Study on ongoing efficiency for Dutch gas and electricity TSOs

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Contents

Boxes, figures and tables

Summary

ACM asked Oxera to advise on the dynamic efficiency parameter for the Dutch electricity and gas transmission sectors to be applied over the upcoming regulatory period.

ACM noted that the dynamic efficiency parameter (also referred to in this report as 'the frontier shift') should be based on the productivity gains that an efficient network operator is expected to achieve over the upcoming regulatory period due to technological improvement or cheaper inputs. On this basis, Oxera understands that the dynamic efficiency parameter must capture the combined effects of technical (or technological) change and input price pressure faced by the industry. For the current regulatory period, the corresponding parameter was based on analysis of historical productivity growth achieved by indirect comparators,[1] past decisions of economic utility regulators from other countries, and a review of academic research.[2] A similar approach has been undertaken in this study.

Preferred empirical estimates

The analysis presented in this report relies on Total Factor Productivity (TFP) and Output Price Index (OPI) measures. The TFP approach is well established in the academic literature,[3] and widely used in regulatory determinations.[4] The OPI analysis has also been considered by economic regulators such as the GB energy regulatory Ofgem[5] and the ACM.[6,7]

The OPI analysis, under a simplified economic framework,[8] seeks to capture the 'combined' effect of technological change and input price pressure. Hence, it can be used directly to inform the dynamic efficiency target for the Dutch transmission system operators (TSOs). Where input price pressure relative to economy-wide inflation is estimated to be narrow, as was determined to be the case at the last review,[9] the TFP and OPI estimates are comparable.[10]

OPI and TFP can both be measured using gross output (GO) or value-added (VA) methods. These two measures are theoretically valid means of estimating productivity. GO measures are better suited to reflect an industry's technical change, and can better account for the role of intermediate inputs. In light of these considerations, and as GO-based measures were used as part of the

[1] In particular, comparable sectors of the Dutch economy.
[2] CEPA (2012), 'Ongoing efficiency in new method decisions for Dutch electricity and gas network operators', November.
[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] For example, in the UK, the energy regulator (Ofgem) conducted TFP analysis using EU KLEMS data for the transmission price control RIIO-T1 over the period 1 April 2013 to 31 March 2021, and the railway regulator (Office of Rail Regulation, now the Office of Rail and Road) commissioned TFP analysis for the control period CP5 over the period 1 April 2014 to 31 March 2019.
[5] Ofgem (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix', December, pp. 23–26. Available at: https://www.ofgem.gov.uk/sites/default/files/docs/2012/12/5_riiogd1_fp_rpe_dec12_0.pdf.
[6] ACM (2013), 'Methodebesluit GTS 2014-2016', October; ACM (2013), 'Methodebesluit Transporttaken Tennet 2014-2016', October.
[7] While Ofgem considered OPI analysis as a cross-check on the results from the TFP and input price pressure analyses, the previous method decision by the ACM was based [primarily] on OPI analysis.
[8] See section 2.5: 'OPI approach'.
[9] 'TFP (GO) and output price indices annual percentage movements are similar […] This similarity indicates that the input prices have historically grown at a similar rate to CPI'. CEPA (2012), op. cit., p. 58.
[10] The relationship between OPI and TFP, and the underlying assumptions, is discussed in section 8 of the report.

previous method decisions,[11] **the focus in this report is on GO-based measures**.

Productivity data used

We derived our core dataset using EU KLEMS and OECD data covering the period 1988–2009. An alternative dataset of CBS data was used as a sensitivity over the period 1995–2011. CBS data is considered on a stand-alone basis due to methodological differences in combining it with EU KLEMS, and as a sensitivity alone due to the limited period of available data.

Oxera's comparator selection

Since CEPA's 2012 report for ACM, EU KLEMS has adopted a new industry classification framework.[12] In light of this methodology change, the comparator selection process undertaken for this report has necessarily differed from past work. The new industry classification presents a number of revised industry definitions that improve the representativeness of the comparator set.

To provide a robust framework for identifying relevant industries, we have also used international studies (one of which includes the Dutch electricity TSO).[13,14]

Based on a detailed review of the activities relevant to electricity and gas transmission operators, we have used the following comparator set.[15]

Comparator set of industries
Telecommunications
IT and other information services
Professional, scientific, technical, administrative and support service activities
Construction
Financial and insurance activities
Transportation and storage
Other manufacturing; repair and installation of machinery and equipment
Electricity, gas and water supply

Source: Oxera analysis.

Appropriate period of analysis

We reviewed regulatory practice using regulatory precedents in the Dutch energy sector alongside common practice in other jurisdictions and sectors. From this, we concluded that:

- *complete* business cycles should be considered;
- earlier data should be discarded if there is evidence of structural breaks or atypical fluctuations that could introduce bias into the long-run productivity estimates;

[11] CEPA (2012), op. cit., p. 7.
[12] See EU KLEMS (2009), 'EU KLEMS Growth and Productivity Accounts: Data in the ISIC Rev. 4 industry classification', http://www.euklems.net/, last accessed 19 October 2015.
[13] Sumicsid (2009), 'e3 GRID Final Results, Final report', version 1.2, March.
[14] Sumicsid (2014), 'Benchmarking European gas transmission system operators: a feasibility study', December.
[15] In Appendix A2.2, we show the results of sensitivity analysis using the TFP and OPI estimates stemming from the updated comparator set used in CEPA (2012).

- a very short timeframe (in particular, covering *one incomplete* business cycle) may not be appropriate.

We also noted that Dutch regulatory precedents in the energy sector have tended to include complete and *incomplete* business cycles.

Using a growth cycle definition[16] and economy-wide data, we identified two *complete* business cycles (1992–2001 covering the first business cycle, and 2002–08 covering the second). Over this period:

- TFP growth shows evidence of pro-cyclical behaviour, which is consistent with academic literature;
- TFP fluctuations are both above- and below- trend, as deemed appropriate to reflect long-run productivity growth.

Results of empirical analysis

Having identified the preferred comparator set and timeframe of analysis, we present the results of our analysis below. Our preference, as noted above, are the GO-based measures estimated using TFP and OPI analysis.

Core estimates from TFP and OPI analysis

Measure	Two complete cycles, core comparator set
TFP, GO	0.4%
OPI, GO	-0.5%

Note: In this table, a negative OPI estimate indicates a fall in output prices, and a positive number indicates an increase in output prices (relative to the consumer price index, CPI).

Source: Oxera analysis using EU KLEMS and OECD data.

Over the period 1992–2008, average per-annum TFP (GO) growth was 0.4%. In our analysis, the input price pressure relative to CPI is estimated to be -0.1%. Hence, a dynamic efficiency target that captures the ‘combined effect’ of productivity growth using the TFP (GO) measure and input price pressure is estimated to be 0.5% per annum (0.4+0.1). The corresponding OPI estimate, which captures the combined effect, is -0.5% (i.e. a 0.5% per-annum improvement). The two estimates are quite similar in this case.[17]

The robustness of these estimates were checked against a number of sensitivities using an alternative data source, comparator sets and timeframe of analysis (see Appendix 2).

Literature review and regulatory precedents[18]

We have identified a limited number of *relevant* academic studies and regulatory determinations of dynamic efficiency assessment of transmission operators.

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[16] According to a ‘growth cycle’ definition, a complete business cycle is a period between two points with zero output gap including both a peak and a trough.
[17] In this instance, the simplified relationship between OPI, input price pressure and TFP as in the formula $\Delta OPI - \Delta CPI = (\Delta IPI - \Delta CPI) - \Delta TFP$ holds as $(\Delta OPI - \Delta CPI) = -0.5\%$, $(\Delta IPI - \Delta CPI) = -0.1\%$, and $-\Delta TFP = -0.4\%$. See section 8 for details on the derivation of the relationship.
[18] The central estimate presented here are rounded to one decimal place.

The regulatory precedents point to a range of 0–1.5% per annum for the electricity TSOs and 0.3–1.5% per annum for the gas TSOs, although the upper-end estimate (of 1.5%[19]) may encompass catch-up effects.

The academic studies point to a range of -1% to 2.4% per annum for the electricity TSOs, with a central estimate of 1.5% per annum. A number of studies on the electricity TSOs determine a per-annum productivity estimate above 2%; however, these are based on analysis undertaken over short timeframes (here, using less than four years of annual data). The range for the gas TSOs is between 0.5% and 0.8% per annum, with a central estimate of 0.7% per annum.

In the case of academic sources, the range of estimates on the electricity TSOs is wide, giving less confidence that they can be relied upon; while the range on the gas TSOs was based on two studies alone. Also, some of the regulatory determinations are not clear in terms of the methodology and data employed, and whether the estimates presented in them consider the combined effect and exclude catch-up effects. As such, in this instance, we consider that less weight should be placed on estimates from external sources, and that the primary analysis undertaken using indirect comparators should be given more weight.

[19] The upper-end target of 1.5% per annum is from BNetzA, the German energy regulator, which sets a uniform target for both electricity and gas transmission companies.

1 Introduction

1.1 Remit and objectives of the study

The Netherlands Authority for Consumers and Markets (ACM) commissioned Oxera to conduct a study on dynamic efficiency for the Dutch transmission system operators (TSOs). The objective of the study is to advise on the scope of productivity improvement that an efficient operator can achieve due to technological improvement (also referred to as 'frontier shift') or cheaper inputs for TenneT (the electricity transmission operator) and Gasunie Transport Services (GTS) (the gas transmission operator) to be applied over the regulatory period starting in 2017. The objective of the analysis is to produce productivity growth estimates using Total Factor Productivity (TFP) and Output Price Index (OPI) measures. We understand that the OPI measure was the basis for the previous method decision.[20]

To this end, we have:

- built a dataset with productivity-related information for all sectors of the Dutch market economy, by sourcing up-to-date productivity data using the latest methodology standards;
- derived a robust set of comparator industries to capture productivity trends in activities relevant to electricity and gas TSOs;
- identified the most appropriate measurement period for productivity analysis;
- collated a range of estimates from academic sources and regulatory precedents. To inform the range of the dynamic efficiency estimates, the ACM framework requires consideration of academic and consultancy studies alongside empirical ones; separately, regulatory determinations are examined in this report as a cross-check.

1.2 Structure of the report

To derive an appropriate frontier-shift estimate using indirect approaches, the following analytical steps are required:

- review the relevant productivity measures and select the preferred approach;
- gather the necessary data to derive such measures;
- select the appropriate set of comparators;
- derive empirical estimates using data over the appropriate period of analysis;
- adjust estimates to translate them into frontier-shift targets;
- undertake sensitivity analysis.

The report follows these steps, and is structured as follows:

- section 2 gives an overview of the concept of productivity, and how to select an appropriate productivity measure to capture the frontier shift for the Dutch electricity and gas TSOs;

[20] 'In the empirical study frontier shift needs to be established on the indicator output prices as was the case in the previous method decision'. ACM (2015), 'Request for tender. Study for ongoing efficiency for Dutch gas and electricity TSOs', July, p. 4.

- in section 3, we review the productivity data available for empirical analysis. We present the main features of our core dataset using EU KLEMS and OECD data, as well as alternative data from Centraal Bureau voor de Statistiek (CBS);
- using the most recent industry classification (NACE 2), section 4 builds indirect comparators for TFP and OPI analysis based on industry knowledge and recent regulatory studies;
- in section 5, we present our empirical analysis to identify the most appropriate number of business cycles and the optimal timeframe of analysis. In addition, we present regulatory precedents for business-cycle selection in the Dutch energy sector, as well as in other jurisdictions and industries. Bringing this all together, we explain the rationale underlying our 'core' dataset;
- in sections 6 and 7 we present the results from the TFP and OPI analysis, respectively, on the 'core' dataset;
- in section 8 we present our recommendation for how TFP and OPI measures can be translated into dynamic efficiency targets;
- section 9 contains selected academic evidence that is used to inform the range of dynamic efficiency estimates, and the regulatory precedents that are examined for cross-checking purposes;
- section 10 summarises our findings, and provides a final range and central estimate based on the results in sections 6–9.

The appendices include additional discussion of the methodology underpinning the empirical analysis, the sensitivity analysis, and summaries of the academic literature, studies and regulatory determinations used to cross-check the empirical estimates.

- Appendix 1 considers the pros and cons of productivity growth measures based on value-added (VA) and gross output (GO).
- Appendix 2 shows a number of sensitivities using different comparator sets, data sources and timeframes of analysis.
- Appendices 3 and 4 summarise the studies and the regulatory precedents reviewed in section 8, respectively.

2 Common approaches to frontier-shift estimation

2.1 Productivity

Economic production is the transformation of the elements of production (inputs) into a set of outputs. Productivity is then defined as the ratio of outputs to inputs:

$$A = \frac{Y}{f(I)}$$

where:

- A is the productivity of company, and Y is the output of that company;
- I are the inputs used for the production of Y; and
- $f(I)$ is the function that describes the transformation process of production.

Productivity can improve by increasing outputs while the inputs are held constant; decreasing inputs while the outputs stay constant; or a combination of the two.

Companies produce goods and/or services by utilising a number of inputs. Some of these inputs are consumed in the production process (e.g. raw materials), while others remain and can be used in the future (e.g. plant and equipment). The empirical challenge is to aggregate different types of goods and/or services produced and different inputs into a meaningful indicator of the performance of the production process.

In competitive industries, the aggregation of outputs is relatively simple: instead of using physical quantities of discrete outputs, economists commonly use the aggregate *value* of all outputs produced as the numerator of the productivity ratio. This is possible because, in competitive industries, the price of final outputs is generally available and, more importantly, meaningful in an economic sense.

The aggregation of inputs requires estimation of the contribution of each input (e.g. labour, capital and materials) into an overall measure of output. This can be achieved using several estimation techniques. The methodology considered in this report is based on the growth accounting (GA) approach, which relies on the neoclassical production framework. This approach seeks to estimate the rate of productivity change as a 'residual' between the growth rate of output and the growth rate of the combined inputs used in the production process.[21]

2.2 Decomposing changes in productivity

Changes in productivity estimates provide a measure of productivity change ($\Delta\, productivity$), which can be decomposed in the following way:[22]

$$\Delta\, productivity = \Delta\, catch-up\ efficiency \times \Delta\, technology\ (frontier\ shift) \times \Delta\, scale\ efficiency$$

where:

[21] EU KLEMS set out its approach in Timmer, M., O'Mahony, M. and Van Ark, B. (2007), 'EU KLEMS Growth and Productivity Accounts: Overview', November. Available at: http://www.euklems.net/data/overview_07ii.pdf, Section 3.
[22] Multi-factor productivity growth (including TFP growth) is calculated as a residual. As such, it may be driven by technology change as well as other factors, such as scale and catch-up efficiency change. For an overview, see Timmer, O'Mahony and Van Ark (2007), op. cit., Section 3.

- $\Delta\, catch-up\ efficiency$ measures performance changes from one period to the next with reference to a set of comparators and period-specific technology (i.e. it measures the degree to which performance has caught up to best practice);
- $\Delta\, scale\ efficiency$ relates to performance changes due to changes in a company's operational scale;
- $\Delta\, technology$ captures how best practice has changed over the period of analysis.

Separately, some regulators also consider the differential between the input price pressure faced by the sectors and the economy-wide inflation and net this off from $\Delta\, technology$. For example, for the RIIO price controls, the GB energy regulator, Ofgem, determined the combined target by assessing ongoing efficiency using a GA-based TFP approach, and input price inflation using input price forecasts.[23]

In this report, we seek to determine the dynamic efficiency factor that captures the combined effect of $\Delta\, technology$ and the difference between input price inflation of the sectors and economy-wide inflation (here, CPI). Also, approaches that estimate $\Delta\, productivity$ but cannot decompose this into its components may require a suitable adjustment to determine $\Delta\, technology$.

2.3 Direct and indirect comparisons

There are two main approaches to establishing a benchmark rate for the future potential for dynamic efficiency in a regulated sector:[24]

- **direct comparisons**—using data across regulated companies and over time, it is possible to estimate the historical rate of frontier shift that operators have achieved. On the assumption that the past rate of technological progress is a good indicator of the potential future rate, this approach provides the most direct and relevant evidence for establishing a benchmark for the future potential for frontier shift in the sector. An example of this approach would be the dynamic efficiency assessment undertaken in the 2012 pan-European benchmarking study of electricity TSOs[25] that used data on direct comparators (TSOs) over time and Data Envelopment Analysis (DEA)[26] to estimate dynamic efficiency gains over the period of analysis;
- **indirect comparisons—**based on data on other regulated companies or sectors in the economy, it is possible to estimate the historical rate of frontier shift that other regulated companies or sectors have achieved. On the assumption that the past rate of technological progress is a good indicator of the potential future rate, and that the rate of technological progress in these sectors is a good indicator of the rate of technological progress in the regulated sector in question, this approach also provides useful evidence for establishing a benchmark for the future potential for frontier shift. An example

[23] See, for example, Ofgem in RIIO-T1/GD1. Ofgem (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix', December. Available at: https://www.ofgem.gov.uk/sites/default/files/docs/2012/12/5_riiogd1_fp_rpe_dec12_0.pdf.
[24] For a review, see Oxera (2011), 'How can the NMa assess the efficiency of TenneT?', prepared for the NMa, April.
[25] Frontier Economics, Consentec and Sumicsid (2013), 'E3GRID2012 – European TSO Benchmarking Study: A report for European Regulators', July.
[26] 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.

of this approach would be Ofgem's use of growth accounting-based TFP performance of UK sectoral data from EU KLEMS to estimate frontier shift of the UK gas and electricity TSOs in the most recent price control review in 2012.[27]

The assessment of dynamic efficiency presented in this report relies on the use of indirect comparators—this is driven in part by the lack of multiple transmission operators in the Netherlands. Also, our remit was to follow the framework used in the previous method decision, which was based on indirect comparators. The literature review (section 9) does include studies that use direct comparisons of pan-European transmission operators or of multiple TSOs in other jurisdictions.

The use of indirect comparators enables an assessment of the potential for productivity improvements by examining the productivity performance of sectors of the economy with characteristics comparable to the industry in question, based on national accounts data (sourced from national statistical agencies, international organisations or academic studies). To draw robust indirect comparisons, some important methodological decisions need to be made, which typically include:

- choosing the appropriate productivity measure—for example, real unit operating expenditure (RUOE), partial productivity measures, TFP;
- the type and number of external comparators for benchmarking purposes;
- the period over which historical performance will be examined;
- the potential adjustments required to translate productivity estimates into frontier shift.

Our remit is to consider TFP and OPI measures (both were used as the basis of the previous method decision). Below, we review the pros and cons of each, as well as providing an overview of partial productivity measures.

2.4 Total Factor Productivity approach

The GO-based TFP growth measures represent the residual that remains after subtracting the growth rate of labour, capital and intermediate inputs from the growth rate of GO. The equation below illustrates this:

$$gTFP\ (GO) = gGO - w_L x gL - w_k x gK - w_I x gI$$

where:

- gGO represents the rate of change in gross output;
- gL represents the rate of change in labour, weighted by the labour share of GO w_L;
- gK represents the rate of change in capital, weighted by the capital share of GO w_k;
- gI represents the rate of change in intermediate inputs, weighted by the intermediate inputs share of GO w_I.

The major advantage of TFP analysis as used to determine frontier-shift benchmarks is that it relies on composite benchmarks that can be implemented

[27] Ofgem (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix', Final Decision, December.

where there are no direct comparators, or when the available data is of insufficient quality to rely on direct comparisons. For TFP analysis to be valid, the group of comparators must carry out activities similar to those of the company in question.

The TFP approach requires consistent data on inputs, outputs and prices for the sectors of the economy that form the comparator group. Pan-European productivity databases or national statistical agencies can provide this information.

Using such datasets, it is generally possible to derive GO and VA TFP (and OPI) measures. The GO-based TFP growth measures represent the residual after subtracting the weighted growth rates of labour, capital and intermediate inputs from the growth rate of gross output. VA-based TFP growth measures subtract the weighted growth rate of labour and capital from the growth rate of value-added.[28]

We review both GO and VA measures in Appendix 1. The GO-based measures are better suited to reflect an industry's technical change, and can better account for the impact of intermediate inputs. We therefore place greater emphasis on the GO-based measures, which were also used in the analysis underpinning ACM's previous method decision.[29]

In general, TFP measures provide a robust quantification of the 'combined target' under two conditions:

- the input price inflation faced by the comparator set compared with that of the Dutch CPI is negligible; and
- the TFP estimates capture the effects of technological change only—there are no catch-up or scale effects embedded in the estimates.[30]

In both instances, specific adjustments can be considered to make the TFP estimate comparable. In section 8, we use external evidence to assess whether any of these adjustments are required.

Next, we examine the OPI analysis.

2.5 OPI approach

Similar to TFP analysis, the data required to derive OPI growth estimates is relatively straightforward to derive using national accounts data. However, OPI analysis could be argued to rest on a stylised view of economic activity. OPI is related to TFP based on the equation below:[31]

$$\Delta OPI - \Delta CPI = (\Delta IPI - \Delta CPI) - \Delta TFP$$

where:

- ΔOPI measures a change in output price inflation;
- ΔCPI measures change in the consumer price index (CPI), or more generally economy-wide inflation;

[28] The weights are derived using each input's contribution to the total output.
[29] CEPA (2012), op. cit., p. 7.
[30] While catch-up efficiency measures the degree to which performance has caught up to best practice, scale efficiency relates to performance changes due to changes in a company's operational scale.
[31] See for example CEPA (2012), op. cit., p. 22.

- ΔIPI measures input price inflation;
- ΔTFP measures TFP change.

The equation above states that changes in a company's output prices (relative to the CPI) are the result of two factors only: changes in input prices (relative to the CPI), and general productivity growth.[32] In particular, if productivity improves and input prices stay constant, all the cost savings would be passed on immediately to consumers through a decrease in the price of the output produced by the company. Also, if input prices increase, assuming that productivity is stagnant, the company would immediately pass the cost of this increase to the consumer by raising the price of its output.

As such, the relationship makes simplified assumptions about the dynamics of the market in which companies engage,[33] and assumes that production is unaffected by (dis)economies of scale or scope, or possibly other market dynamics. To that end, for the above equation to hold, it must be assumed that companies are operating in a perfectly competitive market.

As noted, OPI analysis was the basis of the previous method decision. This form of analysis is simple to implement as it requires data on output prices from comparable sectors only. Also, following the simplified relationship presented above, OPI is assumed to capture the combined effect of productivity improvements in the sectors and the inflation differential, and has been considered by regulators in other jurisdictions.[34]

Under the assumption that there is no input price pressure ($\Delta IPI = \Delta CPI$), the equation simplifies to:

$$\Delta OPI - \Delta CPI = -\Delta TFP$$

In section 8, we assess whether this assumption can be considered valid for the purposes of our empirical analysis, in which case the OPI and TFP estimates are comparable.

In the following section, we briefly review partial productivity measures for the sake of completeness. We note that they are not in the scope of our assignment, but were considered as part of the previous method decision.[35]

2.6 Partial productivity measures

In the analysis underlying the previous regulatory decision, CEPA considered labour, energy, materials and services (LEMS) and RUOE.[36] According to CEPA (2012), the (LEMS) (cost and productivity) measures provide an estimate of how much labour and intermediate inputs are decreasing for constant capital. CEPA (2012) also notes that the LEMS cost measure can reflect both productivity improvements and the inflation differential.

[32] Under the assumption that $\Delta IPI = \Delta CPI$, rearranging ∆OPI - ∆IPI = -∆TFP gives ∆OPI = -∆TFP + ∆IPI.
[33] For example, regarding the pricing strategy of a firm, its competitive position and market share (market power) and the existence of substitutes.
[34] For example, Ofgem, the GB energy regulator, used the OPI approach to compare estimates for the net impact of input price inflation differential and TFP in RIIO-GD1 and RIIO-T1. See Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July.
[35] CEPA (2012), op. cit.
[36] CEPA (2012), op. cit., section 6.

Such partial productivity measures do not take into account (the contribution of) all inputs used in the production process. Examples of partial productivity measures include:

- LEMS unit costs at constant capital. LEMS cost measures reflect growth in labour costs and intermediate inputs, excluding capital expenditure (CAPEX);
- RUOE estimates. The RUOE measure is calculated by dividing real operating expenditure (OPEX) (i.e. adjusted for inflation) by an output measure and estimating its rate of change over time to determine productivity;[37] and
- labour productivity (VA) at constant capital, or labour and intermediate inputs productivity (GO) at constant capital.[38]

These 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 of a particular input set.[39] Moreover, it may not be appropriate to use partial productivity measures in order to derive productivity targets that apply to the total cost base.

For these reasons, we do not consider the partial productivity measures to be useful in the context of informing the scope for dynamic efficiency, especially where robust estimates using TFP and OPI methods are feasible.

2.7 Conclusion

The analysis presented in this report relies on TFP and OPI measures. Both measures are straightforward to implement and rely on sectoral data that is available from national accounts databases.

TFP and OPI can both be based using GO and VA. GO-based measures are better suited to reflect an industry's technical change, and can better account for the role of intermediate inputs. In addition, GO-based measures were used as part of the previous method decision. We therefore place greater emphasis in this report on the GO-based measures.

In the next section, we discuss the data used in our analysis.

[37] For an example of LEMS and RUOE analysis, see Reckon (2011), 'Productivity and unit cost change in UK regulated network industries and other UK sectors: initial analysis for Network Rail's periodic review', May.
[38] For an example, see Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July, p. 18.
[39] For a detailed review, see discussions in Oxera (2011), op. cit., and OECD (2001), op. cit.

3 Data

For our productivity analysis, we considered multiple data sources. This section gives an overview of the data sources available, and discusses the derivation of the dataset used for the analysis presented in sections 6 and 7. In Appendix 2, an alternative dataset with data sourced from CBS is also used for sensitivity analysis.

3.1 Overview of datasets

To derive an updated dataset covering the largest set of productivity data, we considered three main sources. Table 3.1 summarises each dataset.

Table 3.1 Data sources considered

Source	Description
EU KLEMS database (November 2012 release)	Provides data on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all EU member states
OECD STAN database for structural analysis (ISIC revision 4)	Provides data on annual measures of output, labour input, investment and international trade. STAN is primarily based on tables of member countries' annual national accounts by activity, and estimates any missing details using data from other sources, such as national industrial surveys/censuses
CBS (growth accounting and price index databases)	Data taken from two CBS databases: growth accounting data from 'Groeirekeningen; kerncijfers'; and price index data from 'GDP, production and expenditures; output and income by activity 1969 – 2012'. This latter database contains quarterly and annual data on production, expenditure, income and external economic transactions of the Netherlands

Source: Oxera based on EU KLEMS, OECD and CBS.

In November 2012,[40] EU KLEMS released an updated Dutch productivity dataset based on a new industry classification. Both OECD and CBS provide the latest data using the same revised set of industry-level information. Below, we examine each data source in detail.

3.1.1 EU KLEMS

The latest version of the EU KLEMS dataset,[41] which is based on a new industrial classification (ISIC revision 4, NACE 2), has the following features:

- it contains sufficient data to derive only VA productivity growth measures;
- it can be used to estimate VA-based TFP only since 1988—capital price indices (and thus capital volumes) are not available before that date. It contains VA-related data to derive productivity growth estimates up to 2009.

To derive GO productivity measures, additional information about intermediate input volumes and prices is necessary, which can be found in the OECD STAN dataset.

[40] See EU KLEMS (2009), 'EU KLEMS Growth and Productivity Accounts: Data in the ISIC Rev. 4 industry classification, available at: http://www.euklems.net/. Last accessed: 19 October 2015.
[41] O'Mahony, M. and Timmer, M.P. (2009), 'Output, Input and Productivity Measures at the Industry Level: the EU KLEMS Database', *Economic Journal*, **119**:538, pp. F374–F403.

3.1.2 OECD STAN

The STAN database for industrial analysis[42] includes annual measures of output, labour input and investment using a NACE 2 (ISIC revision 4) industry classification. Primarily based on countries' national accounts, STAN uses data from other sources to estimate any outstanding variables.[43, 44] The raw OECD data extracted to derive GO-based productivity estimates includes:

- intermediate input values (1970–2011);
- intermediate input prices (1988–2011);
- production (GO) values (1970–2011);
- production (GO) prices (1988–2011).

OECD and EU KLEMS data can be combined to derive both VA- and GO-based estimates of TFP and OPI growth starting from 1989.

3.1.3 CBS

In addition to EU KLEMS and OECD, we considered an alternative dataset produced by the Dutch national statistical agency, CBS.[45] The CBS dataset is provided according to the Dutch industry classification (SBI 2008), which corresponds to ISIC revision 4 at two digit levels. CBS has made all data necessary for the estimation of GO-based productivity change available online. The available data is based on the neoclassical model,[46] as with EU KLEMS, and can be combined with price index data[47] to construct a stand-alone dataset. The CBS dataset contains data on all variables to estimate TFP VA and TFP GO up to 2011. However, data is not available prior to 1995, which limits its effectiveness for this study.

3.2 Methodological differences between datasets

To maximise the timeframe of analysis, we considered combining the EU KLEMS and CBS data. However, we identified several discrepancies in the VA data from CBS and EU KLEMS over the period covered by both sources (1995–2007), which indicates that the two sources are not compatible.

Moreover, CBS and EU KLEMS break down the output variables (GO and VA) differently, leading to different values of labour and capital compensation. Thus, for example, although sector-specific VA figures may match, labour and capital values may differ.[48] This is because EU KLEMS calculates capital compensation (CAP) as a residual between labour compensation and VA:

[42] Available in OECD (2013), 'STAN Database for Structural Analysis (ISIC Rev. 4)', available at: http://stats.oecd.org/Index.aspx?DataSetCode=STANI4, last accessed 12 October 2015.
[43] Since some of the data points in STAN are estimated, they may not represent official member country submissions.
[44] For example, industry-specific revision 4 intermediate input estimates before 1987 are based on ISIC Rev.3 version of STAN using a standard conversion key based on two-digit sector detail. However, these estimates are not used because pre-1987 price index data is not available.
[45] For productivity data, see CBS (2015) 'Groeirekeningen; kerncijfers', available at: http://statline.cbs.nl/Statweb/selection/?VW=T&DM=SLNL&PA=81429NED&D1=14,45&D2=a& D3=l&D4=a&HDR=G2,T,G3&STB=G1, last accessed 12 October 2015.
[46] For a review of the GA methodology under neo-classical assumptions, see Timmer, O'Mahony, and Van Ark (2007), op. cit., Section 3.
[47] See CBS (2015), 'GDP, production and expenditures; output and income by activity', available at: http://goo.gl/8PeLBJ, last accessed 12 October 2015.
[48] See EU KLEMS (2012), 'EU KLEMS growth and productivity accounts 2012 release', pp. 3–4.

for the period for which official NACE 2 output and labour data is available, CAP is derived using the standard EU KLEMS approach where CAP equals VA minus labour compensation (LAB).[49]

Differences in the treatment of capital depreciation, and public and private capital, are examples of further methodological differences between the two datasets. In addition, we noted a number of differences in the level of granularity available in the CBS and EU KLEMS datasets.[50] For these reasons, the two datasets were not merged.

EU KLEMS and OECD data does not present major compatibility issues. We have assessed internal consistency by testing the validity of the following identity:

$$GO\ (OECD) = capital\ (EU\ KLEMS) + labour\ (EU\ KLEMS) + intermediate\ inputs\ (OECD)$$

In general, this accounting identity is not violated.[51] For this reason, we conclude that, from a methodological perspective, EU KLEMS and OECD are compatible sources, and combine the two to derive a full dataset over the period 1988–2009.

3.2.4 Conclusion

Our **core dataset** is based on **EU KLEMS and OECD data** covering the period 1988–2009. We recommend the latest version of the EU KLEMS dataset (ISIC revision 4, NACE 2) as it provides two extra years of data to complete the recent business cycle and the recent industry classification (NACE 2) allows for a more accurate mapping of TSO activities (see Section 4). In addition, data from further in the past could be argued to be prone to more measurement errors than more recent data (see Section 5 for additional discussion). Hence, data quality played a role in the choice of the dataset.

An **alternative dataset** using **CBS data** is used as a sensitivity over the period 1995–2011. CBS is considered on a stand-alone basis[52] due to methodological differences with EU KLEMS in deriving input splits from aggregate value and because it covers a shorter timeframe.

In the next section, we discuss comparator sector selection based on the sectoral classification of the datasets.

[49] EU KLEMS (2012), 'EU KLEMS growth and productivity accounts 2012 release', pp. 3–4.
[50] For instance, EU-KLEMS reports sectors 20-21 (Chemicals and chemical products) jointly, while CBS reports them separately (20 Manufacture of chemicals and 21 Manufacture of pharmaceuticals).
[51] We observed minor discrepancies before 1988; however, our core dataset covers the period between 1988 and 2009 only.
[52] Although we attempted to derive a combined dataset using OECD, EU KLEMS and CBS data, a number of discrepancies prevented us from matching CBS with EU KLEMS data. In particular, CBS capital (labour) figures tend to be systematically higher (lower) than EU KLEMS after 1995 due to different estimation methods.

4 Comparator selection

We selected the comparator set based on the following considerations.

- **Revised industry classification**. Since CEPA (2012), EU KLEMS has introduced a new industry classification.[53] In light of this methodology change, the comparator selection process must necessarily differ from past work. The new industry classification presents some revised industry definitions that improve the representativeness of the comparator set.

- **Regulatory precedents and other studies.** The industry selection in CEPA (2012) is based on Ofgem's RIIO-GD1/T1 and DPCR5 price reviews.[54] To provide a robust framework for identifying relevant industries, we have used international studies (one of which includes the Dutch electricity TSO).[55, 56] We believe that comparator industries can be deemed relevant if it is possible to identify TSO functions with common characteristics. Such studies provide more information about the detailed processes and activities carried out by the TSO.

The comparator set resulting from our review is used to derive our core productivity estimates in sections 6 and 7. Next, we explain in detail the impact of the industry classification change on comparator selection.

4.1 Change in industry classification

With the new industry classification introduced by EU KLEMS in 2012, the comparator analysis no longer matches that used in CEPA (2012).

Nevertheless, several of the ensuing classification changes allow for a more accurate mapping of TSO activities. For example, 'machinery 'not elsewhere classified' (n.e.c.) (29) is no longer available, while EU KLEMS introduced 'other manufacturing; repair and installation of machinery and equipment' (33). This is an improvement over 'machinery n.e.c.' in that it is less generic. The sector used in revision 3 represented a broader range of potentially irrelevant activities, such as manufacture of machinery and equipment for general purposes and domestic appliances.[57]

In addition to changes in definition, NACE 2 contains a set of industries that were previously not available in EU KLEMS' revision 3. These industries, which fall under 'Information and communications', are:

- publishing, audiovisual and broadcasting activities (56–58);
- telecommunications (61);
- IT and other information services (62–63).

These activities consist of multiple NACE 1 industries belonging to more granular ('two-digit') sectors. Industries 61 and 62–63 are potentially relevant to

[53] See EU KLEMS (2009), 'EU KLEMS Growth and Productivity Accounts: Data in the ISIC Rev. 4 industry classification', http://www.euklems.net/, last accessed 19 October 2015.
[54] Ofgem's selection was in turn informed by Reckon (2007), 'Gas distribution price control review: Update of analysis of productivity improvement trends', September.
[55] Sumicsid (2009), 'e3 GRID Final Results, Final report', version 1.2, March.
[56] Sumicsid (2014), 'Benchmarking European gas transmission system operators: a feasibility study', December.
[57] See United Nations Statistics Division (2015), 'Detailed structure and explanatory notes. ISIC Rev. 4 code 33', http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=17&Co=29&Lg=1, last accessed 29 October 2015.

our comparator analysis and can be used to represent several common and system operations carried out by TSOs.

Another important addition to the revision 4 dataset is ‘professional, scientific, technical, administrative and support service activities’ (M–N),[58] which allows us to capture important TSO activities such as market facilitation, system operations and grid planning.

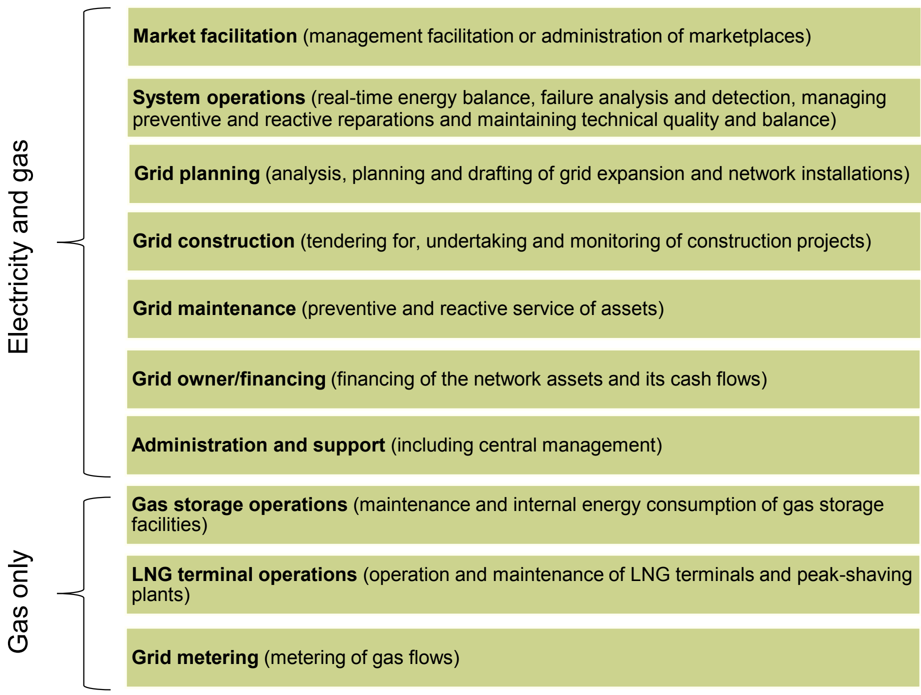
In terms of alternative datasets, OECD and CBS industry-level data broadly aligns with that covered in EU KLEMS. However, CBS data occasionally presents a slightly different level of aggregation from that in the core (OECD and EU KLEMS) dataset.[59]

The next section presents the framework we developed for allocating sectors of the economy to relevant TSO activities.

4.2 A framework for identifying relevant sectors of the economy

Our set of comparators aims to reflect the activities and operations that represent as closely as possible those of TSOs. The activities carried out by electricity and gas TSOs in Europe are listed in Figure 4.1. The list is informed by the work undertaken in the e^3-Grid Project[60] (which included the Dutch electricity TSO) and a pan-European gas transmission feasibility study.[61]

Figure 4.1 TSO functions (gas and electricity)



Source: Oxera based on Sumicsid (2009), ‘e3 GRID Final Results, Final report’, version 1.2. Project no: 340, p. 22, and Sumicsid (2014), ‘Benchmarking European gas transmission system operators: a feasibility study’, December.

[58] Although industries 29 and 71–74 were not part of CEPA’s core comparator set, they were part of the unweighted and weighted averages for a broader set of market sectors.
[59] For example, ‘electricity and gas supply’ and ‘water supply and waste management’ are presented separately in the CBS dataset.
[60] Sumicsid (2009), ‘e3 GRID Final Results, Final report’, version 1.2. Project no: 340. Release date: 9 March 2009.
[61] Sumicsid (2014), ‘Benchmarking European gas transmission system operators: a feasibility study’, December.

The Sumicsid (2009) study note that the first three activities (market facilitation, system operations and grid planning) are 'strategic functions with a long-term impact on system performance',[62] while grid construction and maintenance relate to functions with a shorter-term impact. Grid owner/financing activities ensure the long-term minimal cost financing of the network assets and its cash flows.[63] Administration and support (including central management) relate to activities such as human resources, financing, legal services, communications, strategy, auditing, IT and general management. These activities can be considered to be common to electricity and gas TSOs.

In addition, the gas transmission feasibility study states that gas TSOs are characterised by three further functions:

- grid metering—gas TSOs also carry out metering activities for gas flows in parts of the pipelines, stations and interconnections to other grids, which involve IT and administrative activities;
- grid storage operations, which involve maintenance activities and internal energy consumption;
- liquefied natural gas (LNG) terminal operations.

We understand that, in the Netherlands, gas storage and LNG are activities carried out not by GTS (the TSO), but rather by Gasunie (its parent company). Table 4.1 shows that none of the industries selected relates exclusively to these two activities. With these eight 'core' functions in mind, we developed a set of comparator industries for the electricity and gas TSOs.

4.3 Candidate industries

Table 4.1 below presents the candidate industries for the TSOs.

[62] Sumicsid (2009), 'e3 GRID Final Results, Final report', version 1.2. Project no: 340, p. 20.
[63] Sumicsid (2009), 'e3 GRID Final Results, Final report', version 1.2. Project no: 340, pp. 24–25.

Table 4.1 Candidate industries for TSOs

Industry	Relevant activities
IT and other information services	Market facilitation activities System operations Grid metering
Professional, scientific, technical, administrative and support service activities	Market facilitation activities System operations Grid planning Grid finance Administration and support (including central management) Grid metering
Telecommunications	Market facilitation activities System operations Grid maintenance Grid construction
Construction[1]	Grid construction Grid maintenance
Electricity, gas and water supply[1]	Grid construction Grid maintenance
Transportation and storage[1]	Grid maintenance
Other manufacturing; repair and installation of machinery and equipment (manufacturing)	Grid construction Grid maintenance
Financial and insurance activities	Grid finance Administration and support (including central management)

Note: [1] 'Construction', 'Electricity, gas and water supply', and 'Transportation and storage' are relevant to LNG terminal operations. 'Transportation and storage' is relevant to gas storage activities. However, because these two activities are not carried out by GTS, but by Gasunie (its parent company), we do not report them in the table.

Source: Oxera analysis.

Each industry is examined in more detailed next.

IT and other information services

As discussed in the previous section, 'IT and other information services' were not available under the NACE 1 classification. This industry aims to capture activities in the field of IT, including the creation of software and communication technologies, data processing, and other professional and technical computer-related activities.

IT and other information services can be used to represent monitoring and enforcement activities relating to electricity exchange, market research and compliance with public service obligations, all of which are carried out through IT and represent market facilitation activities.

In addition, all system operation activities relating to energy balance, congestion management, and monitoring of performance for failure detection require IT systems, which therefore represent an appropriate comparator. This sector also captures grid-metering activities that are specific to gas transmission.

Professional, scientific, technical, administrative and support service activities

This industry represents a wide range of activities, including legal and accounting (i.e. grid finance and planning), scientific research and development (i.e. market facilitation and system operations), and office support (i.e. administration and support). For this reason, it can be used as an important comparator for all activities performed by TSOs, with the exception of grid maintenance and construction.

Telecommunications

Market facilitation activities involve substantial information flows—for example, with regard to the clearing, trading and management of financial instruments for the electricity market and the final settlement of delivery.[64] Moreover, because system operations are important for coordination purposes (for example, with neighbouring grids, operations management, and contractors acting on the live grid), the telecommunications industry is particularly relevant.

Telecommunications also plays a key role in relation to grid maintenance activities and, to a lesser extent, grid construction. In both cases real-time data flows are relevant to the coordination of a geographically dispersed workforce and getting the relevant network data into the hand of the employee on the ground.

More generally, many of the productivity improvements in Europe over the last 20–30 years arose as IT and telecommunications advances have been deployed to allow for delayering and broader spans of control. This has potentially resulted in IT and communications forming a larger share of the cost base.[65,66]

Construction

Construction covers several relevant activities, such as the connection of new pipes and the construction of substations. In Ofgem (2012), it was used as the main comparator to estimate TFP growth for CAPEX and replacement expenditure.[67] The use of 'construction' as a suitable comparator for replacement expenditure targets indicates that it is also appropriate to capture the productivity growth of grid maintenance activities.

Financial and insurance activities

TSOs carry out finance-related activities, including 'debt financing, floating bonds, equity management, general and centralized procurement policies,

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[64] See Sumicsid (2009), 'e3 GRID Final Results, Final report', version 1.2. Project no: 340. March, p. 22.

[65] For example, in Ofgem's final proposal for the UK electricity transmission operator, National Grid Electricity Transmission (NGET), the regulator determined the following IT and telecommunications-related costs: £108m of 'non-operational' IT CAPEX to provide (inter alia) new Transmission Front Office (TFO) and Strategic Asset Management (SAM) systems; £132m of operational IT and telecoms 'closely associated indirect OPEX'; about £100m of business support IT and telecoms costs. Separately, Ofgem allowed NGET (SO) £230m of internal CAPEX and £600m of internal OPEX; the majority of the CAPEX and some of the OPEX is likely to be related to IT and communications. For additional details, see Ofgem (2012), 'RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Grid Gas', December.

[66] The investments in IT and Telecommunications are potentially linked to efficiency savings. For example, NGET argues that the TFO systems are fundamental to maintaining the safety and reliability of the electricity transmission system to the benefit of customers, as they provide a suite of replacement systems to integrate: the central asset register (including geo-spatial asset mapping); capital and maintenance work planning and scheduling; and the mobile applications, drawing and document management required by the geographically distributed workforce. The overall cost of the investment allowed by Ofgem was £47.6m and NGET offered incremental operating efficiency benefits of £5m per annum. Similarly, NGET notes that the SAM system will enable higher reliability, environmental and safety outputs than would otherwise be the case. The SAM system provides enhanced asset management capabilities to facilitate the move to risk-based asset maintenance and replacement strategies. It also allows NGET to exploit the new condition-monitoring capabilities being built into assets. The overall cost of the investment allowed by Ofgem was £26.5m, and NGET offered incremental operating efficiencies of £3.8m per annum, as well providing a path to future savings on maintenance and replacement expenditure. For additional details on the benefits of IT and telecommunications-related investments, see National Grid (2011), 'Detailed plan: National Grid Electricity Transmission', July.

[67] Ofgem (2012), 'RIIO-T1/GD1: Real price effects and ongoing efficiency appendix', December, p. 15.

leasing arrangements for grid and non-grid assets, management of receivables and adequate provision for liabilities (suppliers, pensions, etc)'.[68] These can be captured using 'financial and insurance activities', which represent financial services (including insurance and pension funding) and auxiliary activities.

Repair and installation of machinery and equipment (manufacturing)
'Repair and installation of machinery and equipment (manufacturing)' covers: i) repair of fabricated metal products, machinery and equipment (331); and ii) installation of industrial machinery and equipment (332). The presence of repair activities makes this industry relevant to grid maintenance. Moreover, installation activities are relevant to grid construction activities.

Electricity, gas and water supply

'Electricity, gas and water supply' contains the following industries: i) electricity, gas, steam and air conditioning supply, water collection, treatment and supply; ii) sewerage; iii) waste collection, treatment and disposal activities; materials recovery; and iv) remediation activities and other waste management services. We note that some of the activities are related to the water sector, of which only a small portion is subject to regulation in the Netherlands. We consider the industries listed under the sector to reflect activities undertaken by the TSOs (especially grid construction, grid maintenance, but also all their other functions).

By construction, the electricity, gas and water sector includes gas and electricity transmission activities. Therefore, using this sector as a benchmark might (i) introduce a degree of *endogeneity* in the benchmarking process, since the benchmarks would be partially informed by the past performance of the companies under assessment; and (ii) capture the impact of catch-up post-privatisation.[69] Nevertheless, there are three counterarguments to excluding this sector:

- gas and electricity transmission activities form only a small part of the electricity, gas and water sector: in the UK, the costs for electricity transmission are approximately 4% of the total electricity bill, and for gas transmission approximately 2% of the total gas bill.[70] In the Netherlands, the same split is not available, but the component of the final energy bill to 'small and medium-sized businesses' that relates to both transmission and distribution is 18% of the total bill.[71] As such, the past performance of gas and electricity transmission is likely to have relatively limited impact in the aggregate electricity, gas and water sector TFP;
- the past performance of the sub-sectors under assessment provides valuable information about the potential for future productivity gains, especially when it is combined with information from other comparators;
- the electricity, gas and water sector has been used in previous cases by other regulators and consultants.[72]

[68] Sumicsid (2009), op. cit., p. 25.
[69] In the Netherlands, the deregulation process in the utilities sector started in 1989. See Hulsink, W. and Schenk, H. (1998), 'Privatisation and deregulation in the Netherlands', in D. Parker (Ed.), *Privatisation in the European Union: Theory and Policy Perspectives*, pp. 242–57, Routledge.
[70] http://www.uswitch.com/gas-electricity/guides/utility-bills/
[71] Frontier Economics (2011), 'International comparison of electricity and gas prices for commerce and industry', final report on a study prepared for CREG, November.
[72] For example, it is our understanding that First Economics used the electricity, gas and water sector in its initial report for Water UK. See First Economics (2011), 'Frontier Shift: An Update', April.

We also examine the need to adjust the TFP growth estimated from the comparator group for catch-up effects using external evidence in section 8.

Given the above, the impact of endogeneity is likely to be limited (and catch-up effects are considered in section 8). We consider that endogeneity cannot counterbalance the fact that the activities undertaken by the energy and water production and distribution sub-sectors are potentially the most comparable with activities in the energy transmission sector.

Transportation and storage

Transportation and storage (H) includes the provision of passenger or freight transport by rail, pipeline, road, water or air and associated activities. The renting of transport equipment is included. The last two sectors can also be used to capture LNG terminal operations that are specific to gas TSOs. We note that, compared with transportation and storage (49–52), this industry contains postal and courier activities. Although these activities are not directly relevant, it was not possible to obtain GO and intermediate input price data for sector 49–52 from OECD. We therefore select the more comprehensive industry definition.

Table 4.2 presents our proposed comparator set for the core dataset.

Table 4.2 Oxera's comparator set

Sector
Telecommunications
IT and other information services
Professional, scientific, technical, administrative and support service activities
Construction
Financial and insurance activities
Transportation and storage
Other manufacturing; repair and installation of machinery and equipment
Electricity, gas and water supply

Source: Oxera analysis.

4.4 Comparison with the CEPA (2012) comparator set

As noted above, in this report we provide a sensitivity using the CEPA (2012) comparator set,[73] as detailed in the table below.

Table 4.3 CEPA (2012) comparator set

Sector
Manufacturing of chemicals and chemical products
Manufacture of transport equipment
Construction
Sale, maintenance & repair of motor vehicles/ motorcycles; retail sale of fuel
Transport and storage
Financial intermediation

Source: CEPA (2012), p. 78.

Below, we compare CEPA's comparator set with ours:

[73] Subject to limitations due to changes in industry definitions.

- ‘manufacture of chemicals and chemical products’ is a more appropriate comparator for gas transmission than for electricity transmission.[74] We do not consider it suitable to include this in the core comparator set, which is used to derive estimates applicable to both electricity and gas TSOs. However, in Appendix 5, we consider the impact of its inclusion, where we assess the sensitivity of the TFP and OPI estimates to gas- and electricity-specific industries;
- ‘manufacture of transport equipment’ comprises a large number of industries that are not relevant to electricity and gas TSOs.[75] It is not clear why these industries present characteristics that are comparable to the TSOs, so we excluded them;
- ‘construction’ is retained in the core set and is considered highly relevant to construction and maintenance activities;
- ‘sale, maintenance & repair of motor vehicles/ motorcycles; retail sale of fuel’ is unlikely to be similar to activities undertaken by TSOs. Its analogous revision 4 industry, ‘wholesale and retail trade and repair of motor vehicles and motorcycles’, similarly captures activities relating to motor vehicles and motorcycles and was not deemed relevant;
- ‘transport and storage’ is suitable for assessing grid maintenance and gas-only activities;
- we used the equivalent of ‘financial intermediation’ in NACE 2 (i.e. financial and insurance activities) to capture grid finance and administration support activities.

4.5 Aggregating sectoral productivity estimates to an overall composite measure

In this report, we estimate OPI and TFP measures at the sectoral level using our preferred comparator set. Such measures need to be aggregated to derive a composite estimate that is reflective of the activities carried out by the TSOs. In the previous method decision, selected industry productivity estimates were aggregated using unweighted averages. In this report, we follow the same approach.

In the next section, we identify the appropriate timeframe over which to undertake the analysis.

[74] Oxera (2012), ‘Review of Ofgem’s RIIO/GD1 initial proposals on ongoing efficiency’, September.
[75] For example, building of ships and boats, manufacture of railway locomotives and rolling stock, manufacture of air spacecraft and related machinery, manufacture of military fighting vehicles. United Nations (2015), ‘Detailed structure and explanatory notes, ISIC Rev. 4 code 30’, http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=30, last accessed 29 October 2015.

5 Selecting the appropriate period for the analysis

In this section we identify the appropriate number of business cycles and timeframe for the TFP and OPI analysis. To this end, we:

- reviewed regulatory precedents from the Dutch energy sector relating to this issue, and common practice in other jurisdictions and sectors; and
- examined data from the Dutch economy and sectors that are comparable to energy and gas transmission to identify the optimal period of analysis. The data analysis involved identifying atypical fluctuations in economic growth, structural breaks in productivity data, and business-cycle periods.

5.1 Regulatory precedents

5.1.1 Dutch energy sector

The most recent regulatory precedent in the Dutch energy sector was based on ‘four business cycles’:

> with 4 business cycles, the output price measure estimate on which the method decision for the frontier shift is based is 0.0%.[76] (Oxera translation)

However, CEPA (2012) advised on the use of two business cycle, of which the second cycle happened to be incomplete.[77] CEPA (2012) also presented results using data over the longest measurement period covering two complete and two incomplete business cycles. In addition to CEPA (2012), we review three other important regulatory precedents in the Dutch energy sector, which we use to inform our view for the appropriate timeframe for analysis.

Analysis for the regulatory period 2014–16: CEPA (2012)

ACM’s final decision was based on the longest measurement period used for OPI analysis (1978–2007). CEPA’s core OPI analysis uses two business cycles, with data over the period 1989 and 2007. Because CEPA could not assess the latest business cycle in full, its analysis was limited to one complete and one incomplete business cycle.

Moreover, CEPA (2012) presented the OPI analysis results using the longest measurement period, over 1978–2007; however, the TFP estimates were presented over 1980–2007.[78] Over the latter period, the analysis covers only two complete cycles, as the first and last growth cycles were incomplete (the first started in 1978, while the most recent one did not end in 2007).[79] As such, the TFP analysis was based on two complete business cycles and two incomplete

[76] The original Dutch version states: ‘met 4 business cycles komt de maatstaf outputprijzen waarop het methodebesluit zich voor de frontier shift baseert, uit op 0,0%’. ACM (2015), ‘Herstel dynamische efficiëntie in methodebesluit GTS 2014-2016’, May.
[77] In its method decision for GTS, the ACM set the frontier-shift target at 1.3% based on a midpoint between 0.5% (the growth in OPI relative to CPI over two business cycles) and 2.1% (the average of estimates from academic studies). After GTS appealed the ACM’s decision, the frontier-shift target was revised to 1.1%. The ACM noted that this revision reflected the change in the timeframe used for the core OPI results. Sources: ACM (2013), ‘Methodebesluit GTS 2014-2016’, September; GTS (2013), ‘Zienswijze GTS op ontwerp-methodebesluit GTS 2014-2016’, June.
[78] CEPA (2012), ‘Ongoing efficiency in new method decisions for Dutch electricity and gas network operators’, November. http://www.cepa.co.uk/corelibs/download.class.php?source=PB&fileName=sysimgdocs/docs/NMa-Ongoing-Efficiency-2012-_pb89_1.pdf&file=NMa%20Ongoing%20Efficiency%20(2012).pdf.
[79] The reason for starting from 1980 instead of 1978 (given in CEPA (2012), op. cit., p. 42) relates to the availability of labour services volume indices; 2007 was the most recent year with data availability from this particular dataset.

business cycles, while the OPI analysis was based on three complete business cycles and one incomplete business cycle.

Analysis for the regulatory period 2011–13: Reckon (2008) and Reckon (2011)

In 2008, Reckon prepared a report that informed the regulatory decision over the period 2011–13.[80] It used the timeframe 1979–2004 (or 2005, depending on data availability) since the EU KLEMS dataset contained the relevant data for the Netherlands over this period—in effect, the longest measurement period available. Reckon stated that:

> other things being equal, more recent data should carry more weight, as they are less vulnerable to the criticism that there have been structural changes in the economy and the data sources are clearer and appear more robust'[81]

Reckon (2008) did not explicitly examine business cycles in the Netherlands, but reviewed an academic paper using US data over the period 1954–91[82] and concluded that the effect of fluctuations in economic output was likely to be 'modest in magnitude (relative to the inaccuracies inherent in the measurement of productivity)'.[83] In addition, Reckon stated that regulators must take into account the impact of using different analysis periods if using different periods for averaging gives different results.[84]

Although not based on the same dataset, using the evidence in CEPA (2012), it is possible to infer that Reckon (2008) implicitly considered two complete business cycles (1985–89 and 1989–98) and two incomplete ones (the first one should have included 1978 and the last one should have included data from 2005–06 onwards).[85]

In 2011, Reckon examined adjustment factors to OPEX and total costs.[86] To this end, it considered several empirical estimates.[87] We note that, for OPI and unit cost analysis using EU KLEMS data presented in the report, the impact of business cycles was not considered.

Analysis for the regulatory period 2007–10: Europe Economics (2006)

In its 2006 report,[88] Europe Economics produced a productivity benchmark for TenneT based on TFP growth in the Netherlands relative to the economy as a whole. To derive the productivity target, Europe Economics calculated the difference between TenneT's potential outperformance range and economy-wide productivity growth. For the latter, it considered four analysis periods: 1980–90, 1990–95, 1995–2000 and 2000–04.[89] The final economy-wide

[80] Reckon (2008), 'The productivity growth of GTS', July, https://www.acm.nl/nl/download/bijlage/?id=8515.
[81] Ibid, July, p. 18.
[82] Reckon's source was Cooley, T.F. and Prescott E.C. (1995), 'Economic Growth and Business Cycles', pp. 1–38 in T.F. Cooley (ed.), *Frontiers of Business Cycle Research*, Princeton University Press.
[83] Reckon (2008), op. cit., July, p. 18.
[84] Ibid., p. 18.
[85] In Reckon (2008), the core analysis is based on measures of labour costs relative to CPI, assessed over the period 1979–2004 (or 2005).
[86] Reckon (2011), 'Productivity growth of GTS', March, https://www.acm.nl/nl/download/bijlage/?id=6975.
[87] Using the EU KLEMS dataset, Reckon conducted OPI analysis for 30 sectors of the economy over the period 1970–2007. The same timeframe and number of sectors were considered for a unit cost analysis of labour and intermediate costs. In addition, Reckon used an academic paper which presented total cost data over the period 1996–2004, and unit operating cost measures for gas transportation companies in the Netherlands, USA, UK and Australia. In this instance, various timeframes of analysis were considered, spanning between 4 and 18 years.
[88] Europe Economics (2006), 'Research into productivity growth in electricity transmission and other sectors', March.
[89] These periods were not based on business cycles but simply represented decades or five-year periods within decades.

productivity growth estimate (0.5% per annum) was based on the three most recent periods (1990–2004), which were deemed more relevant.[90] Using the evidence in CEPA (2012), it is possible to infer that preferred period of analysis in Europe Economics (2006) considered two incomplete business cycles only.

5.1.2 Precedents from other jurisdictions and sectors

Other economic studies and method decision reports could also provide some useful insights into the appropriate number of business cycles for TFP and OPI analysis. To that end, we used the regulatory precedents[91] reported in Reckon (2008)[92] and CEPA (2012).[93] In addition, we included Oxera's studies examining the issue. Table 5.1 below gives an overview of these studies.[94]

[90] 'The final estimate was derived […] assuming underlying productivity growth in the Netherlands of approximately 0.5% per annum (slightly lower than the 1990s figure but slightly above the level for 2000 – 04)'. Europe Economics (2006), op. cit., p. 43.
[91] We do not include a detailed review of reports that do not present a clear rationale for selecting the analysis period. We also exclude Agrell and Bogetoft (2006) since Sumicsid's 2009 report represents an updated analysis. Agrell, P.J. and Bogetoft, P. (2006), 'ECOM+ Results 2005, Final report 2006-06-01, SUMICSID AB'.
[92] Reckon (2008), op. cit., table 9, 'Recent reports submitted to Western European Utility regulators'.
[93] CEPA (2012), op. cit., table 6.8, 'Productivity/cost measure growth estimates based on other studies'.
[94] This is not an extensive review, but is intended to be indicative.

Table 5.1 Rationale for selecting the analysis period

Country	Sector
UK	**Energy distribution**
CEPA (2003) for Ofgem	CEPA considered four time periods for the estimation of economy-wide TFP growth. The longest timeframe possible was 1974–99. CEPA decided to 'focus on the trend growth rate over the latest *whole* business cycle' (emphasis added).[1]
Oxera (2013) for ENW Ltd	Oxera noted that TFP growth comparisons 'are made over a *complete* business cycle to avoid misrepresenting the impact of recessionary or growth periods' (emphasis added).[2] Oxera examined productivity growth and concluded that there are potentially two business cycles between 1970 and 1981, but that there is significant volatility before 1980. Two other business cycles were identified (1982–91 and 1992–2009).
UK	**Gas distribution**
Europe Economics (2007) for Ofgem	Europe Economics' productivity dataset covered the period 1950–99. In choosing the analysis period, Europe Economics aimed to 'balance the need for a long time series of data to get an underlying productivity improvement against fundamental changes in the trend'.[3] Moreover, it noted that the privatisation of network industries (in the comparator set) in the late 1980s and early 1990s could have had an impact on TFP trends.
Reckon (2007) for Ofgem	Reckon's[4] starting year (1973) was based on Europe Economics (2007). The analysis was extended to 2004 using an alternative dataset.
First Economics (2011) for Northern Gas	Although First Economics noted difficulties with approaches that seek to extrapolate from past data, a much greater weight was given to the most recent business cycle (i.e. 1990–2007). It recognised that Ofgem's precedent was based on a longer time period.[5]
UK	**Water**
NERA (2004) for Water UK	'Baseline' industry TFP growth is based on three existing studies covering around ten years (1990–2000). Economy-wide TFP growth is assessed over the long-run estimates because short-run estimates can be influenced by the economic cycle. These estimates are however taken from after the oil shocks in the 1970s because of possible structural changes in the economy.[6]
UK	**Rail**
Oxera and LEK (2005) for the Office of Rail Regulation (now the Office of Rail and Road)	The report advises the focus on one full business cycle: 'in most productivity studies, performance over a complete cycle is examined'.[7]
Oxera (2008) for the Office of Rail Regulation	Oxera noted that TFP growth comparisons are generally made over *complete* business cycles to avoid bias from above- or below-trend growth. Moreover, Oxera suggested that any frontier-shift benchmark needs to be assessed over a sufficiently long period to mitigate the impact of atypical performance.[8] On assessing the time profile of real VA growth, Oxera concluded that two business cycles (over 1981–2002 or 2004) were sufficient to average out any atypical performance. As a sensitivity, TFP growth was also assessed: a) over the full available dataset; and b) over a shorter (1990–2004) period.
Northern Ireland	**Water and wastewater**
First Economics (2012) for the Utility Regulator	The preferred period of analysis was considered to be 1990–2007, although data was available from the 1970s: 'we [First Economics] have a strong preference for using up-to-date information. It is not at all clear to us how data on productivity growth from the 1970s and, to some extent, the 1980s can act as a reliable indicator of what might be expected of companies in the period 2012/13 to 2014/15. [...] we are much more confident in using data from the most recent business cycle (i.e. 1990 to 2007) in such an exercise'.[9]
Australia	**Gas distribution**

Meyrick and Associates (2007) for three companies	To establish trends in aggregate industry-level productivity growth, 11 years of data (1996–2006) were considered *adequate*.[10]
Economic Insights (2009) for three companies	The authors note that, to calculate trend rates of aggregate industry and 'non-exempt' productivity growth, they use 13 years of data (1996–2008) (12 years, after one year was left out owing to data issues).[11]
Australia	**Electricity and gas**
Australian Energy Market Commission (AEMC) (2011) method report	In 2011, the AEMC reviewed the use of a TFP methodology in determining regulated prices and revenues for electricity and gas. It set four necessary conditions for conducting TFP analysis, covering the availability, robustness and consistency of TFP trends over time and across service providers. AEMC concluded that eight years of robust and consistent data were sufficient to derive TFP estimates: 'we [AEMC] are of the view that at least 8 years of robust and consistent data will be required to establish a TFP growth rate that could be used in a TFP methodology for price and revenue determinations'.[1]2
Finland	**Electricity distribution**
HSEBA (2007) for Finnish electricity DNOs	HSEBA had data over the period 1999–2002 only. For this reason, it noted that calculating a general efficiency target based on this data would involve uncertainty due to the short review period.[13]

Notes/Sources: [1] 'TFP figures will be biased upwards in boom periods and downwards during recessions. […] There are two possible methods for overcoming this problem. The first, and most widely used in empirical studies, is to ensure that the period examined covers a whole number of *full* business cycles' (emphasis added) (CEPA (2003), 'Productivity improvements in distribution network operators', November. pp. 12–13). [2] Oxera (2013), 'The potential for frontier shift in electricity distribution', June. [3] Europe Economics (2007), 'Top down benchmarking of UK gas distribution network operators. A Report by Europe Economics to Ofgem', April. [4] Reckon (2007), 'Gas distribution price control review: update of analysis of productivity improvement trends', September. [5] First Economics (2011), 'First Economics report on productivity. A report prepared for Northern Gas Networks', August. [6] NERA (2004), 'Estimating OPEX and CAPEX efficiency. A Final Report for Water UK', July. [7] LEK and Oxera (2005) Assessing Network Rail's scope for efficiency gains over CP4 and beyond: a preliminary study', December. [8] 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. [9] First Economics (2012), 'The Rate of Frontier Shift Affecting Water Industry Costs', December. [10] Lawrence, D., Meyrick and Associates (2007), 'The Total Factor Productivity Performance of Victoria's Gas Distribution Industry*:* A report prepared for Envestra Victoria', Multinet and SP AusNet, March. [11] Economic Insights (2012), 'The Total Factor Productivity Performance of Victoria's Gas Distribution Industry: A report prepared for Envestra Victoria, Multinet and SP AusNet', March. [12] Australian Energy Market Commission (2011), 'Review into the use of total factor productivity for the determination of prices and revenues', June. [13] EMV (2007), 'Methods for determining the return on electricity distribution network operations during the regulatory period starting on 1 January 2008 and ending on 31 December 2011'.

The precedents cover a number of jurisdictions (UK or Great Britain, Northern Ireland, Australia and Finland) and sectors (energy distribution and transmission, water and wastewater, rail). Our review shows that the following considerations are important for determining the appropriate analysis period.

- The main rationale is to cover *complete* business cycles, not maximise the number of business cycles. For example, Oxera's (2013) advice to Electricity North West concluded that focusing on incomplete cycles might lead to misrepresenting the impact of recessionary or growth periods. Oxera (2008) for the Office of Rail Regulation (which followed another report by Oxera and LEK in 2005) took a similar stance, concluding that covering incomplete business cycles might introduce bias in the productivity growth estimates.
- Older data may be less informative to determine the scope for future productivity growth. For example, First Economics (2011) for Northern Gas placed emphasis on the most recent business cycle, despite having a larger timeframe available. First Economics (2012) for the Utility Regulator stated that productivity growth from the 1970s and, partly, the 1980s was unlikely to be a reliable indicator for future developments.
- In some instances, earlier data should be discarded if there is evidence of structural breaks or atypical fluctuations that introduce bias in productivity estimates. For example, the frontier-shift estimation in water in NERA (2004) does not consider the post-1970s period because of possible structural changes in the economy due to oil shocks. Europe Economics (2007) for Ofgem noted that the privatisation of network industries (in the comparator set) in the late 1980s and early 1990s could have had an impact on TFP trend estimates.[95]
- A very short timeframe (in particular covering *one incomplete* business cycle) may not be appropriate. AEMC (2011) suggested that a minimum of eight years of robust and consistent data is sufficient to derive TFP estimates.

In summary, this review indicates that: complete business cycles should be considered; economic and productivity growth should present no evidence of structural breaks or atypical fluctuations during the period of analysis; and various numbers of business cycles have been used, although one or two appear to be the most common number of cycles used.

The next section examines whether Dutch historical economic growth shows atypical fluctuations, and whether these can have an impact on business-cycle selection.

5.2 Atypical periods of economic growth

When forecasting economic indicators, an important question is how to identify and incorporate periods of atypical economic performance (e.g. during a financial crisis or a sharp economic contraction). If the objective of the analysis is to generate short-term forecasts of economic indicators during such periods, the data must contain periods of similar (atypical) behaviour. However, the purpose of productivity analysis is to arrive at an estimate of medium-term (i.e. over the upcoming regulatory period) frontier shift under stable economic conditions.

[95] In the Netherlands, the deregulation process in the utilities sector started in 1989. See Hulsink, W. and Schenk, H. (1998), 'Privatisation and deregulation in the Netherlands', in D. Parker (Ed.), *Privatisation in the European Union: Theory and Policy Perspectives*, pp. 242–57, Routledge.

Therefore, atypical economic performance needs to be identified in order to determine whether these periods should be included in the analysis.

On our core dataset covering period 1989 to 2009, we note the following.[96]

- **2009–10**: in Europe, 2008 was marked as the start of the most recent financial crisis, causing one the largest (and, in many countries, *the* largest) post-war recessions. In the Netherlands, the recession has had a visible negative impact on the economy since 2008, but the magnitude of contraction became apparent in 2009: in that year, economy-wide (gross) output dropped by 3.8%, while the average decrease in GO for the core comparator set[97] was 4.4%. The scale of this economic contraction alone would be sufficient to qualify it as atypical, but the subsequent slow growth reinforces the view that this period is atypical, and that it should therefore be excluded from the analysis.
- Two other periods of contraction in the Dutch economy. The first was in **1992**, caused by the European Exchange Rate Mechanism (ERM) crisis in late 1992, which was followed by the effective appreciation of the guilder. The second took place between 2001 and 2003, mainly due to external shocks (i.e. the bursting of the dot.com bubble in the USA). In contrast to 2009–10, these periods of economic contraction are not considered atypical. In general, recessions and subsequent periods of growth are a normal part of modern economies and defining characteristics of growth (and business) cycles. Although each recession is unique to an extent, they tend to follow similar patterns and both these contractions display ‘typical’ characteristics of recessions of their type.[98] This is in stark contrast to the 2008 financial crisis, when, at the time of this writing, growth still remains below trend and it is unclear when the economy will revert back to pre-2008 growth levels.

As noted above, the year 2009—i.e. the height of the most recent downturn—is deemed atypical.[99] We therefore recommend that the year 2009 onwards be excluded from the analysis.

Our criteria for period selection using cycle analysis are set out next.

5.3 Criteria for period selection

This section focuses on output and TFP as the basis for identifying cyclicality and growth (business) cycles. The approach used for this study, as well as for CEPA (2012) and the most precedents on this topic, relies on the assumption that the historical trends in TFP change are a reliable indicator of future TFP changes. Maintaining this assumption, to determine an appropriate period to measure these historical trends in TFP growth, the following criteria need to be examined.

[96] We also note that, in general, the 1970s was a period of economic volatility and stagnation for many of the developed Western economies. A number of country-specific factors contributed to this (e.g. monetary instability in the USA and political instability in the UK). The factor that was common among almost all industrialised nations was volatility in energy supply and energy costs. The net effect in the Netherlands was substantial volatility in output growth during the 1970s, followed by a relatively deep recession in 1981 and 1982. These factors suggest that it would be safer to exclude the 1970s from the analysis. However, for our core dataset, data is available only from 1989 onwards.

[97] See Table 4.3 for Oxera’s preferred comparator set.

[98] The 1992 recession was relatively mild and was followed by strong output growth, which is the ‘typical’ behaviour of V-shaped recessions. Although more severe than the 1992 recession, the 2001–03 downturn also displays ‘typical’ characteristics of a U-shaped recession initiated in the financial sector of the economy, namely a protracted period of below-average growth, followed by relatively modest growth.

[99] Data from CBS also covers 2010 and 2011, and shows that the economy has not yet returned to a normal trajectory, in terms of output growth or TFP growth.

- **Is TFP change stable over time?** If productivity change is stable over the timeframe available to the analysis, then the choice of selecting an appropriate period in which to measure TFP is simple; the longest possible period should be selected since this will reduce the variation in the estimated TFP change. On the other hand, if productivity change if not stable, the analysis should assess whether patterns in productivity change can be detected. If productivity change from earlier years is not stable then weight should be placed on more recent data.[100]
- **Does TFP change display cyclical behaviour?** A series of data over time is cyclical if it exhibits patterns of rises and falls that are not of a fixed period. If productivity change is indeed cyclical and fluctuates around its long-run growth average, TFP forecasts should be based on a timeframe that includes both below and above long-run average TFP change, to ensure that it captures the full variation in TFP change over a period.
- **Is TFP change pro-cyclical relative to output change?** We need to assess whether TFP change is positively correlated with output change. If TFP change is pro-cyclical, the period of the analysis can be informed on the basis of business or growth cycles, since this will also ensure that the periods contain both below and above long-run average TFP change. Box 5.1 gives a short review of academic evidence on the pro-cyclical nature of TFP.

Box 5.1 The pro-cyclical nature of TFP

Taking a narrow view of productivity theory, changes in output should not affect productivity change, since additional output would require more inputs to produce, and vice versa. However, in real-world situations, increasing or decreasing the inputs used in the production process is not without cost. For example, a company facing a decrease in demand would need to decide quickly if it should reduce its labour force. This decision is not costless since it would probably need to pay compensation to the staff who were made redundant. Furthermore, if the decrease in demand were temporary, the company would need to incur additional costs to recruit more staff in the future when demand increases. A similar situation arises when a firm faces an increase in demand. As such, in periods of economic downturn or economic expansion, productivity is affected because firms cannot respond immediately to changes in demand. This effect is likely to be more pronounced in capital-intensive companies or industries, since capital inputs cannot easily be reduced in the short term.

The current consensus in the academic literature is that productivity is *pro-cyclical*, at least in the short term. This means that productivity will grow faster in periods of economic expansion (growth) and, similarly, deteriorate faster in periods of economic contraction (decreasing demand).

From the OECD manual (2001):

> In the discussion on capital and capacity utilisation in Section 5.6, allusion was made to the pro-cyclicality of many productivity measures: productivity growth tends to accelerate during periods of economic expansion and decelerate during periods of recession.

From Boisso, Grosskopf, and Hayes (2000):

> we have found that during recessions productivity decreases as a result of both diminished efficiency and reduced technical innovation. During booms it is both improved efficiency and greater innovation that lead to increased productivity.

From the UK Department for Business, Innovation & Skills (2011):

> The evidence about the cyclicality of productivity at the aggregate level suggests that productivity is pro-cyclical.

Sources: OECD (2001), op. cit., p. 119. Boisso, D., Grosskopf, S. and Hayes, K. (2000), ‘Productivity and efficiency in the US: effects of business cycles and public capital’, *Regional*

[100] This point was also highlighted in a past report on productivity growth for the NMA: ‘other things being equal, more recent data should carry more weight, as they are less vulnerable to the criticism that there have been structural changes in the economy and the data sources are clearer and appear more robust’. Reckon (2008), ‘The productivity growth of GTS’, July, p. 18.

Science and Urban Economics, **30**, pp. 663–681. Department for Business, Innovation & Skills (2011), 'Productivity and the Economic Cycle', BIS Economics paper No. 12, March, p. viii.

- **Do aggregate GDP-based growth cycles coincide with the comparator-specific GO-based growth cycles?** Our analysis relies on a set of comparators that capture TSO-specific activities. As a sensitivity, it is important to assess whether GDP growth cycles coincide with the comparator-specific GO-based growth cycles. If there is limited correspondence between the two, it is likely that the comparator sectors are not affected by economy-wide fluctuations in output.

Another important consideration for period selection is whether data quality changes over time. Data from further in the past is prone to more measurement error than more recent data, for a number of reasons.

- The process of collecting and compiling the data in national accounts has greatly benefited from the rapid technological progress in the field of information and communications technology (ICT) that took place in the late 1980s/early 1990s and that continues today. Arguably, computer-based databases and data-handling technology, as well as increased processing power, better data coverage and the means to produce and communicate the findings of analysis quickly, have significantly improved the quality and accuracy of published national accounts in more recent years.
- In addition, there is the issue of changing definitions and accounting standards over the years. The accounting standards in place when the data was first collated in the 1970s and 1980s differ from those in use today. In the previous EU KLEMS revision, national statistical agencies had to revisit older data and recompile it based on the then-adopted standards (the European System of National and Regional Accounts, ESA 1995). Such a revision, albeit on a more limited scale, was also necessary for the current version of EU KLEMS. As such, an argument could be made that data from the 1970s and 1980s is likely to contain more measurement errors than more recent data. The main reason that the current version of EU KLEMS contains shorter time series (fewer years in revision 4 than in revision 3) is the lack of data from these earlier periods.[101]

Given the discussion above, there are two possible bases for determining the period of analysis:

- one or more growth (business) cycles, if productivity is pro-cyclical;[102]
- a full productivity cycle—i.e. a period that includes both below and above long-run average TFP change—if TFP change is cyclical.

Based on Oxera's core dataset (using EU KLEMS/OECD NACE 2 data), our analysis uses GO-based measures consistent with regulatory precedents. To identify the appropriate timeframe, given the potentially cyclical nature of productivity change, it is first necessary to select our preferred definition of 'business cycle'. We have examined three main definitions:

[101] EU KLEMS (2012), 'EU KLEMS Growth and Productivity Accounts, 2012 release, Description of methodology and country notes for the Netherlands', http://www.euklems.net/data/nace2/nld_sources_12i_update_may.pdf
[102] That is, productivity grows faster in periods of output growth and deteriorates faster in periods of decreasing output.

- 'peak-to-peak' business cycle: the peak refers to the highest point in the cycle when the output gap[103] is greater than 0% (i.e. positive). The cycle hence begins with a peak and ends with the next peak. During the business cycle, the economy experiences both below- and above-trend fluctuations;

- 'trough-to-trough' business cycle: the trough refers to the lowest point in the output gap, when the output gap is less than 0% (i.e. negative). The cycle begins with a trough and ends with the next trough, and involves below- and above-trend fluctuations;

- 'growth cycle': one could define a business cycle by assuming that the cycle begins and ends with a 0% output gap, after a period of below- and above-trend output growth.

We consider all three definitions to be equally valid. In conducting our analysis, we adopt a 'growth cycle' definition, consistent with the analysis supporting ACM's previous method decision.[104]

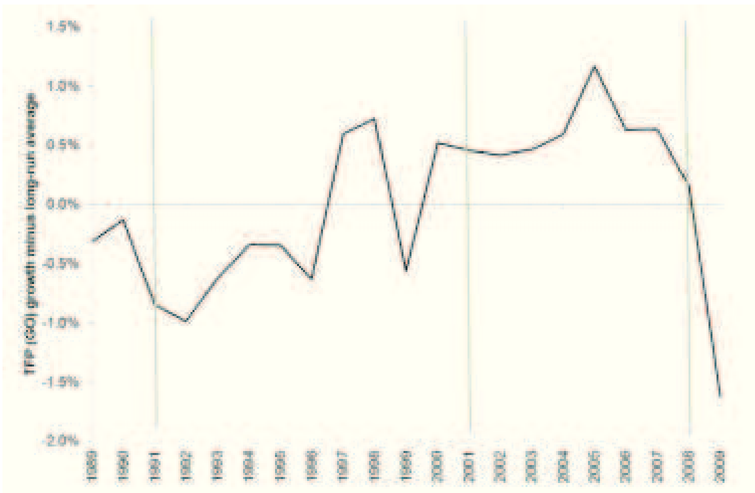
5.4 Period selection

The comparator set used in this analysis is set out in Table 4.3 (Oxera's recommended comparator set). The analysis presented next is structured on the basis of the criteria for period selection identified in section 5.3.

5.4.1 Is TFP change stable over time and does it display cyclical behaviour?

Figure 5.1 shows that, over the period 1989–97, TFP was below trend.[105] Over the period 1997–2008, it was above trend.[106] For a robust estimation of TFP growth, we recommend the inclusion of both below- and above-average periods.

Figure 5.1 TFP (GO) change around the long-run average



Note: The vertical lines represent the end/start points of the comparator-specific GO-based growth cycles.

Source: Oxera analysis.

[103] The output gap is defined as the difference between the actual output growth and the 'potential' output growth of an economy. Potential output growth is usually estimated as the long-run average output growth of the economy.
[104] CEPA (2012), op. cit., p. 41.
[105] That is, the difference between year-on-year gross output growth and the average growth trend is negative.
[106] With the exception of 1999.

To assess further whether TFP change is stable over time, we ran a regression model of TFP change with time dummies. The results are shown in Table 5.2.

Table 5.2 Regression of TFP (GO) change time dummy variables

	Coefficients	Standard error	T-statistic	P-value
Intercept	-0.003	0.001	-2.3	0.03
2009 dummy	-0.011	0.004	-2.8	0.01
1997-2008 dummy	0.010	0.002	6.1	0.00
R^2	76.1%			

Note: If significance is less than 10%, the coefficient is considered statistically significant.

Source: Oxera analysis.

Regression analysis indicates that 2009 may represent a structural break in the series. The coefficient is negative and significant, the p-value being close to zero.

In addition, we note that a time dummy for the period 1997–2008 is statistically significant. Although this does not represent a structural break, it indicates an inflection point. Over this period, TFP (GO) growth is consistently above average, with the exception of 1999. Prior to 1997, TFP (GO) growth was consistently below the long-run period average.

5.4.2 Is TFP change is pro-cyclical relative to output change?

Econometric analysis of TFP (GO) against GO change can show that there is a significant and positive relationship between changes in TFP and output, which is evidence of pro-cyclical behaviour. The regression table below summarises the results.

Table 5.3 Regression of TFP (GO) on GO change

	Coefficients	Standard error	T-statistic	P-value
Intercept	-0.01	0.004	-2.35	0.03
GO change	0.09	0.0401	2.34	0.03
Trend	0.00	0.0002	2.84	0.01
R^2	34.7%			

Note: If significance is less than 10%, the coefficient is considered statistically significant.

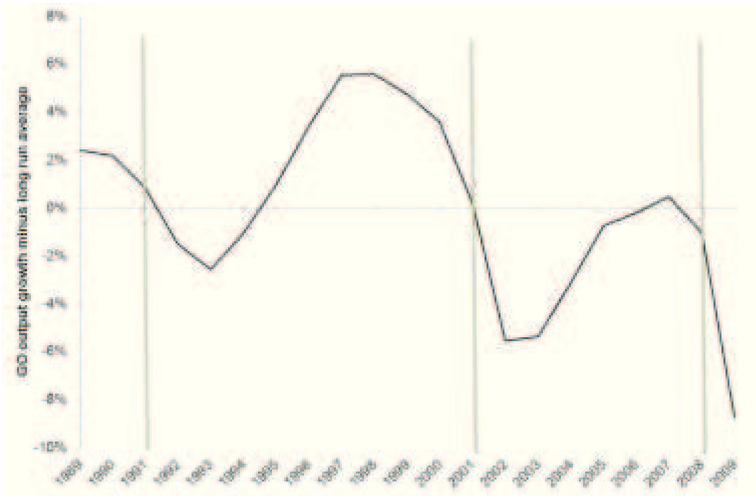
Source: Oxera analysis.

The coefficient on GO change is positive (0.09) and statistically significant at the 5% level. This indicates that there is significant correlation between productivity and economic growth in the comparator set.

5.4.3 Do aggregate GDP-based growth cycles coincide with the comparator-specific GO-based growth cycles?

Aggregate GDP-based growth cycles coincide almost perfectly with the comparator-specific GO-based growth cycles. Figure 5.2 below presents the GO-based output gap for the core comparator set, with the straight lines representing the start/end years of the aggregate GDP-based growth cycles.

Figure 5.2 GO change around the long-run average, core comparators and data



Note: The vertical lines represent the start/end years of the aggregate GDP-based growth cycles.

Source: Oxera analysis.

Details of the growth cycles are provided in Table 5.4 below.

Table 5.4 Aggregate GDP-based growth cycles and comparator-specific GO-based growth cycles

Aggregate GDP-based growth cycles	Comparator-specific GO-based growth cycles
1989[1]–1991	1989[1]–1991
1992–2001	1992–2001
2002–2008	2002–2008[2]

Note: [1] Incomplete business cycle. [2] It is unclear whether the end of the business cycle is 2007 or 2008.

Source: Oxera analysis.

Based on this analysis, we recommend that **data between 1992 and 2008 be used**. Aggregate GDP-based growth data identifies **two complete business cycles, one between 1992 and 2001 and the other between 2002 and 2008**. The results are robust to the use of average GO growth from our recommended selection of industries.

5.5 Conclusion

In summary, **we recommend that two *complete* business cycles (1992–2001 and 2002–2008) be considered for productivity growth analysis**.

Our review of regulatory precedents in the Netherlands and other countries indicates that **it is good practice to consider *complete* business cycles**. Using incomplete business cycles may bias productivity growth estimates. In general, one or two business cycles are sufficient to capture long-run trends.

On our core dataset, Dutch economic growth shows **atypical fluctuations from 2009 onwards**.

Analysis using comparator GO data indicates that there are three business cycles (1989–91, 1992–2001 and 2002–08), the first of which is incomplete.

These findings are robust to the use of economy-wide data, and are supported by evidence indicating that TFP is pro-cyclical. We note that using two complete business cycles over the period 1992–2009 would allow below- and above-trend TFP growth to be covered.

Having identified the preferred comparator set and analysis period, we present the TFP and OPI growth estimates in sections 6 and 7, respectively.

6 TFP estimates

In this section, we present our TFP estimates using our core comparator set in section 4 over the business cycles identified in section 5.

We present the average growth rates of GO-based TFP. Table 6.1 shows period averages over each cycle, and over two complete business cycles:

Table 6.1 Average TFP (GO) growth

Sector	TFP (GO), two cycles, 1992–2008
Telecommunications	2.2%
IT and other information services	0.3%
Professional, scientific, technical, administrative and support service activities	-0.7%
Construction	-0.4%
Financial and insurance activities	0.3%
Transportation and storage	0.8%
Other manufacturing; repair and installation of machinery and equipment	0.6%
Electricity, gas and water supply	0.1%
Unweighted average (core set)	**0.4%**

Source: Oxera analysis.

When both cycles are considered, we observe that **average TFP (GO) growth is 0.4%**.

As discussed in section 3, TFP change may reflect components other than the technology change. This is examined further in section 8.

7 OPI estimates

In this section, we present the productivity estimates from our OPI analysis using our core comparator set in section 4 over the business cycles identified in section 5.

As previously shown, TFP (GO) growth analysis indicates that annual growth is 0.4% (1992–2008). To derive comparable OPI estimates, we first examine the average growth rate of CPI. Average CPI growth is netted off from the OPI growth rate to derive a measure of output price growth relative to economy-wide inflation. (The CPI is sourced from CBS.)[107, 108]

Table 7.1 presents changes in OPI (GO) relative to economy-wide CPI using Oxera's core comparator set. A positive number indicates an increase in output prices; a negative number indicates a fall in output prices (relative to CPI).

Table 7.1 Average OPI (GO) growth relative to CPI inflation

Sector	OPI (GO), two cycles, 1992–2008
Telecommunications	-4.5%
IT and other information services	-0.4%
Professional, scientific, technical, administrative and support service activities	0.5%
Construction	0.6%
Financial and insurance activities	-0.5%
Transportation and storage	1.4%
Other manufacturing; repair and installation of machinery and equipment	-0.8%
Electricity, gas and water supply	-0.6%
Unweighted average (core set)	**-0.5%**

Source: Oxera analysis.

Over both business cycles (1992–2008), GO prices decreased relative to the CPI by 0.5% per annum.

As discussed in section 3, OPI measures reflect both productivity change and input price effects. As OPI encompasses TFP change, it may also reflect catch-up and scale effects, which may require suitable adjustment. These are investigated further in the next sections.

[107] CBS (2015), 'Consumer prices; price index 1990=100', February, available at: http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=71905eng&D1=0&D2=0%2c10%2c20%2c30%2c40%2c50%2c60%2c63%2c70%2c80-114&LA=EN&HDR=T&STB=G1&VW=D, last accessed 1 November 2015.

[108] Average (logarithmic) year-on-year CPI change is 2.31% over the core timeframe (1992–2008) derived from business-cycle analysis. The results are relatively stable across the two business cycles, although more recently inflation appears to have grown at a lower rate. Assuming constant industry GO price growth, we expect OPI measures (relative to CPI) to be lower during the first business cycle.

8 Translating empirical estimates to frontier shift

Sections 6 and 7 present the core TFP and OPI estimates. Given the ACM's objective of determining a dynamic efficiency parameter that accounts for technical progress as well as input price changes (the 'combined effect'), we check for two conditions over the period of assessment for these measures to be considered in the case of the Dutch TSOs:

- the variance in the input price pressure faced by the comparator set of industries and that of the wider economy is reflected in the gap between TFP and OPI estimates. If the variance is negligible, the TFP and OPI productivity estimates are comparable;
- the TFP estimates capture the effects of technological change only. In particular, there are no catch-up effects embedded in the estimates.

If either of these conditions do not hold, specific adjustments should be applied, either to TFP or to both estimates, to make them comparable. This issue should be examined separately.

8.1 Accounting for 'input price effects'

Based on the OPI framework discussed in Section 2.5, output prices are reflective of two main drivers: i) changes in input prices; and ii) technological improvements (measured via TFP growth).

The relationship between TFP and OPI measures can therefore be expressed as:[109]

$$\Delta OPI - \Delta CPI = (\Delta IPI - \Delta CPI) - \Delta TFP$$

where:

- ΔOPI measures a change in output price inflation;
- ΔCPI measures change in the CPI, or, more generally, economy-wide inflation;
- ΔIPI measures input price inflation of sectors;
- ΔTFP measures TFP change.

All OPI estimates in section 7 are net of CPI inflation. The first term in the equation ($\Delta OPI - \Delta CPI$) reflects such empirical estimates. The estimates presented in section 6 capture ΔTFP.

The equation shows that OPI and TFP measures are identical in the absence of inflation differential—that is, where $\Delta IPI - \Delta CPI = 0$. In the previous determination, CEPA noted that there was little difference in the input price change in the sectors relative to CPI and, hence, the OPI and TFP estimates were deemed comparable.[110]

It is also possible to examine the validity of this assumption using EU KLEMS data, as discussed in the next section.

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[109] ΔCPI is subtracted from both terms of the equation to derive a measure of OPI relative to CPI inflation; see section 7.

[110] 'TFP (GO) and output price indices annual percentage movements are similar – 0.5% compared to 0.5% based on the selected comparator sectors. This similarity indicates that the input prices have historically grown at a similar rate to CPI'. CEPA (2012), op. cit., p. 58.

8.1.1 Evidence on real price effects

Using EU KLEMS data, it is possible to assess whether economy-wide inflation has been different from sector-specific inflation. Using the eight core comparator sectors identified in Table 4.3, we present average input price inflation relative to CPI inflation over the period 1992–2008 in Table 8.1.

Table 8.1 GO input price inflation and CPI inflation, 1992–2008

Sector	GO-based input price inflation, 1992–2008
Telecommunications	0.1%
IT and other information services	2.2%
Professional, scientific, technical, administrative and support service activities	2.1%
Construction	2.5%
Transportation and storage	2.6%
Electricity, gas and water supply	3.8%
Other manufacturing; repair and installation of machinery and equipment	2.1%
Financial and insurance activities	2.0%
Unweighted average (core set)	**2.2%**
Economy wide CPI inflation	**2.3%**
GO based input price inflation relative to CPI inflation	**-0.1%**

Note: Average annual growth rate of inflation based on Oxera's comparator set. Sector-specific input price inflation is derived by taking a weighted average of annual inflation over the period 1992–2008, where the weights are derived using the sector-specific capital, labour and intermediate input shares of GO.

Source: Oxera analysis using EU KLEMS labour and capital price data, OECD intermediate inputs price data and CBS CPI data.

Our analysis shows that, historically, there is an inflation differential of -0.1% over the period 1992–2008. That is, CPI inflation grew at a marginally higher rate than input prices.

In order for the TFP and OPI estimates in sections 6 and 7 to be consistent, the gap between CPI inflation and input price inflations should indeed be -0.1%. This would suggest that the difference between OPI growth (relative to CPI inflation) and TFP growth could be attributed to input prices.

Next, we assess whether TFP estimates can translate directly into 'frontier shifts'.

8.2 Translating TFP estimates into frontier shift

Changes in TFP estimates provide a measure of total productivity change, but this does not necessarily translate directly into frontier shift. Productivity change ($\Delta\, productivity$) can be decomposed in the following way:[111]

$$\Delta\, productivity = \Delta\, catch\ up\ efficiency \\ \times \Delta\, technology\ (frontier\ shift) \times\ \Delta\, scale\ efficiency$$

[111] Multi-factor productivity growth (including TFP growth) is calculated as a residual. As such, it may by driven by technology change as well as other factors, such as scale and catch-up efficiency change. For an overview, see Timmer, O'Mahony and Van Ark (2007), op. cit.

where:

- $\Delta\ catch\ up\ efficiency$ measures performance changes from one period to the next with reference to a set of peers and period-specific technology (i.e. it measures the degree to which performance has caught up to best practice);
- $\Delta\ scale\ efficiency$ relates to performance changes due to changes in a company's operational scale;
- $\Delta\ technology$ captures how best practice has changed over the period of analysis;

For this reason, it may be necessary to apply an adjustment to TFP estimates in order to derive a dynamic efficiency target. Moreover, as OPI measures are a function of TFP change, OPI estimates should also consider the decomposition of productivity change to appropriately reflect the $\Delta\ technology$ component.

The application of an adjustment to translate TFP estimates into frontier-shift targets may depend on the regulatory framework. For example, the adjustment may be particularly relevant if catch-up targets and changes in operational scale are considered separately.[112]

To examine whether an adjustment is required, we review academic evidence specific to the Dutch economy. We consider the wider economy as the comparator set used for TFP and OPI analysis is based on a number of industries and not necessarily confined to the energy sector alone. While the evidence in limited in this area, we note that the available academic research points to country-specific drivers of productivity that determine the scale of the adjustment that may be appropriate.[113]

In the next section, we examine academic evidence to identify the main drivers of productivity change in the Netherlands.

8.2.2 Evidence on productivity decomposition for the Dutch economy

As noted above, TFP measures can be said to not contain catch-up effects under restrictive assumptions only. More specifically, efficiency improvements are driven solely by technological change under the assumption of significant levels of competition. In addition, scale efficiency change can occur when companies have control over outputs and can improve their cost efficiency by: (i) increasing their size under economies of scale; or (ii) decreasing their size under diseconomies of scale. In a regulatory context where outputs are largely determined by customers and reviewed by regulators, barring exceptional circumstances where the ensuing regulatory period is anticipated to be unusual,[114] scale changes are generally considered not material.

[112] Based on information from CEPA (2012), op. cit., table 4.2 ('Summary of NMa's most recent method decisions for productivity growth'), we note that, for electricity transmission, the ACM sets a catch-up efficiency target based on a unit cost analysis on 19 European transmission operators. The catch-up target was applied to TenneT's high-voltage costs only (approximately 50% of the costs). For gas transmission, GTS was not subject to catch-up efficiency targets.
[113] For this reason, this adjustment cannot be applied to TFP estimates from other countries or studies that focus on productivity change in specific sectors of the economy.
[114] For example, opening of a new terminal in an airport or substantial capital investment planned in an industry.

Economy wide evidence from Giraleas (2013)[115] shows that in the Netherlands **technological change has been the main driver of productivity change**.[116] Analysis over the period 1995–2007 indicated that:

- on average, economy-wide productivity has increased more or less in line with technology improvement;
- annual technical efficiency change (i.e. catch-up to best practice) is close to zero;
- scale efficiency remained constant over time.

Another study by Alvarez et al. (2010)[117] also indicates that **technological change was the main driver of productivity change** in the Netherlands. In particular, the study uses a cross-country analysis of TFP growth in private sectors in the EU to show that, in the Netherlands, the relative efficiency change component remained constant over the period 1986–95, while technical change was reported to have grown at a consistently positive rate over the same period.[118]

Overall, the academic evidence indicates that productivity change in the Netherlands has been driven predominantly by technological change over similar periods to that examined in this report.

8.3 Conclusion

In this section, we have examined how to translate the empirical TFP and OPI estimates into frontier-shift targets. We find that:

- the inflation differentials for the selected sectors in our comparator set have been marginal over the period examined, and that the TFP (GO) and OPI (GO) estimates are consistent once input prices are accounted for;
- academic evidence[119] indicates that technology change has been the main driver of productivity change in the Dutch economy, while scale and catch-up changes have been insignificant. As such, we conclude that empirical productivity measures based on Dutch sectoral data do not require an adjustment for scale or catch-up efficiency change.

[115] Giraleas, D. (2013), 'The measurement and decomposition of economy-wide productivity growth. Assessing the accuracy and selecting between different approaches', Aston University, Section 5.
[116] This evidence is based on two approaches: data envelopment analysis (DEA)-based circular Malmquist indices; a Malmquist index derived from a translog, exponential stochastic frontier analysis (SFA) model. Both can be used to decompose the Malmquist productivity index into its three main components (catch-up efficiency change; technology change; and scale efficiency change).
[117] Alvarez, I., Delgado, M., and Salinas-Jimenez, M. (2010), 'Determinants of TFP growth in EU countries: a sectoral comparison with Malmquist Indices', Table 2.
[118] Alvarez et al. (2010) did not consider TFP growth due to scale efficiency change.
[119] Giraleas, D. (2013), op. cit.; and Alvarez et al. (2010), op. cit.

9 Literature review[120]

This section reports productivity estimates from a range of academic and consultancy studies, as well as productivity targets from regulatory precedents in various jurisdictions. These estimates from other sources can help to inform the range of dynamic efficiency target that can be set on the Dutch TSOs.

9.1 Guiding principles in assessing estimates from other studies

There are two main sources of productivity estimates from other jurisdictions: academic or consultancy studies, and regulatory precedents.

As estimates from other sources do not have the objective of developing a suitable ongoing efficiency estimate in the context of Dutch TSOs, it is important first to develop a set of guiding principles when assessing these. These are set out as follows.

- **The estimates must reflect the combined effect—i.e. technical change net of input price effects—and not include the impacts of catch-up or scale efficiency**.
    - Some studies estimate productivity using the Malmquist Productivity Index approach[121] wherein it is possible to decompose productivity change into its components; namely, catch-up, scale efficiency changes and technical change. In such cases, the estimate of technical change component should be used to provide a benchmark.
    - Studies may also use Törnqvist Index[122] and other methods to estimate productivity change. These methods do not necessarily enable one to identify dynamic efficiency from the overall productivity estimate. Depending on the jurisdictions from which the sectoral data is used, a suitable adjustment for other effects (i.e. catch-up and scale efficiency) must be considered.
    - Estimates of dynamic efficiency should be adjusted for sector-specific input prices. In some jurisdictions, regulators may assume that sector-specific inflation is broadly similar to that of economy-wide inflation, in which case the inflation differential is assumed to be zero.
- **The estimates should be based on studies of energy transmission operators**. The relevant comparators are gas and electricity transmission operators. Estimates based on transmission operators ensure that the scope of activities and productivity improvement closely reflect those of Dutch transmission operators.
- **The studies must focus on total cost measures**, as the objective of this report is to derive a dynamic efficiency target appropriate for the total cost of the Dutch TSOs.

[120] The central estimate presented here are rounded to one decimal place.
[121] Typically they are derived using a mathematical technique called DEA. The application of a DEA-based Malmquist method to measure indices of TFP change—decomposable further into technical efficiency change, scale efficiency change and technological change—follows the methods developed in Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994), 'Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries', *American Economic Review*, **84**, pp. 66–83 and Ray, S.C. and Desli, E. (1997), 'Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries: Comment', *American Economic Review*, **87**, pp. 1033–39.
[122] Törnqvist Index is an index number approach that estimates productivity as a ratio of an output quantity index and an input quantity index. It measures productivity change as a change in these estimates at two points in time.

In general, the robustness of the methodology, time period examined and quality of data are important factors to consider in any study. Specific considerations include whether: the methodology considered in the studies is robust and well-established in the literature; the timeframe of analysis is long enough to capture long-term productivity trends; and the studies have highlighted data issues and cautioned about the interpretability of the results.

In addition, estimates from the studies we have reviewed are largely based on operators from other parts of Europe, such as Norway, or outside the EU, such as the USA. Estimates of ongoing efficiency from other jurisdictions may still be relevant in the context of Dutch transmission operators (so long that they adhere to the criteria set out above). Ongoing efficiency refers to the change in productivity due to technological progress and/or changes in input prices, excluding any catch-up and scale effects. Such efficiency improvements can be considered as broadly informative across jurisdictions. Thus, for the purpose of determining the reasonableness of direct empirical estimates of Dutch sectors, we consider the dynamic efficiency estimates from studies outside of Netherlands and EU to be relevant.

9.2 Estimates from academic and consultancy studies

This section gives an overview of the estimates from academic and consultancy studies. Short summaries of the academic studies and regulatory precedents considered are provided in Appendices 3 and 4.

9.2.1 Gas transmission studies

We had identified two academic studies and one consultancy study that are of relevance. Productivity estimates from these studies are summarised in Table 9.1.

Table 9.1 Estimates from gas transmission studies

No.	Study	Companies/sector	Period of assessment	Estimate (per annum)
1a	Lawrence and Skolnik (2008)	USA oil and gas pipeline transmission sector	1987–2004	1.20%
1b	Lawrence and Skolnik (2008)	USA oil and gas pipeline transmission sector	1987–2004	0.88%
2a	Jamasb, Pollitt and Triebs (2008)	39 USA gas transmission and pipeline companies	1996–2004	-0.5%
2b	Jamasb, Pollitt and Triebs (2008)	39 USA gas transmission and pipeline companies	1996–2004	0.8%
3a	Economic Insights (2011)	1 NZ gas transmission operator	1997–2010	0.5%

Notes: A positive estimate reflects a positive productivity growth, i.e. costs have reduced while output remained constant. A negative estimate reflects a regress in productivity, i.e. more inputs or greater costs are required to produce the same amount of output.

Sources: Lawrence, M. and Skolnik, K (2008), ‘Estimating Multifactor Productivity (MFP) in Pipeline Transportation, 1987-2004’, Transportation Research Board, 87th Annual Meeting, January 13–17 2008, Washington, DC; Jamasb, T., Pollitt, M. and Triebs, T. (2008), ‘Productivity and Efficiency of US Gas Transmission Companies: A European Regulatory Perspective’; and Economic Insights (2011), ‘Regulation of Suppliers of Gas Pipeline Services – Gas Sector Productivity’, Initial report prepared for Commerce Commission, 10 February.

As shown in Table 9.1, the most recent study, by Economic Insights (2011), provided an estimate of about 0.5% per annum. This study indicated that the input price differential between the sector and the wider economy was zero as there was minimal difference between labour costs and wages in the utility sector and the whole economy; moreover, there was insufficient information to conclude whether there was a differential in assets/capital costs.

The estimates of 1.20% p.a. and 0.88% p.a. from Lawrence and Skolnik (2008) were derived from oil and gas pipeline transportation sector data in the USA between 1987 and 2004.[123] While this study was considered in CEPA (2012), as the study was not limited to the gas transmission sector alone, we ignore the estimates in our assessment.

Finally, Jamasb et al. (2008) report dynamic efficiency estimates ranging from -0.5% to 0.8% (per annum).[124] The study examines the productivity of the US gas transmission and pipeline industry based on Malmquist productivity indices, which enabled the decomposition of overall productivity into technical and scale change. The authors considered two models that differed depending on whether delivery volume was included as a cost driver. The authors estimate models based on costs and revenues; however, in the context of this study only the productivity estimates from the cost models are considered. In addition, the authors note that the inclusion in cost models of delivery volume as a cost driver is not conclusive from a statistical and conceptual perspective. Hence, we consider the technical progress of 0.8% per annum to be the most relevant estimate.

Ignoring the estimate from Lawrence and Skolnik (2008), estimates from the other two studies—0.8% and 0.5%—provide the scope for ongoing efficiency in the range from 0.5% to 0.8%, with a point estimate of 0.7% per annum.

9.2.2 Electricity transmission studies

We have identified four consultancy studies and one study by the Australian Productivity Commission, which are of relevance.

Table 9.2 shows estimates for electricity transmission studies. The lowest frontier estimate is by Frontier and Sumicsid (2013), which reported a regress of 1% based on a group of EU TSOs. The highest estimate, of 3.51%, is based on a Sumicsid (2009) study on a group of EU TSOs.

[123] The authors used data from the Bureau of Labour Statistics and Bureau of Economic Analysis.
[124] Jamasb et al. (2008) also report overall productivity estimates of 2.9% and 5.9%. These estimates, along with the technical change estimates, were considered by CEPA (2012), although the 5.9% was excluded on the basis that it appeared to be too high.

Table 9.2 Dynamic efficiency estimates from electricity transmission studies

No.	Study	Companies/sector	Period of assessment	Estimate (per annum)
1a	Sumicsid Group (2009)	22 EU TSO operators	2003–06	2.20%
1b	Sumicsid Group (2009)	22 EU TSO operators	2003–06	2.50%
1c	Sumicsid Group (2009)	9 to 16 EU TSO operators	2003–06	2.60%
2	Sumicsid Group (2010)	51 Regional TSOs, Norway	2001–04	2.10%
3a	Sumicsid Group (2010)	114-139 US interstate transmission grid operators	1994–2005	2.41%
3b	Sumicsid Group (2010)	114-139 US interstate transmission grid operators	1994–2005	3.51%
4	Frontier Economics, Sumicsid, Consentec (2013)	21 EU TSOs	2007–11	-1.00%
5	Productivity Commission (2012)	Australian Electricity supply sectors	1975–2009	1.30%

Note: A positive estimate reflects a positive productivity growth—i.e. costs have reduced while output remained constant. A negative estimate reflects a regress in productivity—i.e. more inputs or greater costs are required to produce the same amount of output.

Source: Sumicsid (2009), 'International Benchmarking of Electricity Transmission System Operators', e3GRID Project, Final Report; Sumicsid (2010a), 'Benchmarking TenneT EHV/HV, Final Results, Project Stena'.

The Sumicsid (2009) study is based on a group of electricity transmission operators in the EU. The estimates presented in 1a–1c refer to frontier shift; the highest of these—2.60% per annum—appears to be where certain CAPEX costs were excluded from the analysis.

The Sumicsid (2010) study reporting an estimate of 2.10% is based on a group of regional TSOs in Norway. Sumicsid (2010) also noted that, of the two estimates based on US TSOs, 2.41% and 3.51%, 2.41% should be considered as the more robust estimate.[125]

The more recent Frontier/Sumicsid study (2013) is based on a group of EU transmission operators. Unlike the previous studies, this study reported a regress of the frontier of 1.0%. The authors note that this may be due to structural organisational changes owing to unbundling requirements for some companies resulting in higher costs in the last year of the study (2011).

Finally, the study by the Productivity Commission (2012) estimates multifactor productivity (MFP) of the utilities sector relating to the electricity supply chain (i.e. including generation, transmission, distribution and retail), not electricity transmission in isolation. Also, the authors appear not to consider input price pressures separately for the sector. The resulting estimate of 1.30% therefore reflects productivity growth of the overall sector.[126] While the period of analysis considered in the study is considerably long and comparable to the empirical analysis undertaken in this report, we ignore the estimate from the study as it does not conform to some of the criteria set out upfront.

Oxera considers that, with the exception of the estimate of 1.3% from the Productivity Commission (2012), other estimates could be a useful guide for the dynamic efficiency target for the Dutch electricity TSO. The

[125] The estimate is based on an OPEX weighting instead of a simple average of the Malmquist index.
[126] Electricity generation; electricity transmission; electricity distribution; on selling electricity and electricity market operation.

remaining studies result in a range of -1% to 2.4% per annum, with a central estimate of 1.5% per annum.[127]

9.2.3 Regulatory approaches

Regulatory precedents are listed in Table 9.3 from Ofgem (GB), BNetzA (Germany), E-control (Austria), CRE (France) and the Utility Regulator (Northern Ireland). The table also demonstrates the information available on the type of productivity estimate for each regulator.

Table 9.3 Regulatory precedents for dynamic efficiency

Regulator	Sector	Estimate (per annum)
Electricity transmission		
Ofgem, Great Britain, 2013–21	National Grid Electricity Transmission (Transmission Operator)	0.0% (TOTEX)
BNetzA, Germany	Electricity transmission, 2014–18	1.25% in the first regulatory period, 1.50% in the second period
CRE, France	Electricity transmission, 2013–16	(RPI - 1%) ‘other purchases and services’ (RPI - 0.3%) ‘salaries’ ‘costs’ OPEX only
Ofgem, Great Britain, 2013–21 (final proposals)	National Grid Electricity Transmission (System Operator)	0.6% (TOTEX)
Gas transmission		
Ofgem, Great Britain, 2013–21	National Grid Gas Transmission (Transmission Operator)	0.3% (TOTEX)
Ofgem, Great Britain, 2013–21	National Grid Gas Transmission (System Operator)	0.7% (TOTEX)
BNetzA, Germany	Gas transmission, 2014–17	1.25% in the first regulatory period, 1.50% in the second period
CRE, France	Gas transmission, 2013–16	Increasing over the regulatory period from 0.25% to 0.75% starting from 2014 on a like-for-like basis

Source: Bundesnetzagentur (2006), ‘Bericht der Bundesnetzagentur nach § 112a EnWG zur Einführung der Anreizregulierung nach § 21a EnWG’ (also refer to http://www.gesetze-im-internet.de/aregv/__9.html); Ofgem (2012), ‘RIIO-T1/GD1: Real price effects and ongoing efficiency appendix’; CRE (2012), ‘Deliberation of the French Energy Regulation Commission of 13 December 2012 deciding on the tariffs for the use of natural gas transmission networks’; CRE (2013), ‘Deliberation of the French Energy Regulatory Commission of 3 April 2013 deciding on the tariffs for the use of a high-voltage public electricity grid’.

The targets used by Ofgem appear to be suitable for comparing empirical TFP estimates based on the Dutch economy. Ofgem estimated ongoing efficiency (frontier shift) using an approach similar to that considered in this report in sections 6 and 7. Ofgem estimates input price pressures separately; once incorporated, the net dynamic efficiency target was between 0% and 0.6% per annum on electricity transmission, and between 0.3% and 0.7% per annum on gas transmission. BNetzA’s estimate of 1.5% may reflect catch-up effects.

[127] In arriving at this range, we have averaged he first two sets of estimates (i.e. ignoring 1c as it may not reflect dynamic efficiency on total expenditure, TOTEX) resulting in an average of 2.35% per annum. This is then averaged with the remaining estimates leaving out estimate 3b as the authors note that it is not their preferred estimate, and 5 as it is not specific to the transmission sector.

The CRE regulatory determinations do not appear to present a target on TOTEX that could be considered.

This provides a range of 0–1.5% per annum for electricity and 0.3–1.5% per annum for gas; however, the upper-end estimate of 1.5% may include catch-up effects and not account for input price pressure.

9.3 Conclusion

The regulatory precedents point to a range of 0–1.5% per annum for electricity TSOs and 0.3–1.5% per annum for gas TSOs, although the upper end of the estimate (of 1.5%) may encompass catch-up effects.[128]

The academic studies point to a range of -1% to 2.4% per annum for electricity TSOs, with a central estimate of 1.5% per annum. We note that a number of academic studies on the electricity TSOs determine a per-annum productivity estimate above 2%; however, these are based on analysis undertaken over short timeframes (here, using less than four years of data).

The range on the gas TSOs is 0.5–0.8% per annum with a central estimate of 0.7%. This range is based on two studies alone.

[128] As noted, the upper-end estimate of 1.5% per annum is from BNetzA, which sets a uniform target for both electricity and gas transmission companies.

10 Conclusion

In this report, we have considered two approaches in TFP and OPI to determine the likely dynamic efficiency target for the Dutch electricity and gas transmission sectors over the next regulatory period. Both methods rely on the use of comparable set of sectors in the economy.

While TFP is a productivity measure, OPI is a cost measure, and shows how output prices decrease relative to CPI. This has been assessed using the same comparator set and timeframe as TFP. We decided to focus on GO-based measures, which were used as part of the previous method decisions.

We selected the period 1992–2008 as it covered complete business cycles and periods of below- and above-trend fluctuations consistent with the academic literature. Over this timeframe, TFP is pro-cyclical with gross output, which aligns with existing evidence.

The core TFP and OPI estimates are consistent, since the gap between the two can be explained by the differential between CPI and input prices. Over the period 1992–2008, for our preferred comparator set:

- average year-on-year TFP (GO) growth was 0.4%. The gap between CPI and input price inflation was 0.1%. Hence, a combined estimate that captures productivity improvements and input price pressure is about 0.5% per annum.
- OPI (GO) decreased annually by 0.5% relative to economy-wide CPI.

Hence, a dynamic efficiency target that captures the ‘combined effect’ of productivity growth and input price pressure is estimated to be 0.5% per annum. Extensive sensitivity analysis in terms of alternative data sources, comparator set and timeframe of analysis indicate that the core estimate is largely robust to alternative assumptions.

We have identified a limited number of *relevant* academic studies and regulatory determinations of dynamic efficiency assessment of transmission operators.

In the case of academic sources, the range of estimates on the electricity TSOs is wide, giving less confidence that they can be relied upon; while the range on the gas TSOs was based on two studies alone. Also, some of the regulatory determinations are not clear in terms of the methodology and data employed, and whether the estimates presented in them consider the combined effect and exclude catch-up effects. As such, in this instance, we consider that less weight should be placed on estimates from external sources, and that the primary analysis undertaken using indirect comparators should be given more weight.

A1 VA-based versus GO-based TFP measures

Under 'neo-classical' assumptions, VA and GO TFP estimates are related and it is possible to derive VA-based TFP from GO-based TFP analytically, as demonstrated by Bruno (1978)[129] and Balk (2009):[130]

- Bruno (1978) showed that a scaling factor[131] could be applied to TFP (GO) to derive TFP (VA). Because such a scaling factor is greater than 1, VA-based TFP measures display larger productivity growth than GO-based TFP measures.[132]
- GO and VA TFP measures tend to be close at the economy-wide level.[133] Discrepancies tend to be greater at the sector level.[134]

The GO-based TFP growth measures represent the residual after subtracting the growth rate of labour, capital and intermediate inputs from the growth rate of GO. This can be illustrated as:

$$gTFP\ (GO) = gGO - w_L xgL - w_k xgK - w_I xgI$$

where:

- gGO represents gross output growth;
- gL represents labour growth, weighted by the labour share of GO w_L;
- gK represents capital growth, weighted by the capital share of GO w_k;
- gI represents intermediate input growth, weighted by the intermediate inputs share of GO w_I.

GO-based productivity measures are a valid representation of technical change coming, for example, in the form of better management and improved knowledge.[135] An important advantage of using GO-based TFP measures is that GO is the natural output concept, which includes the contribution of intermediate inputs. The direct inclusion of intermediate inputs in the analysis can avoid potential biases in cases where the mix of inputs used in the production function changes.[136] Moreover, GO measures better reflect the business decisions taken by companies since they assume that intermediate inputs are a controllable factor of production.

VA-based measures are constructed differently. In particular, VA-based TFP growth measures subtract the growth rate of labour and capital from the growth

[129] Bruno, M. (1978), 'Duality, Intermediate Inputs and Value Added', in M. Fuss and D. McFadden (eds.), *Production Economics: A Dual Approach to Theory and Applications*, North Holland.
[130] 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.
[131] The inverse of the share of VA in GO.
[132] At the same time, VA-based TFP measures will always be lower than GO-based TFP measures when productivity change is negative (e.g. in periods of productivity recession, which tend to coincide with periods of output recession).
[133] At the economy-wide level, GO and VA productivity measures differ significantly if a large share of intermediate inputs is sourced from imports. See Schreyer, P. (2001), 'The OECD productivity manual: A guide to the measurement of industry-level and aggregate productivity', International Productivity Monitor, Spring, pp. 37–51.
[134] 'In a closed economy, the differences between the two measures of productivity growth diminish as the level of aggregation increases'. Productivity Commission (2003), 'A comparison of Gross Output and Value-Added Methods of Productivity Estimation. Research Memorandum', November, p. 6.
[135] OECD (2001), op. cit., p. 27.
[136] For more discussion, see Balk (2009), op. cit.

rate of VA. The equation below illustrates how the VA-based growth rate of TFP, $gTFP\ (VA)$ is derived:

$$gTFP\ (VA) = gVA - w_L x gL - w_K x gK$$

where:

- gVA represents value added growth;
- gL represents labour growth, weighted by the labour share of VA w_L;
- gK represents capital growth, weighted by the capital share of VA w_K;

The 2001 OECD manual states that VA-based productivity measures reflect 'an industry's capacity to translate technical change into income and into a contribution to final demand'.[137] A potential advantage of VA-based TFP measures is that they are not sensitive to changes in the vertical structure of firms. If, for example, capital and/or labour are outsourced, intermediate inputs will play a relatively larger role. Such change in the composition of inputs will affect GO TFP more than VA TFP.

As noted by Balk (2009), productivity assessments that utilise micro- or meso-data (for example, where the unit of assessment is either a firm or a group of similar firms) tend to use GO-based TFP measures, while productivity assessments that focus on higher-level aggregates (e.g. whole economies) tend to use VA-based measures.

In summary, it is not clear whether VA measures are directly relevant to estimate technical change at the sector level. GO measures are better suited to reflect an industry's technical change, and can better account for the role of intermediate inputs. In light of these considerations, **we recommend that greater emphasis be placed on the GO-based measures**.

[137] OECD (2001), op. cit., pp. 27–28.

A2 Sensitivities to the core empirical analysis

A2.1 Overview

In this appendix, we provide a number of sensitivities to the core empirical analysis—in particular:

- the TFP and OPI GO estimates using the comparator set from the previous method decision;
- a sensitivity considering gas- and electricity-specific comparators;
- core TFP and OPI estimates using the longest available time period in the core dataset used in sections 7 and 8;
- TFP and OPI estimates using the alternative dataset from CBS;
- VA-based TFP and OPI estimates using the core comparator set and data.

An overview of the results is presented in Table A2.1.

Table A2.1 Overview of main sensitivities, unweighted averages

Measure	Comparator set	Dataset	Timeframe	Point estimate
TFP (GO)	Previous method decision	Core dataset	Core (two cycles)	0.7%
OPI (GO)	Previous method decision	Core dataset	Core (two cycles)	-0.4%
TFP (GO)	Core, plus chemicals and chemical products	Core dataset	Core (two cycles)	0.5%
OPI (GO)	Core, plus chemicals and chemical products	Core dataset	Core (two cycles)	-0.5%
TFP (GO)	Core set	Core dataset	Longest period	0.2%
OPI (GO)	Core set	Core dataset	Longest period	-0.5%
TFP (GO)	Core set	CBS dataset	Second full cycle	1.1%
OPI (GO)	Core set	CBS dataset	Second full cycle	-0.2%
TFP (VA)	Core set	Core dataset	Core (two cycles)	0.9%
OPI (VA)	Core set	Core dataset	Core (two cycles)	-0.7%

Source: Oxera analysis.

These estimates indicate that:

- when the comparator set from the previous method decision is used, the TFP (GO) estimate increases to 0.7% from 0.4% (the core estimate from section 6). The OPI (GO) estimate changes slightly in absolute terms, to -0.4%, compared with Oxera's core estimate of -0.5%;
- the inclusion of a gas-specific comparator ('chemicals and chemical products') does not affect the OPI (GO) estimate, while it increases marginally the corresponding TFP point estimate to 0.5%;[138]
- using the longest possible period (1989–2009), the TFP (GO) estimates decreases to 0.2%, but the OPI (GO) estimate is identical to the core result, at -0.5%. This result contains an incomplete business cycle (1989–1993) and a year with atypical growth (2009);

[138] It was possible to derive VA-based alternative estimates using only an electricity-specific comparator ('electrical and optimal equipment'). See section A2.3.

- the CBS data give TFP (GO) and OPI (GO) estimates of 1.1% and -0.2%, respectively. However, these can only be considered over one full business cycle, and are therefore of limited relevance;
- VA-based estimates are generally higher in absolute terms, as expected (see Appendix 1).

These estimates are presented in more detail in the next sections.

A2.2 TFP and OPI analysis using CEPA's (2012) comparator set

In this section, we present the results of TFP and OPI analysis using the core comparator set in CEPA (2012) and the core updated dataset built by Oxera. This sensitivity requires selecting the NACE 2 comparators that most closely represent the NACE 1 sectors identified by CEPA.

Table A2.2 Core comparator set used in CEPA (2012) based on NACE 2 classification standards

Sector
Chemicals and chemical products
Transport equipment
Construction
Wholesale and retail trade; repair of motor vehicles and motorcycles
Transportation and storage
Financial and insurance activities

Source: Oxera analysis.

Average TFP (GO) year-on-year changes over the two complete business cycles are shown in the next table.

Table A2.3 TFP (GO) change (CEPA's core comparator set using NACE 2 classification, core dataset)

Sector	TFP (GO), two cycles, 1992–2008
Chemicals and chemical products	1.1%
Transport equipment	1.1%
Construction	-0.4%
Wholesale and retail trade; repair of motor vehicles and motorcycles	1.3%
Transportation and storage	0.8%
Financial and insurance activities	0.3%
Unweighted average (core set)	**0.7%**

Source: Oxera analysis.

On average, the TFP (GO) grows at a rate of 0.7% each year over two business cycles.

We also consider OPI measures. The table below presents average OPI (GO) change relative to CPI.

Table A2.4 Change in OPI (GO) relative to CPI (CEPA's core comparator set using NACE 2 classification, core dataset)

Sector	OPI (GO), two cycles, 1992–2008

Chemicals and chemical products	0.2%
Transport equipment	-1.0%
Construction	0.6%
Wholesale and retail trade; repair of motor vehicles and motorcycles	-1.0%
Transportation and storage	-0.5%
Financial and insurance activities	-0.6%
Unweighted average (core set)	**-0.4%**

Source: Oxera analysis.

In absolute terms, OPI (GO) reduces to -0.4% over the period 1992–2008 (two complete business cycles). This is slightly lower in absolute terms than what we found using our preferred comparator set (-0.5%).

A2.3 Sensitivity using gas- and electricity-specific comparators

As an additional sensitivity, we consider the inclusion of gas- and electricity-specific sectors in the core comparator set. While the comparator set aims to capture activities that are common to both electricity and gas TSOs, there may be differences that may motivate the application of different frontier-shift targets for TenneT and GTS. We have identified two relevant industries:

- for electricity, we examine the inclusion of 'electrical and optical equipment' (NACE 2 sector: 26–27). Ofgem used a similar sector in its RIIO-T1/GD1 decision on ongoing efficiency assumptions for gas distribution, electricity transmission and gas transmission.[139] In the previous method decision, this sector was excluded from the comparator set due to data issues;[140]
- for gas, we examine the inclusion of 'chemicals and chemical products'. As discussed in section 4, this sector is a more appropriate comparator for gas transmission than for electricity transmission.[141] For this reason, it is a suitable comparator for the purposes of this sensitivity.

We note that 'electrical and optical equipment' still suffers from data issues, such as the presence of negative capital values. Moreover, it is not possible to derive GO measures because the GO and intermediate input variable in the OECD database present a different level of aggregation.[142]

All sensitivities are run using our core dataset. We present the TFP and OPI estimates over two complete cycles (over the period 1992–2008).

In the table below we show the TFP estimates of the operator-specific sectors and the unweighted average including the two expanded comparator sets.

Table A2.5 Change in TFP (core dataset, using operator-specific sectors)

	TFP (GO), two cycles, 1992–2008
Electrical and optical equipment	n/a

[139] 'Manufacture of electrical and optical equipment; (30–33), Ofgem (2012), 'RIIO-T1/GD1: Initial Proposals – Real price effects and ongoing efficiency appendix', July.
[140] CEPA (2012), op. cit., p. 45.
[141] Oxera (2012), 'Review of Ofgem's RIIO/GD1 initial proposals on ongoing efficiency. Note prepared for National Grid', September.
[142] More specifically, the OECD STAN dataset presents price and value indices specific to 'computer, electronic and optical products' (26) and 'electrical equipment' (27), but does not contain values for sector 26–27.

Chemicals and chemical products	1.1%
Unweighted average (core comparator set)	**0.4%**
Unweighted average (electricity, including electrical and optical equipment)	**n/a**
Unweighted average (gas, including chemicals and chemical products)	**0.5%**

Source: Oxera analysis.

Owing to data limitations, it is not possible to calculate TFP (GO) growth for 'electrical and optical equipment'. However, we note that the TFP (GO) growth estimate for 'chemicals and chemical products' is 1.1%, resulting in an unweighted average TFP (GO) growth of 0.5%. This is around 1 percentage point higher than the point estimate based on the core comparator set.

Because it would not otherwise be possible to examine the inclusion of an electricity-specific comparator, we examine VA-based measures, for which data on 'electrical and optical equipment' is available.

Results indicate that the TFP (VA) of electrical and optical equipment, our electricity-specific comparator, grew at a 1.4% annual rate over the period 1992–2008. The inclusion of such an estimate in the unweighted average does not affect our results, which remain stable at around 0.9%.[143] Over the same period, the average TFP (VA) growth of 'chemicals and chemical products' is 4.1. Its inclusion in the unweighted average increases the point estimate by around 3 percentage points, thereby increasing it to 1.2%.

We present the main results for the OPI change relative to CPI below.

Table A2.6 Change in OPI relative to CPI (core dataset, using operator-specific sectors)

	GO price index, two cycles,1992–2008
Electrical and optical equipment	n/a
Chemicals and chemical products	0.2%
Unweighted average (electricity, including electrical and optical equipment)	**n/a**
Unweighted average (gas, including chemicals and chemical products)	**-0.5%**

Source: Oxera analysis.

The GO-based estimates compared with the (unweighted) average OPI (GO) change relative to CPI was of -0.5%. The estimate is unaffected by the inclusion of 'chemicals and chemical products'; however, it has not been possible to assess the impact of including 'electrical and optical equipment' in the comparator set due to lack of GO data.[144]

A2.4 Core TFP and OPI estimates over the longest available period

In this section, we present the core TFP and OPI estimates over the longest available period. The analysis therefore includes the period 1989–1992, as well as 2009. The core analysis excludes period 1989–92 because, as noted in section 5, it forms an incomplete cycle and its inclusion is therefore likely to

[143] See section A2.5.

[144] Using the core comparator set, the unweighted average OPI (VA) change relative to CPI is -0.7%. This average decreases further to -1% and 0.8% when electricity- and gas- specific sectors are included, respectively.

bias the results. The year 2009 is characterised by atypical (negative) output and TFP growth, and marks the start of a new cycle.

Notwithstanding these limitations, we present the results for completeness. The next table shows average TFP (GO) growth over the period 1989–2009.

Table A2.7 Average TFP (GO) growth, 1989–2009

Sector	TFP (GO), longest period, 1989–2009
Telecommunications	1.4%
IT and other information services	0.2%
Professional, scientific, technical, administrative and support service activities	-0.6%
Construction	-0.5%
Financial and insurance activities	0.2%
Transportation and storage	0.6%
Other manufacturing; repair and installation of machinery and equipment	0.3%
Electricity, gas and water supply	0.1%
Unweighted average (core set)	**0.2%**

Source: Oxera analysis.

On average, TFP (GO) grew at 0.2% over the longest timeframe available from the core dataset. The table below shows average OPI (GO) growth relative to CPI inflation over the same period.

Table A2.8 Average OPI (GO) growth relative to CPI inflation, 1989–2009

Sector	OPI (GO), longest period, 1989–2009
Telecommunications	-3.9%
IT and other information services	-0.8%
Professional, scientific, technical, administrative and support service activities	0.4%
Construction	0.6%
Financial and insurance activities	-0.7%
Transportation and storage	1.2%
Other manufacturing; repair and installation of machinery and equipment	-0.8%
Electricity, gas and water supply	0.0%
Unweighted average (core set)	**-0.5%**

Source: Oxera analysis.

On average, OPI (GO) decreased by -0.5% relative to CPI over the longest timeframe available from the core dataset.

A2.5 TFP and OPI results using CBS data

In order to generate TFP and OPI estimates using CBS data, we use a comparator set that captures a set of activities similar to those examined in Table 4.3 for the core dataset. The set of comparator industries is presented in the next table.

Table A2.9 Oxera's core comparator set (alternative CBS dataset)

Oxera's comparator set for the CBS dataset
31-33 Other manufacturing and repair
D Electricity and gas supply
E Water supply and waste management
F Construction
H Transportation and storage
61 Telecommunications
62-63 IT- and information services
K Financial institutions
69-71 Management, technical consultancy
72 Research and development

Source: Oxera analysis.

The average TFP (GO) growth rates are presented in the table below.

Table A2.10 TFP (GO) change (Oxera's core comparator set, alternative dataset)

Sector	TFP(GO), second complete cycle, 2002–08
Other manufacturing and repair	0.6%
Electricity and gas supply	3.1%
Water supply and waste management	-0.2%
Construction	0.2%
Transportation and storage	0.6%
Telecommunications	3.7%
IT- and information services	0.0%
Financial institutions	3.8%
Management, technical consultancy	-0.5%
Research and development	0.0%
Unweighted average (core set)	**1.1%**

Source: Oxera analysis.

The TFP (GO) for the core comparator set using CBS data over the second complete business cycle over which data is available is about 1.1%.

In addition, we examine the CBS-based OPI estimates. The timeframe considered is consistent with the analysis in section 5, but is limited due to data availability. GO-based results are shown in the table below.

Table A2.11 Change in OPI (GO) relative to CPI (Oxera's core comparator set, alternative dataset)

Sector	GO price index, second complete cycle, 2002–08
Other manufacturing and repair	-0.1%
Electricity and gas supply	1.1%
Water supply and waste management	0.6%
Construction	1.0%
Transportation and storage	0.3%
Telecommunications	-4.0%
IT- and information services	0.1%

Financial institutions	-2.8%
Management, technical consultancy	1.4%
Research and development	0.8%
Unweighted average (core set)	**-0.2%**

Source: Oxera analysis.

During the only complete business cycle that is possible to examine (2002–08), OPI (GO) decreases by on average 0.2% relative to CPI.

A2.6 Value-added TFP and OPI estimates

In this section, we derive the VA-based TFP and OPI estimates on the core dataset, comparator set of industries identified in section 4, and over the preferred period of analysis, 1992 to 2008.

Table A2.12 Average TFP (VA) growth

Sector	TFP (VA) two cycles, 1992 to 2008
Telecommunications	5.2%
IT and other information services	0.5%
Professional, scientific, technical, administrative and support service activities	-1.3%
Construction	-1.2%
Financial and insurance activities	0.6%
Transportation and storage	1.6%
Other manufacturing; repair and installation of machinery and equipment	1.3%
Electricity, gas and water supply	0.5%
Unweighted average (core set)	**0.9%**

Source: Oxera analysis.

As expected, the absolute year-on-year growth rate of VA-based productivity measures is higher than under GO-based approaches.[145] The longer-run estimate considering two complete business cycles indicates that TFP (VA) growth is on average 0.9%.

Table A2.13 Average OPI (VA) growth relative to CPI inflation

Sector	OPI (VA), two cycles, 1992 to 2008
Telecommunications	-5.7%
IT and other information services	-0.8%
Professional, scientific, technical, administrative and support service activities	0.7%
Construction	1.8%
Financial and insurance activities	-1.5%
Transportation and storage	1.4%
Other manufacturing; repair and installation of machinery and equipment	-0.6%
Electricity, gas and water supply	-0.8%
Unweighted average (core set)	**-0.7%**

[145] As noted in Appendix 1, Bruno (1978) showed that TFP (GO) is by construction lower than TFP (VA). Bruno, M. (1978), 'Duality, Intermediate Inputs and Value Added', in M. Fuss, and D. McFadden (eds.), *Production Economics: A Dual Approach to Theory and Applications*, North Holland.

Source: Oxera analysis.

Overall, average VA-based estimates appear to be in line with the corresponding GO estimates. Over the two full business cycles, VA-based output prices decreased by 0.7% relative to CPI.

A2.7 Conclusion

Extensive sensitivity analysis around the comparator set of industries, source data and period of analysis indicate that the core set of productivity estimates derived in sections 6 and 7 are largely robust to this analysis. In some instances, the productivity estimates are materially different to the core estimates (for example, when using the CBS dataset that has the highest variance to the core estimates). However, we consider such sensitivities to be less robust for reasons of the shorter period of analysis covering only one business cycle (CBS data), the period of analysis encompassing incomplete business cycles or atypical growth (longest period), or the use of an alternative productivity method in VA-based measures that are theoretically expected to come out with higher values than the corresponding GO-based measures.

A3 Summary of studies reviewed in section 9

This section gives an overview of the studies referred to in section 9 of the main report. Three studies on gas transmission, and a further three studies on electricity transmission, are summarised.

A3.1 Gas transmission

A3.1.1 Jamasb, Pollitt and Triebs (2008)

The authors examine the productivity of a panel of US interstate gas transmission network operators (TNOs).[146] The dataset was based on information from the Federal Energy Regulatory Commission (FERC), which contained financial and operating data for 39 pipelines over nine years (1996–2004).

To determine the productivity growth achieved by the US TNOs, the authors used a DEA-based Malmquist approach. The DEA models considered used TOTEX or revenue as the input of focus. We have focused on the TOTEX-based productivity estimates in our review. The specifications (i.e. set of output measures) considered in the two TOTEX-based models were different. In particular, model 1 considered delivery volume, compressor capacity and network length as the output measures, while model 2 excluded delivery volume from the specification.

Overall productivity growth was decomposed into technical change, technical efficiency change, and scale efficiency change. Based on the first TOTEX model, which included delivery volume as a cost driver, the overall productivity growth estimate was 2.9% per annum. This was the estimate that CEPA considered in its study.[147] The relevant technical change component is a regress of 0.5% per annum. A second TOTEX model, excluding delivery volume, provided an overall productivity estimate of 5.9% per annum, and a technical change component of (a progress of) 0.8% per annum.

The authors note that the inclusion in cost models of delivery volume as a cost driver is not conclusive from a statistical and conceptual perspective. Hence, we consider the technical progress of 0.8% per annum to be the most relevant estimate.

A3.1.2 Lawrence and Skolnik (2008)

The authors estimate annual MFP in the oil and gas pipeline transportation industry in the USA from 1987 to 2004 using growth-accounting TFP and the Törnqvist index number approach.[148]

The productivity estimates were based on indices of gross output, capital, labour, land, energy and intermediate inputs for the pipeline sector, as defined by the North American Industry Classification System (NAICS). Importantly, the data refers not only to transmission pipelines, but also to pipelines used for the transmission of crude oil and refined petroleum products.

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[146] Jamasb, T., Pollitt, M., and Triebs, T. (2008), 'Productivity and Efficiency of US Gas Transmission Companies: A European Regulatory Perspective', April.
[147] CEPA (2012), 'Ongoing Efficiency in New Method Decisions for Dutch Electricity and Gas Network Operators', Final Report, November.
[148] Lawrence, M. and Skolnik, K. (2008), 'Estimating Multifactor Productivity (MFP) in Pipeline Transportation 1987-2004', Transportation Research Board, 87th Annual Meeting, January 13–17 2008, Washington, DC.

Based on the growth accounting approach, productivity growth was estimated to be 0.88% per annum. However, the estimate appears to be derived using a non-standard approach, and hence is not considered in our review.

The estimate based on the Törnqvist index approach suggests a per-annum productivity growth of 1.20%.

While this study was considered in CEPA (2012), as the study was not limited to the gas transmission sector alone, we do not consider the estimates in our assessment.

A3.1.3 Economic Insights (2011)

The authors undertook productivity analysis of gas pipeline businesses (GPBs) in New Zealand.[149] The study assessed, in particular, the difference in the long-run growth rate between gas transmission and distribution businesses and the rest of the New Zealand economy.

The authors used three approaches in the study. The first approach used direct information on the NZ GPBs. In the second and third approaches, the authors considered productivity estimates from external sources such as studies based on gas transmission and distribution sectors (second approach), and productivity estimates from studies based on other comparable sectors such as electricity distribution (third approach).

In the first approach, TFP indices were constructed using data on the outputs and inputs of a single gas transmission company in New Zealand over the period 1997 to 2010. This resulted in a productivity estimate of 0.9% per annum. The authors noted that company data could not be verified and information was missing. In light of this, they suggest that this estimate of TFP be considered as exploratory.

The authors note that, given the shortage of complete, consistent and robust relevant data, their initial review of direct and indirect approaches suggests that the TFP growth in the gas transmission sector is similar to that of the New Zealand economy as a whole. In other words, an appropriate frontier-shift estimate for the New Zealand GPBs was deemed to be about 0.5% per annum.

On input price differentials, the authors note that there was minimal difference between the growth rates of labour costs and wages in the utility sector and the overall economy. Furthermore, there was insufficient evidence to conclude on whether there was a differential in capital costs. On this basis, an input price differential of 0% was recommended.

A3.2 Electricity transmission

A3.2.1 Sumicsid studies: 2009 and 2010

The objective of the Sumicsid studies (2009[150] and 2010[151]) was to estimate the static efficiency of electricity transmission operators. As part of these studies, frontier-shift estimates were also reviewed for a sample of US transmission operators (1994–2005), a sample of EU transmission operators (2003–06) and a group of Norwegian operators (2001–04).

[149] Economic Insights (2011), 'Regulation of Suppliers of Gas Pipeline Services – Gas Sector Productivity', Initial report prepared for Commerce Commission, February.
[150] Sumicsid (2009), 'International Benchmarking of Electricity Transmission System Operators e3GRID Project', Final report, 2009-03-09.
[151] Sumicsid (2010), 'Project Stena, Benchmarking TenneT EHV/HV', Final results, 2010-03-10, version 3.2.

Estimates of frontier shift from the Sumicsid studies are based on the TOTEX data of the companies. For the analysis of a set of EU and Norwegian transmission operators, the authors used construction, maintenance, planning and administration costs. The study on the US operators was based on data from FERC.

Each study estimated overall productivity using a DEA-based Malmquist approach. The studies also presented results of the decomposition of the overall productivity estimate into its components in efficiency change and frontier shift. In particular, per-annum frontier-shift estimates of:

- 2.2%, 2.5% and 2.6% were reported based on a sample of European TSOs;[152]
- 2.1% was reported for the sample of transmission grids from Norway;[153]
- 2.41% and 3.51% were reported for the US operators.[154]

Of the estimates based on the sample of European TSOs (2.2% to 2.6%), the higher one (2.6%) is disregarded as it excludes certain CAPEX costs.

Of the two estimates based on US operators, the authors considered the lower one (2.41%) to be more robust. The estimate of 3.51% is thus ignored in our assessment.

The relevant estimates are therefore 2.2% and 2.5% based on the European TSOs (average of 2.35%); the 2.1% based on the Norwegian transmission grids; and the 2.41% based on the US operators. (All estimates are per annum.)

A3.2.2 Frontier Economics, Sumicsid and Consentec (2013)

The objective of the E3GRID2012 study was to determine the static efficiency of a group of European electricity TSOs, including TenneT.[155] Using the same set of operators, a dynamic efficiency analysis was undertaken based on a dataset containing information on 21 transmission operators for the years 2007–11. The cost base comprised companies' TOTEX (construction, maintenance, planning and administration costs), with grid assets, population density, and value of weighted angular towers as the output measures.

Frontier Economics, Sumicsid and Consentec (2013) used a DEA-based Malmquist approach to estimate productivity growth, which was then decomposed into technical and catch-up efficiency changes. Overall productivity growth was estimated to be a regress of 1.4% per annum over the period; catch-up efficiency improved by 2.4% per annum and technical change experienced a regress of 1.0% per annum. The authors note that the technical regress might have been due to the cost data used in the analysis, which might reflect structural organisational changes owing to unbundling requirements for some companies during the period.

Although this study reported a regress of the frontier of 1% per annum, the analysis used to derive the estimate meets our criteria considered in section 9.

[152] Sumicsid (2009), 'International Benchmarking of Electricity Transmission System Operators e3GRID Project', Final report, 2009-03-09.
[153] Before correcting for inflation, the frontier-shift estimate was 2.0%.
[154] Before correcting for inflation, the frontier-shift estimate was a regress of 0.6%.
[155] Frontier Economics, Sumicsid and Consentec (2013), 'E3GRID2012 – European TSO Benchmarking Study, A report for European Regulators', July.

We therefore consider -1% to be a relevant estimate for the study, and have included it in the relevant range of estimates in our assessment.

A3.2.3 Productivity Commission (Australia) (2012)

The Australian Productivity Commission estimated MFP growth for the utilities sector using sectoral data from the economy over the period from 1975 to 2009.[156] MFP was calculated as the ratio of outputs to a combined input index based on capital and labour.[157]

As part of the study, the Commission estimated MFP growth for the electricity supply and gas supply sectors as a whole. In particular, the study considered four sub-groups:

- electricity generation;
- electricity transmission;
- electricity distribution; and
- selling electricity and electricity market operation.

For electricity supply, the study reported a growth in MFP of 1.3% per annum and for gas supply 5.4% per annum. Both estimates are based on VA output measures. However, the study notes that the share of industry value added for electricity transmission out of the entire electricity supply sector is about 11%. Productivity estimates for electricity supply should therefore be interpreted as only partially relating to the transmission sector.

For the gas supply sector, the productivity estimates reflect gas distribution and retail activities. That is, the transmission of gas is excluded from the MFP estimates for the gas supply sector, and hence should not be considered a relevant benchmark for the gas transmission sector. Also, the authors appear not to consider input price pressures separately for the electricity and gas supply sectors. The resulting estimates therefore reflect productivity growth of the overall sector, and, hence, have not been considered in the study.

The estimate of 1.3% refers to the electricity sector as a whole (and not only on transmission), hence we ignore the estimate in our assessment. The gas supply estimate of 5.4% reflects gas distribution and retail activities only, and excludes gas transmission activities. This estimate is also disregarded in our assessment.

[156] Productivity Commission (Australia) (2012), 'Productivity in Electricity, Gas and Water: Measurement and Interpretation', March.
[157] The combined input index is computed as a Törnqvist index.

A4 Summary of the regulatory precedents reviewed in section 9

This section gives an overview of the regulatory precedents discussed in section 9 of the main report, and summarises recent regulatory precedents from Germany, the UK and France.

A4.1 BNetzA, Germany

For the first regulatory period covering 2009–2013,[158] BNetzA set a general productivity target of 1.25% per annum. For the second regulatory period covering 2013–18,[159] the general productivity target was set at 1.5% per annum. Both targets apply to gas and electricity distribution and transmission network operators.

According to the Bundesministerium der Justiz und fur Verbraucherschutz,[160] which provides the Ordinance on the general productivity factor, the general productivity targets were determined from the productivity differential between the sector and the wider economy, net of the differential in input price inflation. However, the methodology underlying the productivity estimates has not been described.[161]

In a regulatory document, Bundesnetzagentur (2006),[162] which reports the general productivity factor, the Tornquist method was mentioned as being appropriate for deriving the general productivity target. On this basis, it appears that the targets of 1.5% and 1.25% are set using the Tornquist index number methods, net of the input price differential. Hence, the targets may capture the effects of catch-up efficiency as well.

A4.2 Ofgem, GB

Under the RIIO regulatory regime, Ofgem based the ongoing efficiency targets for gas and electricity transmission (and distribution) operators on productivity growth indices of indirect comparators, using EU KLEMS datasets, over the period 2013 to 2021.

The comparator sectors were selected based on similarity of business processes between the sectors and transmission and distribution operators, as well as similarity in terms of the proportion of labour, materials and other inputs used in the production process. TFP was estimated based on VA and GO. Ofgem also estimated partial factor productivity (PFP) measures for labour based on VA, as well as for labour and intermediate inputs based on GO.

For gas and electricity transmission operators, the OPEX ongoing efficiency assumption was set at 1% per annum, while for CAPEX it was set at 0.7% per annum. The TOTEX ongoing efficiency assumption was 0.7% per annum for the transmission operators and 0.9% per annum for the system operators.

[158] The regulatory period is 2009–13 for the electricity transmission sector, and 2009–12 for the gas transmission sector.
[159] The second regulatory period is 2014–18 for the electricity transmission sector and 2013–17 for the gas transmission sector.
[160] See Ordinance on incentive regulation of energy networks (Incentive Regulation - ARegV) § 9 General sectoral productivity factor, available at http://www.gesetze-im-internet.de/aregv/__9.html
[161] Correspondence with BNetzA confirmed that the general X factor targets for electricity and gas TSOs are determined by law. However, no information was provided about the methodology behind the targets.
[162] Bundesnetzagentur (2006), 'Generelle sektorale Produktivitätsentwicklung im Rahmen der Anreizregulierung', 26 January.

To derive the real price effect assumptions, Ofgem examined historical data of price indices, company outturn data, and HM Treasury's forecast of input price growth. For the price indices, Ofgem examined both labour and non-labour price indices.[163] The average annual real price effect assumption ranges from 0.2% to 0.8% per annum.[164]

Together, this resulted in a per-annum net ongoing efficiency estimate of 0–0.6% for the electricity transmission operators, and 0.3–0.7% for the gas transmission operators.

A4.3 CRE, France, gas transmission

In determining the tariffs between 2013 and 2016 (known as the ATRT5 tariffs), the French Energy Regulation Commission (CRE) established productivity targets defining the trajectory for OPEX over the tariff period.[165] The gas transmission operators relevant to the deliberation are GRTgaz and Transport et Infrastructures Gaz France (TIGF).

CRE applied a productivity target, which it referred to as a 'predefined coefficient', to OPEX for 2014 to 2016 ranging from 0.25% in 2014 and gradually rising to 0.75% in 2016.[166] In its Deliberation, CRE did not state whether the coefficients refer to ongoing efficiency alone, or whether catch-up effects were included.

For investment programmes (relating to CAPEX), CRE noted that the French Energy Code stipulates that tariffs must cover all the costs borne by the operators, so long that they are determined to be efficient. CRE set up incentives based on the return on investment expenses. There appears to be no explicit productivity target per se.

In sum, for gas transmission operators in France, the productivity target applies to OPEX alone. Moreover, it is not clear from the description whether the productivity estimate is limited to frontier shift alone or captures other effects.

A4.4 CRE, France, electricity transmission

For the determination of tariffs for the high-voltage public electricity grid between 2013 and 2016 (TURPE 4 HB),[167] CRE established productivity targets for OPEX only, which ranged from 0.3% to 1.0% per annum.[168] It was noted in the Deliberation that the targets were negotiated between CRE and the Réseau de transport d'électricité (RTE, the electricity transmission operator). However, it was not discussed whether the targets referred to ongoing efficiency only, or reflected overall efficiency as well.

[163] Ofgem examined price indices for labour based on the private sector, construction, transport and storage, civil engineering and electrical engineering. Sectors from non-labour real price effects include infrastructure materials, steel works, plastic pipes, copper piping, plant and road vehicles, machinery and equipment.
[164] For transmission operators at National Grid Electricity Transmission and National Grid Gas Transmission, the real price effect assumptions are 0.8% and 0.4% per annum. For system operators at National Grid Electricity Transmission and National Grid Gas Transmission, the real price effect assumptions are 0.3% and 0.2%, respectively.
[165] Commission de Regulation De l'Energie (2012), 'Deliberation of the French Energy Regulation Commission of 13 December 2012 deciding on the tariffs for the use of natural gas transmission networks', 13 December.
[166] CRE set a level of OPEX for 2013 based on 2011 levels of OPEX adjusted for inflation.
[167] Commission de Regulation De l'Energie (2013), 'Deliberation of the French Energy Regulatory Commission of 3 April 2013 deciding on the tariffs for the use of a high-voltage public electricity grid', 3 April 2013.
[168] The target for 'Other purchases and services' was set at 1.0% between 2013 and 2016, and between 2011 and 2013, costs were allowed to rise according to inflation. For 'Staff expenditure', CRE set the target at 0.3% per annum over 2013–16.

The deliberation for TURPE 4 further sets out the incentive regulation framework for interconnection investments (related to CAPEX). These incentives do not relate directly to productivity. CRE noted that RTE will have to provide an assessment of the value of any planned interconnection investments, which CRE will incorporate into an 'ad hoc tariff decision'.[169]

[169] Commission de Regulation De l'Energie (2013), 'Deliberation of the French Energy Regulatory Commission of 3 April 2013 deciding on the tariffs for the use of a high-voltage public electricity grid', 3 April 2013, p. 24.

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