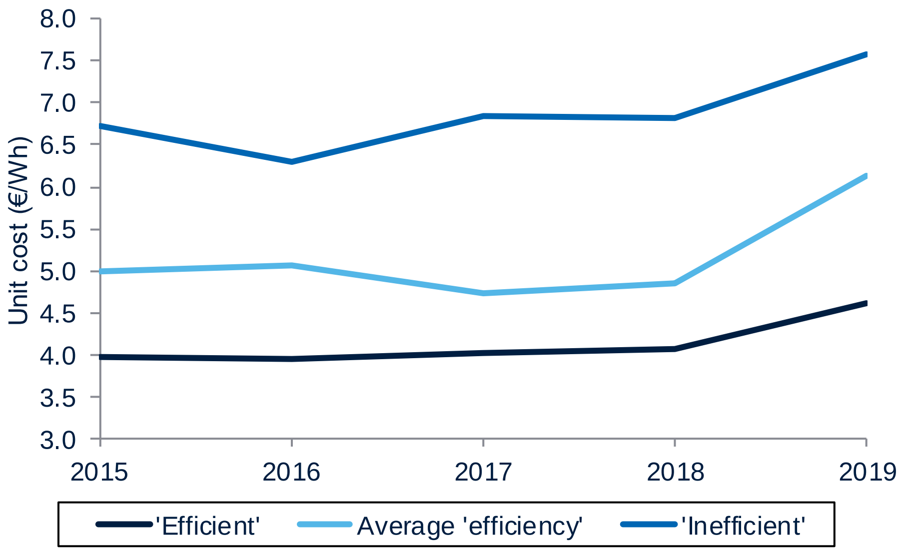
In three out of the four output variables that we consider, there is evidence that much of the productivity improvement in the current regulatory period has been driven by frontier shift. Alongside the evidence from DEA modelling, we therefore consider our conclusions to be consistent—the current framework already accounts for frontier shift in electricity distribution, and no incremental frontier shift is required.

A5.2 Unit cost trends—gas distribution

In gas distribution, evidence from unit cost trends presented in the main report and DEA modelling supports the view that the current framework does not already account for frontier shift, and therefore the full net frontier shift target estimated via TFP analysis could be applied.

Figure A5.4 below shows the expenditure per unit of energy delivered for gas DSOs. Using this output measure, the most efficient DSOs increase their unit costs in the analysis period. This evidence supports the view that frontier shift is not driving the cost trends in gas distribution.

Figure A5.4 Expenditure per unit of energy delivered—gas distribution

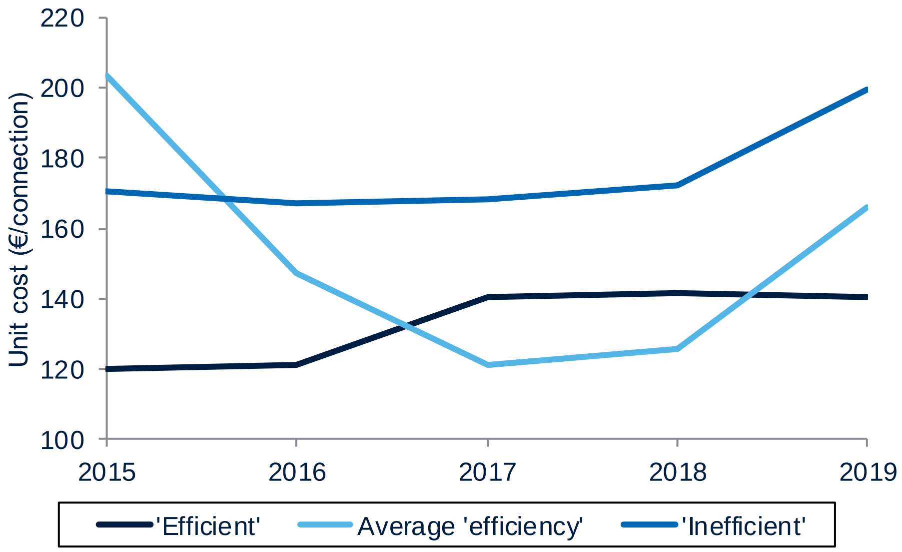


Note: The chart shows the cost per unit of energy delivered. A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is an average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is an average of the three least efficient DSOs; and the averagely efficient unit cost is an average of the remaining DSOs.

Source: Oxera analysis of Fluvius data.

Figure A5.5 shows the unit cost trends for gas DSOs when number of connections is used as the measure of output. The chart is extreme, with the averagely efficient DSOs in the sample making such significant unit cost reductions that, in two years of the analysis period, the least efficient DSOs had the lowest unit costs. Alongside the slight increase in unit costs experienced by the most efficient DSOs, this is clear evidence that frontier shift is not already accounted for in the regulatory framework.

Figure A5.5 Expenditure per connection—gas distribution

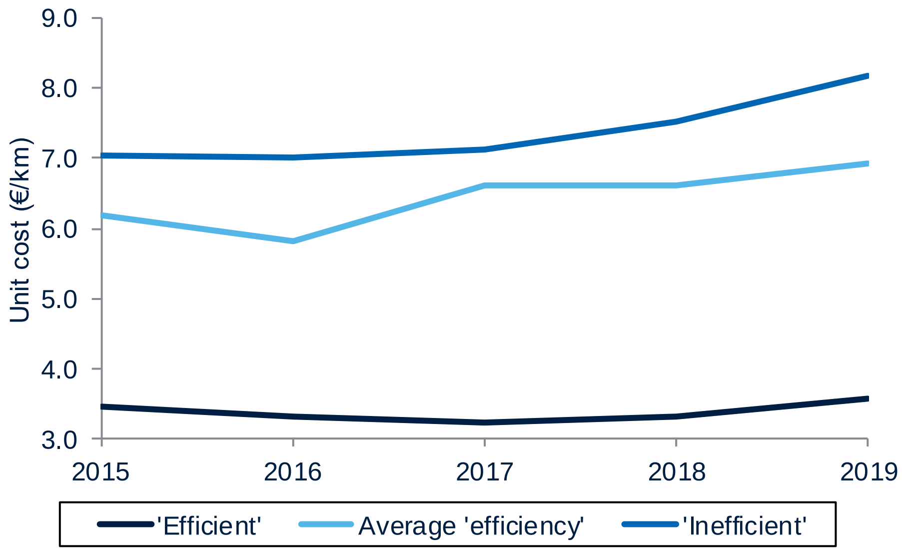


Note: The chart shows the cost per connection. A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is an average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is an average of the three least efficient DSOs; and the averagely efficient unit cost is an average of the remaining DSOs.

Source: Oxera analysis of Fluvius data.

The unit costs with respect to the network length show that unit costs of the most efficient DSOs in the industry have not decreased in the analysis period, as shown in Figure A5.6. This supports the conclusions of the main report.

Figure A5.6 Expenditure per kilometre of network—gas distribution



Note: The chart shows the cost per kilometre of the network. A DSO's efficiency ranking is estimated as its average unit cost across the modelling period. The efficient unit cost in each year is a simple average of the unit costs of the three most efficient DSOs; the inefficient unit cost in each year is a simple average of the three least efficient DSOs; and the averagely efficient unit cost is a simple average of the remaining DSOs. Data regarding network length was unavailable for the year 2019, and has therefore been estimated by applying the average annual growth of the variable (in the period 2012–18) to the 2018 value for each DSO.

Source: Oxera analysis of Fluvius data.

Given that the weight of evidence supports the view that frontier shift in gas distribution is not accounted for in the current regulatory framework, an incremental frontier shift is required.

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