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NMa Energiekamer **15 July 2008**

The productivity growth of GTS

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1 EXECUTIVE SUMMARY

1.1 This report was prepared by Reckon LLP for the office of energy regulation (Energiekamer) of the Netherlands competition authority (NMa). It presents information that could be used by Energiekamer to determine the productivity gains to be taken into account in setting a price control for the transport business of Gas Transport Services (GTS).

1.2 This executive summary outlines the main results from the research.

1.3 Section 2 provides an overview of the productivity and unit cost measures that can be derived from macroeconomic data, and their relationship to measures of GTS's operating expenditure.

1.4 Section 3 provides sensitivity analysis of calculations based on a macroeconomic database published by the EU KLEMS academic research project.

1.5 Appendices provide further information. Appendix A surveys some utility price control decisions in Western European countries and other reports and articles on productivity improvement and expenditure trends in regulated utilities. Appendix B details definitions of productivity and expenditure measures, and methods used to estimate them. Appendix C provides productivity and unit cost statistics for each of the sectors for which relevant data are available from the EU KLEMS database for the Netherlands.

Unit labour costs in comparator sectors

1.6 We agreed with Energiekamer to focus our analysis on measures of productivity or expenditure change that would be most closely comparable with changes in GTS's operating expenditure relative to the Netherlands consumer price index (CPI).

1.7 On that basis, we highlighted results for measures of labour costs relative to CPI. These measures combine trends in productivity and input prices.

1.8 The main source of macroeconomic data that we use is the EU KLEMS database, which we have combined with inflation data from Statistics Netherlands (CBS). This provides sector-level productivity, input price and unit labour cost measures annually from 1979 until 2005 (or 2004 for some sectors). There are no particular problems with this data source, and we are not aware of any alternative sources of similar data.

1.9 Our results are expressed against the Dutch consumer prices index (CPI), which is generally used as a general price index in utility price controls in the Netherlands.

1.10 We have chosen to focus on data for the Netherlands. This is so that proper account is taken of any specific features of the CPI index relative to input prices.

1.11 Table 1 summarises the trends that we have calculated in selected sectors using data for the Netherlands from the EU KLEMS database.

Table 1 Unit labour cost trends (1979–2005)

Comparator sector	Reduction in unit labour costs relative to CPI	Reduction in unit labour costs relative to CPI adjusted for constant capital
Manufacture of chemicals, chemical products and man-made fibres	**3.5%**	**6.3%**
Manufacture of transport equipment	3.9%	4.7%
Wholesale trade and commission trade, except of motor vehicles and motorcycles	3.0%	3.6%
Manufacture of textiles, textile products, clothing and footwear	2.7%	2.6%
Manufacture of rubber and plastic products	2.6%	2.4%
Manufacture of electrical and optical equipment	2.7%	2.1%
Manufacture of food products, beverages and tobacco	2.0%	1.9%
Transport and storage	**1.5%**	**1.7%**
Manufacture of basic metals and fabricated metal products	1.5%	1.5%
Manufacture of machinery and equipment not elsewhere classified	1.7%	1.5%
Manufacture of wood and wood products	1.3%	1.3%
Manufacture of pulp, paper and paper products; publishing and printing	1.3%	0.7%
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	**1.0%**	**0.6%**
Manufacture of coke, refined petroleum products and nuclear fuel	(0.5%)	0.2%
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	0.4%	0.1%
Construction	**(0.1%)**	**(0.4%)**
Manufacture of other non-metallic mineral products	(0.0%)	(0.5%)
Financial intermediation	**0.9%**	**(0.5%)**
Market economy	0.9%	0.6%
Whole economy	0.9%	0.5%

Source: Reckon LLP analysis of published EU KLEMS and CBS data. Selected sectors only: full results are in appendix C. Annual rates of change are expressed in logarithms. Negative numbers (i.e. increases faster than CPI) are in brackets. Sectors in bold were used by Ofgem in 2007 as comparators for gas distribution operating expenditure.

1.12 The figures shown in table 1 are rates of reduction (expressed in logarithms) of labour costs relative to CPI per unit of output. Output in each sector is measured as value added at constant prices. This means that productivity and unit cost measures relate to the value added within the sector. For example, in the case of the manufacture of tobacco products, the productivity and cost measures used do not include the labour used in agriculture to produce tobacco leaves.

1.13 The data for unit labour costs relative to CPI adjusted for constant capital are derived from total factor productivity data. They reflect the reduction in unit labour costs that would have been achieved if the volume of capital input per unit of output (measured by value added) had been kept constant. This is based on standard assumptions about marginal rates of substitution between labour and capital inputs. This adjustment reduces the risk that comparisons of trends in unit labour costs across different activities are affected by different rates of investment in machinery.

1.14 In making comparisons between unit labour cost figures and projected trends for GTS's operating expenditure, the following points need to be taken into account:

(a) GTS incurs operating expenditure that cannot be attributed to labour costs. Although some of the expenditure on subcontractors and suppliers is a cost of labour, as an input to upstream elements of the supply chain, this will not cover everything. In particular, spending on gas (for own use or to cover leakage), local taxes, and regulatory fees includes significant amounts which are not in any sense labour costs. The same goes for any expenditure on capital inputs that is classified as operating expenditure as a result of operating lease arrangements, or because the capital is provided by suppliers or subcontractors as part of a supply of materials or services.

(b) GTS's operating expenditure reflects productivity and input price changes throughout the supply chain for its operations, including subcontractors and suppliers as well as GTS's direct labour costs. Insofar as sectors are used as comparators, what matters is similarity to activities in GTS's whole operations supply chain, not just operating activities directly under GTS's control.

1.15 Nonetheless, the combination of direct labour costs and indirectly incurred labour costs through the operating supply chain represents an important part of GTS's operating expenditure. For this reason, information about trends in unit labour costs and trends in unit labour costs adjusted for constant capital in other sectors can be taken into account in making assumptions about future trends in operating expenditure for GTS.

1.16 Table 1 is sorted by the rate of reduction in unit labour costs adjusted for constant capital (in descending order). It does not include every sector for which data are available (full results are in appendix C). Sectors were omitted from table 1 where either of the following conditions was met:

(a) There are data within the database for a more disaggregated sector.

(b) The nature of the activities or the inputs and outputs are very different from those involved in operating expenditure for a gas transmission network.

1.17 For example:

(a) Data for the telecommunications sector are not included in table 1 as they relate primarily to the exploitation of capital-intensive electronic networks, rather than operating expenditure on such networks.

(b) Data for the mining and quarrying sector relate primarily to the extraction of existing mineral resources and not to anything similar to operating expenditure.

(c) Data for public administration and defence are not included as measures of output volume growth for such activities are difficult to compare to the more tangible measures of outputs relevant to gas transmission operating expenditure.

1.18 The remaining sectors share certain similarities with parts of the supply chain behind the operating activities of a gas transmission network in terms of their nature of work. These similarities are summarised as follows:

(a) Each of the comparator sectors, except financial intermediation, involves an element of asset management and health and safety responsibilities comparable, in some respects, to those of GTS and its supply chain.

(b) The construction sector, the transport and storage sector and parts of the wholesale and retail trade sectors involve a similar geographical spread of activities (rather than factory-based work) as a gas transmission network. They also include management of operations, contracts, suppliers and customers which have similarities to some of the activities undertaken by GTS and its supply chain.

(c) The maintenance activities undertaken as part of the repair and maintenance of motor vehicles and motorcycles involve a similar level of skilled labour and technology as the operation and maintenance of a gas transportation network.

(d) Financial intermediation has similarities to some administrative functions carried out in operating a gas transmission network such as shipper account management, data management and data audit.

Regulatory precedents and other studies

1.19 The sectors that are shown in bold in table 1 were highlighted in Ofgem's analysis of productivity trends for its 2007 price control review for gas distribution networks in Great Britain. Ofgem considered trends in labour productivity and labour productivity adjusted for constant capital in these sectors for the UK, calculated using the same methods and data source as in this study. Ofgem selected a base figure for productivity growth "towards the lower end of the range" of results from these sectors and added a "comparative competition" assumption (from other sources) to get an industry-wide productivity trend. Ofgem combined this base figure with estimates of input price growth relative to the UK retail prices index to obtain a trend in operating expenditure.

1.20 This example demonstrates one way in which data from macroeconomic sources has been used in a regulatory context. There is one important difference between the data used by Ofgem and the data in table 1: since the data in table 1 relate to expenditure trends relative to CPI, not to labour productivity, there is no need to combine them with estimates of input price trends.

1.21 Appendix A summarises a number of other regulatory decisions and studies in which aspects of productivity growth or expenditure trends in regulated utilities are examined. Whilst all these studies and decisions may be considered informative at a qualitative level, we have not found a robust way of bringing them together into a consistent basis that could be compared with other sources of evidence for GTS's operating expenditure trends.

2 USE OF MEASURES FROM MACROECONOMIC DATA

2.1 This section examines how measures of productivity and cost changes from macroeconomic data might be compared with rates of change in GTS's operating expenditure.

Overview of productivity and cost measures

2.2 The science of productivity measurement has generated many possible measures, and the terminology that has been used in past regulatory debates has not always been completely consistent.

2.3 We identify the main features of a measure of productivity or unit expenditure through the following questions:

(a) Is it a measure of productivity or of cost?

(b) Does it relate to gross output or to value added?

(c) Is it partial factor productivity or total factor productivity?

(d) Does it rely on any hypotheses about any inputs or outputs?

2.4 We now consider the effect of choices in each of these areas on the usefulness of a productivity measure for making comparisons, and identify in each case the approach that we consider likely to be most relevant for the purpose of GTS' s price control.

Is it a measure of productivity or of cost?

2.5 Productivity growth is ordinarily defined as a differential between a change in the volume of outputs and the change in the volume of inputs. This is a non-financial measure.

2.6 In order to estimate an expenditure trend from a productivity trend, information about changes in the prices of inputs is required.

2.7 It is therefore necessary to distinguish between productivity measures and cost or expenditure measures. Within the latter category, further distinctions can be drawn depending on the index — e.g. CPI or the GDP deflator — by reference to which changes in expenditure over time are defined.

2.8 To be useful in setting price controls of the kind envisaged for GTS, results must be converted into cost trends relative to CPI. Absent an overriding basis to use productivity measures, it would therefore seem simplest and most transparent to base comparisons on measures of cost relative to CPI, rather than productivity.

2.9 Given this, our approach is to highlight a concept of cost relative to CPI as our main measure, but also report productivity data for comparison with other analyses.

Does it relate to gross output or to value added?

2.10 A measure of productivity based on gross output relates to a specific step in the production process or supply chain. It treats all purchases by the operator of that step (e.g. services bought in from subcontractors, etc.) as inputs for productivity measurement purposes.

2.11 In a value added measure, labour and capital are the only relevant inputs. Instead of being taken into account as inputs, purchases of materials, services or energy are netted off gross output in order to determine a concept of value added (or net output). This value added, measured at constant prices, is used as the output measure for productivity measurement. The effect is that, for example, an increase in the amount of energy, materials or services purchased contributes to an increase in net output and therefore an increase in productivity, which is combined with the productivity changes resulting from changes in the use of labour and capital inputs.

2.12 A measure of productivity based on value added can usefully be applied to the whole supply chain involved in producing a specific product or service. When value added is aggregated across the supply chain, most elements that were seen as intermediate purchases of energy, materials or services will be analysed in terms of labour, capital, and some further intermediate inputs down the chain. We exclude extractive industries from this aggregation, so that the only the elements of materials and services that are not included in that concept total value added are those that relate to imports or to extracted products (including gas).

2.13 At first sight, a gross output measure is simpler and more directly relevant to GTS's expenditure than a value added measure.

2.14 Whilst data availability is less good for gross output measures than for value added measures, sufficient data are available on gross output measures to permit their use if it were considered appropriate.

2.15 However, we have identified concerns about the reliability of comparisons of productivity trends drawn using gross output measures.

2.16 Productivity measured by reference to gross output depends on the industrial structure of each sector: a vertically integrated sector will show higher productivity growth based on gross output than a vertically disaggregated sector, even if the resources used and the goods and services produced, taken across the whole supply chain, had been the same in the two sectors.

2.17 Furthermore, the intermediate inputs that need to be taken into account in using a measure of productivity based on gross output are specific to each industry. They could well have sector-specific price trends. Absent a countervailing basis to use gross output measures, this potential discrepancy makes comparisons less credible than comparisons based on value added measures, as the latter are based primarily on labour, which is more comparable between sectors.

2.18 Appendix B has more details on these issues. In this report we focus on the value added measures.

Is it partial factor productivity or total factor productivity?

2.19 Total factor productivity seeks to capture all the inputs that go into the production process. Partial factor productivity focuses on certain specified inputs — in particular, labour productivity based on value added ignores capital inputs.

2.20 Which of these measures is appropriate depends on the use that will be made of the results in setting price controls.

2.21 If the results are to be used to estimate some notion of operating expenditure (and then combined with an allowed rate of return on capital and an amortisation term in order to calculate total revenues), then a partial productivity measure based on the inputs that are treated as operating expenditure is the appropriate measure.

2.22 By contrast, if the results are to be used to estimate trends in prices without any direct consideration of the cost of capital or a profit element in price controls, then a total factor productivity measure is more appropriate.

2.23 We have assumed that a cost of capital would be included separately, and therefore we highlight results expressed in terms of partial factor productivity or operating expenditure. We report some total factor productivity numbers for the purpose of comparison with other studies that have used such measures.

Does it rely on any hypotheses about inputs or outputs?

2.24 Our fourth question in defining productivity and related measures is whether any assumptions or hypotheses are made in defining or estimating the measure.

2.25 The main example of such a hypothesis occurs in the case of the measures of labour productivity or unit labour costs assuming constant output and constant services from capital (see appendix B for relevant definitions and calculation rules). This adjusts data on labour volumes to try and make them representative of what would have happened if, instead of whatever net investment actually occurred, the company or sector in question had maintained the plant and machinery used in production at a constant level of capability and capacity for each unit of output (assuming no economies of scale at the sectoral level).

2.26 The purpose of this constant capital hypothesis is to remove from the labour productivity data any effect that might be due to capital substitution.

2.27 This adjustment addresses the concern that it would be unfair to expect that GTS will reduce labour costs to the same extent as some other sectors if these other sectors can only achieve these reductions by investment in new machinery, unless GTS's revenues include a suitable allowance for a corresponding level of investment.

2.28 Using data subject to the constant capital assumption is a way of separating out routine productivity improvement due to managerial and technological changes from the effect of investment.

Relationship between productivity and costs

Productivity is the difference between changes in output and input volumes

2.29 The starting point for a definition of productivity is the difference between input volume growth and output volume growth. Productivity is said to have increased if the increase in the amount of outputs produced exceeds the increase in the amount of resources employed in production.

2.30 This general definition raises issues of measurement of input and output volume. Its use in setting price controls raises the further issue of converting input volumes into prices or revenues. We now turn to these issues.

Output is often measured as a volume of value added, not a quantity of services supplied

2.31 The most direct definition of productivity for an individual company takes output to be the volume of goods or services that it provides to its customers, and inputs as the volumes of capital, labour, energy, materials and services that it uses. This is the "gross output" concept of productivity.

2.32 Much of the macroeconomic evidence on productivity does not relate to this gross output concept. This is because macroeconomic work focuses on growth accounting for the economy as a whole, and on gross domestic product as a main measure of the output of the economy. Gross domestic product is not the aggregate of the goods and services that the firms in the economy provide to their customers: instead it is defined net of the aggregate of the intermediate products that each firm buys. Thus, it is not meaningful to average or aggregate the effect of productivity gains measured by gross output in different firms or sectors in order to study economic growth as a whole.

2.33 Macroeconomic studies often use another definition of output. Instead of defining output growth for a sector as the increase in the volume of goods or services delivered, they define it as the increase in the value added of that sector that would have taken place as a result of changes in output and intermediate input volumes if all prices had been held constant. With that value added definition of output, the only inputs treated as such are labour and capital.

2.34 The advantage of value added measures for macroeconomic studies is that they can be aggregated or averaged between sectors and over the economy as a whole. Gross domestic product is the sum of value added for all firms or all sectors, and economic growth is the change in gross domestic product assuming constant prices.

Productivity measurement in some sectors must be interpreted with care

2.35 In some sectors, capacity utilisation is an important determinant of productivity. When output is at capacity, output per unit of input is typically high and low otherwise. A sector particularly prone to such an effect is the mining and quarrying sector where output and productivity are determined by commodity price changes and the difficulty of extracting the relevant natural resources. Measured productivity in such sectors is therefore not primarily determined by changes to working practices or technologies. There is therefore a risk that productivity or unit costs measures in such sectors will be affected by factors that have no connection to trends for operating expenditure of a gas transmission network operator.

2.36 Another problem arises in sectors that are largely government controlled. Many government departments do not sell their services in a market and thus defining their output is problematic. Output for these government departments is therefore often measured by reference to the efforts or inputs applied to the service — e.g. number of teacher-hours, or number of police patrols. Such an approach does not fully recognise the improvements in productivity that might exist in these sectors.

2.37 If a gross output measure of productivity is used, then there is a further risk in the case of industries that have undergone restructuring. For example, a vertical separation within a supply chain could increase gross output and intermediate inputs by recognising additional transactions in the national accounts. Such a change, especially if it happens suddenly (rather than slowly over a period of time) could distort gross output measures of productivity (but not value added measures).

2.38 These factors need to be borne in mind when considering sectors as potential comparators for GTS.

Productivity and unit costs

2.39 Our terms of reference state that "a clear distinction should be made between the various partial and total productivity measures (OPEX, CAPEX, TOTEX)". It does not suggest a specific definition of productivity. Given that "opex productivity" would be nonsensical as such (opex is not an input or an output volume measure), we take the requirement to be for productivity measures that enable Energiekamer to estimate trends in operating expenditure and in relevant measures of capital expenditure or total expenditure.

2.40 In order to meet this requirement, we think that it is necessary to collect evidence on input prices as well as on productivity. A productivity number on its own would, at best, enable Energiekamer to estimate the reductions in labour (and other inputs if relevant) that might be expected to be achieved by GTS — but this would not help in setting a price control without information on the extent to which these reductions might be offset by increases in wages (and other input prices if relevant).

2.41 We propose to focus the research on input prices on Dutch data.

2.42 This is because labour market conditions and some aspects of inflation are likely to be different from those of other countries, even immediate neighbours.

2.43 For example, in the UK, the most common measure of inflation for regulatory purposes is RPI. This differs quite significantly from the UK CPI measure (also known as HICP), which uses definitions and methods harmonised by Eurostat.

2.44 Thus, arguments based on relationships between RPI and the GDP deflator in the UK cannot legitimately be expected to work in the Netherlands.

2.45 By contrast, we consider it appropriate to rely on foreign evidence for productivity measures properly conceived in terms of volumes (or values at constant prices). This is on the assumption that the technological and managerial changes that underpin reductions in input volume and/or increases in output volumes are comparable between countries.

Relationship between unit labour costs and GTS operating expenditure

2.46 The remainder of this section describes how Energiekamer might use our calculations of unit labour cost trends in comparator sectors using the EU KLEMS database as part of its analysis to set price controls for GTS.

The focus is on estimating a trend for GTS's operating expenditure

2.47 GTS's allowed revenue can be decomposed into two broad components:

(a) a capital element to cover return on capital and amortisation; and

(b) revenue allowed to cover operating expenditure.

2.48 The revenue allowed from capital is outside the scope of this study. The analysis presented in this paper does not relate to this element of revenue.

2.49 However, an assumption is required about the assets that will be delivered by the expenditure on capital because this could affect opex. Our analysis uses a baseline of constant output and constant capital input. Energiekamer can then make assumptions about any deviations away from this baseline in a transparent manner.

2.50 The analysis therefore focuses on trends for operating expenditure given constant output and constant capital inputs.

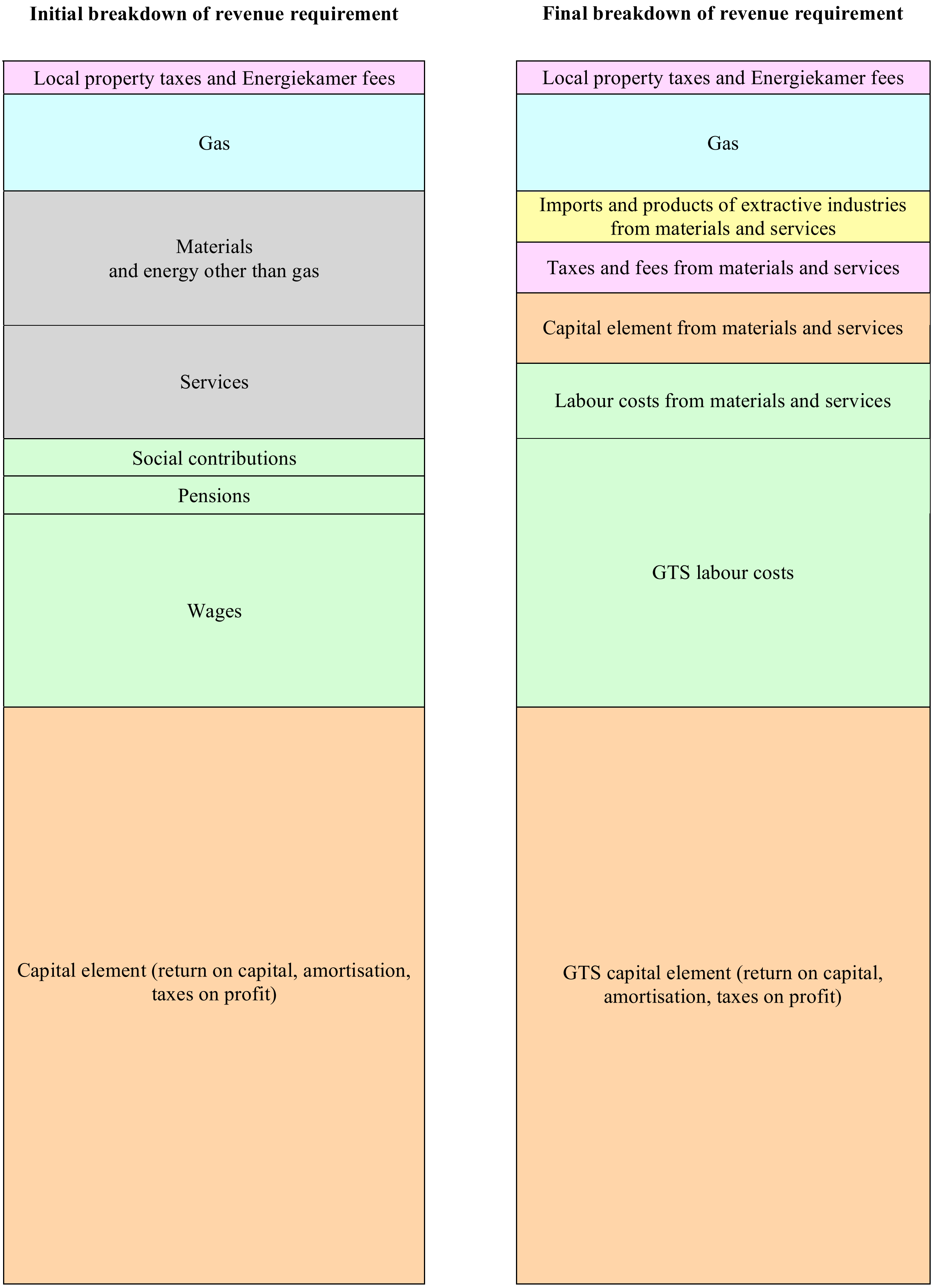
Operating expenditure can be decomposed into several different components

2.51 The use of our measure of unit labour cost trends requires operating expenditure to be separated into its constituent components. The unit labour cost trends will provide evidence for the labour cost component of the decomposed operating costs.

2.52 Operating expenditure can be split into a number of generic components in any industry. For GTS these components might be categorised as wages; social contributions; pensions; gas; materials; services; and taxes and Energiekamer fees.

2.53 Wages, social contributions and pensions can be grouped as labour costs. Part of expenditure on materials and services will relate to imports and products from extractive industries which can be separated from other materials and services costs. The remaining materials and services costs can be grouped as the residual intermediate inputs (i.e. excluding imports and products from extractive industries).

Figure 1 Decompositions of GTS revenue requirement



2.54 These residual intermediate inputs can themselves be traced back up the supply chain where a similar breakdown of their costs can be undertaken. Using the same method as before, the cost of each intermediate input can be split into capital, labour, taxes and fees, and intermediate inputs excluding imports and products from extractive industries. This process can be repeated throughout the entire supply chain until all intermediate inputs have been traced back to costs from labour, capital, taxes and fees, imports and products from extractive industries.

2.55 Figure 1 illustrates the initial and final decompositions when this process is applied to GTS's revenue requirement.

Labour is likely to be the largest component

2.56 The overall effect of this repeated decomposition is that a large proportion of the expenditure will be reattributed to labour and capital elements, even if at each step the intermediate inputs such as materials and services are a significant share of spending. For example, if at each stage of the supply chain the allocation was 45 per cent labour, 20 per cent capital, 5 per cent imports and extracted products, and 35 per cent other intermediate inputs, then at the end of the decomposition process the final shares would be 64 per cent labour, 29 per cent capital and 7 per cent imports and extracted products.

2.57 When this decomposition, which only applies to a portion of GTS's operating expenditure, is combined with GTS's direct labour costs, then the overwhelming element in operating expenditure excluding taxes, fees and gas costs will be labour.

2.58 The next most important element within GTS's operating expenditure excluding taxes, fees and gas costs is likely to be the capital element from the materials and services purchased by GTS. How large this is will depend in significant part on the extent to which GTS uses operating leases for assets used in managing its network: if many vehicles or items of machinery are leased in this way then the services purchased by GTS out of operating expenditure will have a significant capital element. Other services purchased by GTS, e.g. construction, are likely to have a smaller capital element when decomposed as described above. We do not have sufficient information about GTS's supply chain to reach any view as to the significance of the capital element in the decomposition of GTS's operating expenditure excluding taxes, fees and gas costs.

Our analysis relates to trends in labour costs

2.59 The decomposition of operating costs throughout the entire supply chain resulted in GTS's revenue requirement being divided between labour costs, a capital element, gas costs, cost of imports and products from extractive industries, and taxes and fees.

2.60 The capital element and the taxes and fees are completely out of the scope of our work.

2.61 The evidence that we present in this report is relevant to the trend in the combined labour costs of GTS and its supply chain. As noted above, we do not know the size of the capital and other elements in the decomposition of the intermediate products used by GTS: therefore we do not know what proportion of operating expenditure is represented by these labour elements.

2.62 In the face of this uncertainty, some simplifying assumptions might be made to use the evidence on labour costs in comparisons between GTS and other sectors. For example:

(a) The share of products from extractive industries in operating expenditure might be approximated by the share of gas expenditure in GTS's operating expenditure. This makes the assumption that there is negligible use of such products in the other intermediate inputs used by GTS.

(b) The remainder of operating expenditure, after the deduction of products from extractive industries, taxes and fees, might be taken to follow the same trend as labour costs. This would amount to assuming either that capital elements, fees and taxes when the intermediate inputs are decomposed through the supply chain are negligible; or that these elements follow the same trend as labour costs.

2.63 It will be for Energiekamer to decide how to use the evidence in this report on labour cost trends in comparator sectors, in conjunction with its own assessment of the potential effect of simplifying assumptions such as those listed above, when drawing on comparisons of productivity trends to set price controls for GTS.

Estimating labour cost trends

2.64 Our method of estimating a labour cost trend it is to combine a labour productivity trend with a labour price trend.

2.65 The productivity trend gives an indication of the reduction in labour volumes that might be expected, and when the volume trend is combined with a price trend a trend for labour costs can be obtained.

2.66 To calculate labour productivity trends we have used data from the EU KLEMS database. This database allows the estimation of labour productivity trends for a range of sectors using data for the Netherlands from 1979 to 2005. Using this database one can select a range of comparator sectors that are considered to have labour productivity improvements that are representative of the gas transmission sector and its upstream supply chain. Since the inputs of GTS have been reduced to labour and capital it is appropriate to use a value added measure of output when calculating these productivity trends.

2.67 However, the labour productivity improvements that are observed in these sectors may have only been possible due to a shift in the input mix from labour to capital. To make these productivity trends comparable with the assumed baseline for GTS (constant capital and constant output) it is necessary to make an adjustment. This adjustment requires an assumption about the marginal rate of substitution between labour and capital: this is discussed in appendix B.

2.68 The EU KLEMS database also enables the calculation of a labour price trend for each of the comparator sectors. When CPI inflation is deducted this gives a labour price trend relative to CPI. If this labour price trend is subtracted from the relevant capital-adjusted labour productivity trend, then a unit labour cost trend relative to CPI adjusted for constant capital is obtained. These unit labour cost trends for the comparator sectors then provide evidence on the trend to be followed by the labour cost element of GTS's operating expenditure.

Estimating gas expenditure trends

2.69 One element of operating expenditure that is not captured by the above analysis is expenditure on gas.

2.70 Gas expenditure trends could be obtained by combining a gas volume trend with a gas price trend. With an assumed baseline of constant capital input and constant output, it seems appropriate to take gas consumption to be constant: otherwise there is a risk of inconsistency if replacement of assets such as compressors with more efficient modern versions is taken into account in estimating gas consumption without being fully funded in terms of capital expenditure.

2.71 The prime driver of gas expenditure is likely to be gas prices. These prices are often volatile. Past trends are unlikely to informative. Global political events may tend to play a much larger role in determining energy prices than any productivity considerations in the energy supply chain.

2.72 We conclude that the approaches discussed in this report for labour costs cannot be used as part of a method to forecast GTS's gas expenditure. Some other method is needed. This does not fall within the scope of the present study.

3 EU KLEMS SENSITIVITY ANALYSIS AND RELEVANCE OF COMPARATORS

3.1 This section presents the sensitivity of input price, productivity and unit labour cost trends from EU KLEMS data.

Relevance of different time periods

3.2 The estimates from EU KLEMS depend on the period chosen for averaging.

3.3 Absent any other information about the dynamic structure of the data, the natural approach would be to maximise the period over which the average is taken so as to minimise statistical noise.

3.4 In the case of the relevant EU KLEMS data for the Netherlands, this leads to a maximum period of 1979–2005 for some sectoral aggregates and 1979–2004 for others.

3.5 We now consider factors that might be taken into account in determining whether to use an average over the whole period or some other measure.

Effect of the business cycle

3.6 Some authors have considered it necessary to reduce the time period over which the average is taken to take account of business cycles. We have therefore examined some of the literature related to business cycles.

3.7 The concept of business cycle is defined by Cooley and Prescott (1995) as follows:[1]

> An examination of the time path of output for any modern industrialized economy quickly reveals that output tends to fluctuate about a long-term growth path. These fluctuations about trend are what we most often think of as the business cycle. The fluctuations are typically irregularly spaced and of varying amplitude and duration.

3.8 The irregularity of the amplitude of the fluctuations means that it would not be correct to look for the bottom or top of a set of business cycles and calculate productivity growth (or anything else) between these two points. That would be vulnerable to the risk — indeed likelihood — that one of the peaks or troughs was bigger than the other.

3.9 The trends around which the economy fluctuates according to business cycle theory cannot be directly observed. A chartist examination of the historical record in an attempt at separating trend from fluctuations is doomed to fail. When considering growth in a single variable, the best estimate of the trend (if it is deemed constant) is the average growth over the entire data period.

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1 Cooley, T. F. and E. C. Prescott (1995) "Economic Growth and Business Cycles" Chapter 1 in T. F. Cooley, ed., *Frontiers of Business Cycle Research*, Princeton University Press, pages 1–38.

3.10 What the business cycle theory and analysis in Cooley and Prescott (1995) points to, rather than any attempt at identifying any kind of business cycle periods, is the importance of correlations between the fluctuations of different variables.

3.11 Insofar as the analysis of 1954–1991 US data reported by these authors can be taken as representative of the behaviour of data for the Netherlands, the most important features for the present study are captured by the following extracts from Cooley and Prescott (1995):

> The magnitude of fluctuations in output and aggregate hours of work are nearly equal.
>
> The capital stock fluctuates much less than output and is largely uncorrelated with output.
>
> Productivity is slightly procyclical but varies considerably less than output.
>
> Wages vary less than productivity.
>
> The correlation between average hourly compensation and output is essentially zero.

3.12 In these statements, wages refer to inflation-adjusted figures (measured in 1982$), and productivity refers to total factor productivity based on value added.

3.13 The procyclical nature of productivity might be understood as a result of lower rates of utilisation of the production capacity in periods of below-trend output (combined with a measurement method for services from capital which treats them as proportional to capital stock, and therefore spread over time essentially uniformly irrespective of utilisation). It is however uncertain to what extent the economy-wide fluctuations will be reflected in individual sectors or companies.

3.14 Overall, the analysis of business cycles outlined above might be taken to indicate that the effect of fluctuations in economic output on the 20-year average of a productivity growth rate are likely to be modest in magnitude (relative to the inaccuracies inherent in the measurement of productivity) and that there is little scope for improving the estimates by making adjustments for business cycle effects. Essentially if using different periods for averaging gives different results then that differences represent a genuine element of uncertainty about productivity trends, which must be taken into account in reaching regulatory decisions.

3.15 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. In order to identify the element of uncertainty noted above whilst taking account of the priority to be given to more recent data, we therefore present some of our results in the form of a chart showing the effect of the start date of the averaging period on the average growth value, keeping the end date of the averaging period to the latest available data (in the case of EU KLEMS data, this is 2004 or 2005, depending on the sector and data series under consideration). The sensitivity of trends to the choice of averaging period is examined empirically later in this section.

Correlations between input price and productivity movements

3.16 One other source of fluctuation in productivity data unconnected to the output-based notion of business cycle discussed above is the hypothesis that there is a correlation between input price growth and productivity growth.

3.17 At the level of the economy as a whole, it is reasonable to expect a strong correlation between a measure of total factor productivity and the difference in price trends between the inputs and outputs that are relevant to the notion of total factor productivity in question. The same theoretical point is raised in Bernstein and Sappington (1998) and discussed in appendix A of this report.

3.18 The same theoretical point also applies at the level of an individual sector too: if productivity rises, then either wages or profits (or, if a gross output measure is used, prices of inputs) will need to rise relative to output prices to maintain financial balance. Whichever of those rise, this will count as input price growth relative to output prices, provided that operating surplus is used as the basis of price measurement for capital inputs.

3.19 But the cases of the whole economy and an individual sector differ materially from each other when partial productivity measures are used. In that case, the financial balance condition does not apply, and it is possible for significant independent variations to occur for the price of a unit of input and number of units of outputs obtained per unit of input.

3.20 As labour is the main input in the economy, and by far the main input on the operating expenditure measures on which we focus in this report, our main interest is in the possibility of a correlation between wage growth (relative to a general inflation measure such as CPI) and productivity growth.

3.21 If there is such a correlation, then it would be incorrect to combine independently constructed productivity and wages estimates into a unit cost measure: this would run the risk of inconsistency between, for example, the reference periods used to measure trends in productivity and in wages.

3.22 To address this risk, we think that productivity trends and input price trends should be calculated over the same period in order to provide appropriate estimates of historic unit cost trends. Our unit labour cost measures deliver this by combining contemporaneous input price and productivity data into a single measure.

Review of productivity and unit cost data for comparator sectors

Presentation of results

3.23 In order to analyse the impact of the averaging period on the results, we have produced charts for different sectors using the following format:

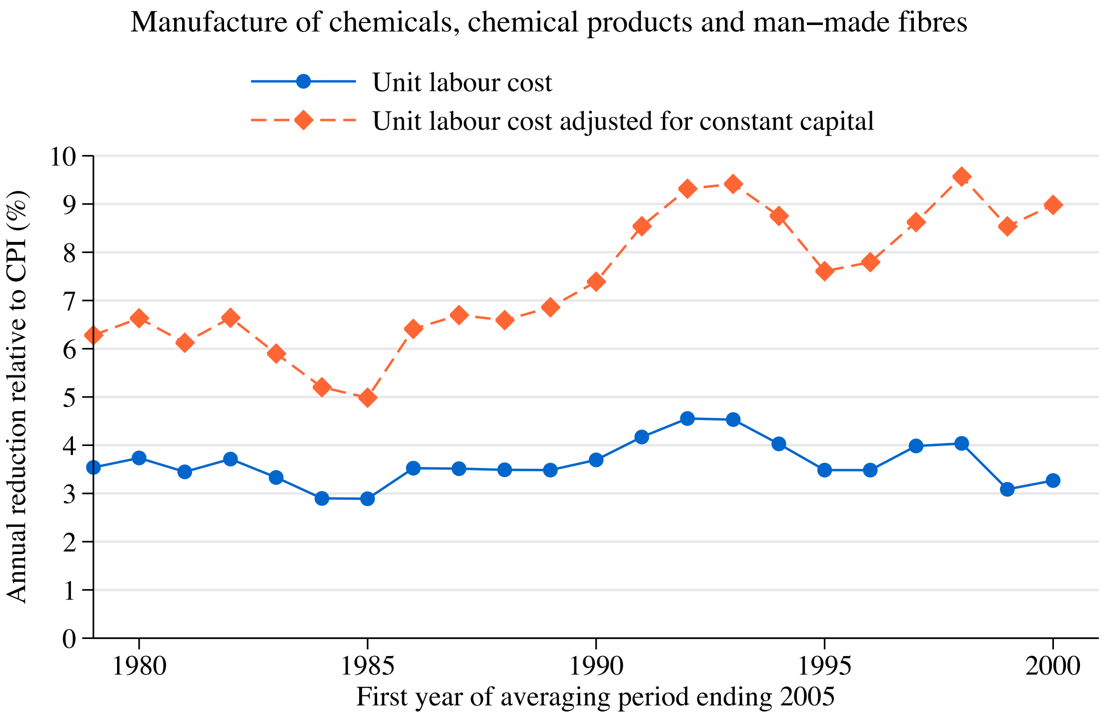
(a) The horizontal axis is a year ranging from 1979 to 1999: this is the first year of the period over which variables have been averaged. The last year of the averaging period is 2004 or 2005 and is shown on the chart.

(b) The vertical axis is an annual percentage change (expressed as a logarithm). This is defined as a productivity increase (e.g. labour productivity adjusted for constant capital), a reduction in unit labour costs relative to CPI, or an increase in wages relative to CPI.

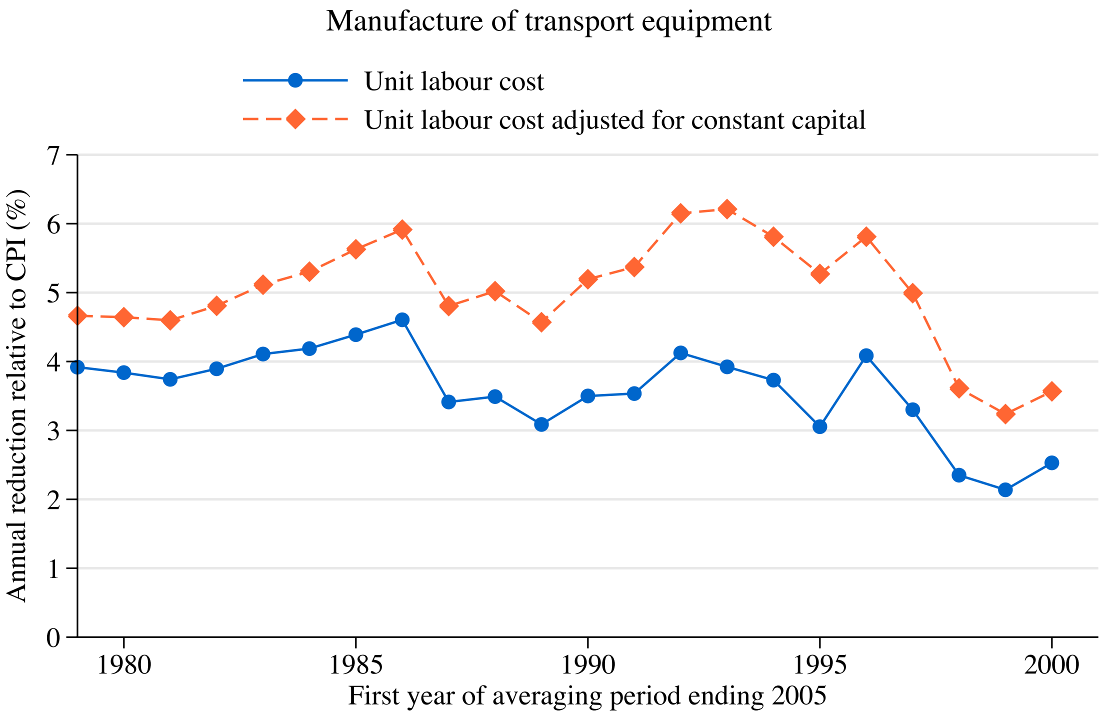
3.24 All the data presented in these charts are based on volume of value added as the output measure.

Comparator sectors highlighted in table 1

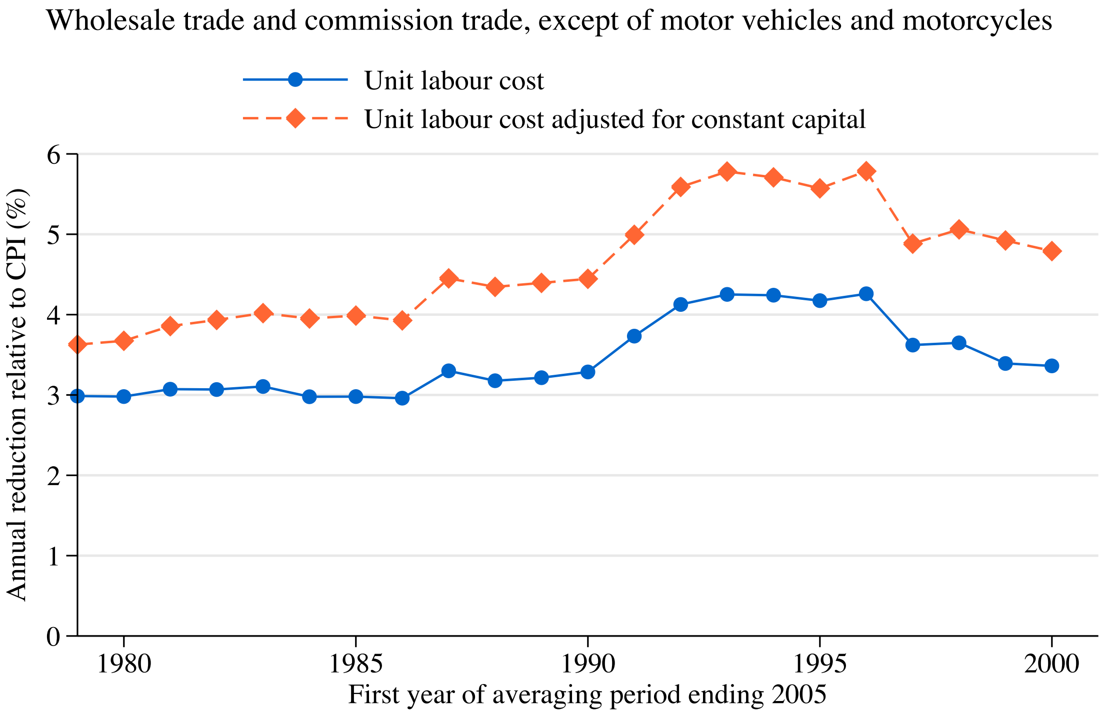
3.25 Manufacture of chemicals is a process industry involving management of fluids in high-pressure vessels and pipes. It also involves asset management and health and safety responsibilities. These features are similar to the activities involved in operating a gas transmission network.



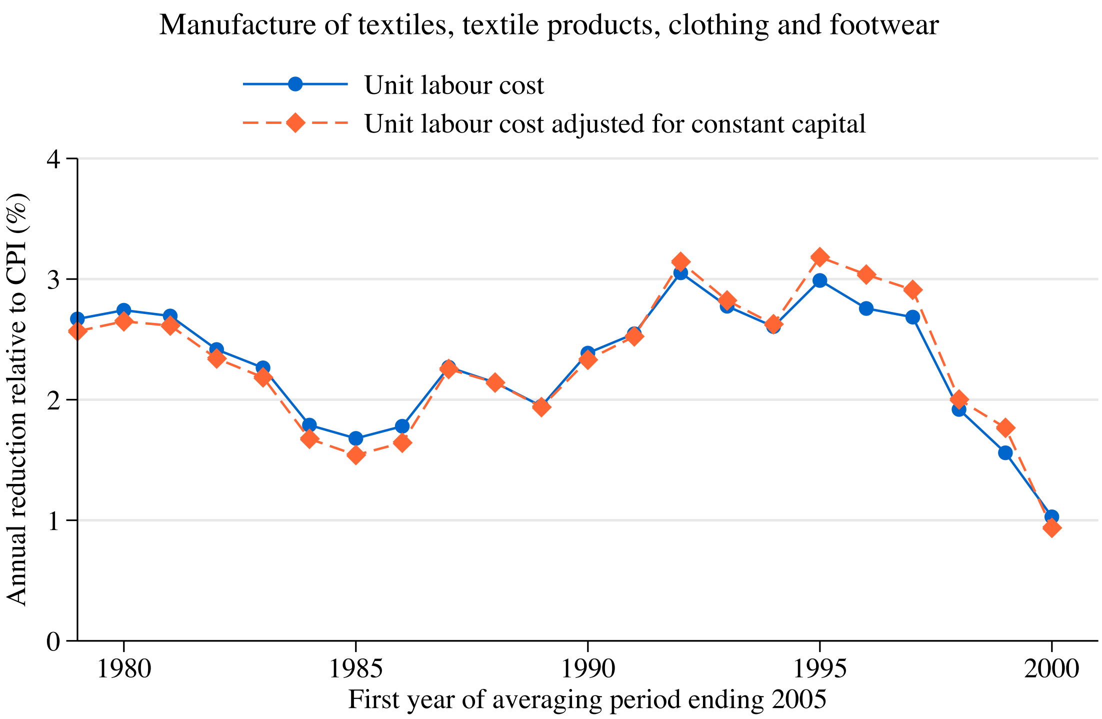
3.26 Manufacture of transport equipment involves large factories with similar asset management and health and safety responsibilities to the activities of GTS and its supply chain.



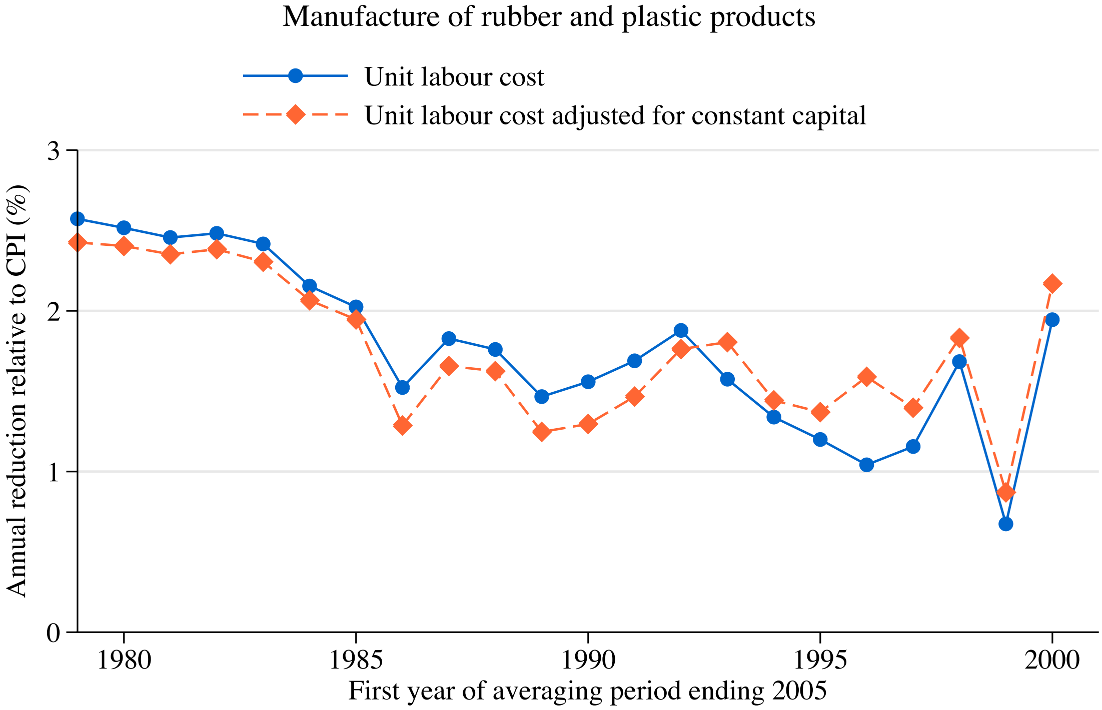
3.27 The wholesale and commission trade sector involves a similar geographical spread of activities as gas transmission network and its supply chain. It also includes management of operations, contracts, suppliers and customers which have similarities to the activities involved in providing a gas transmission network.



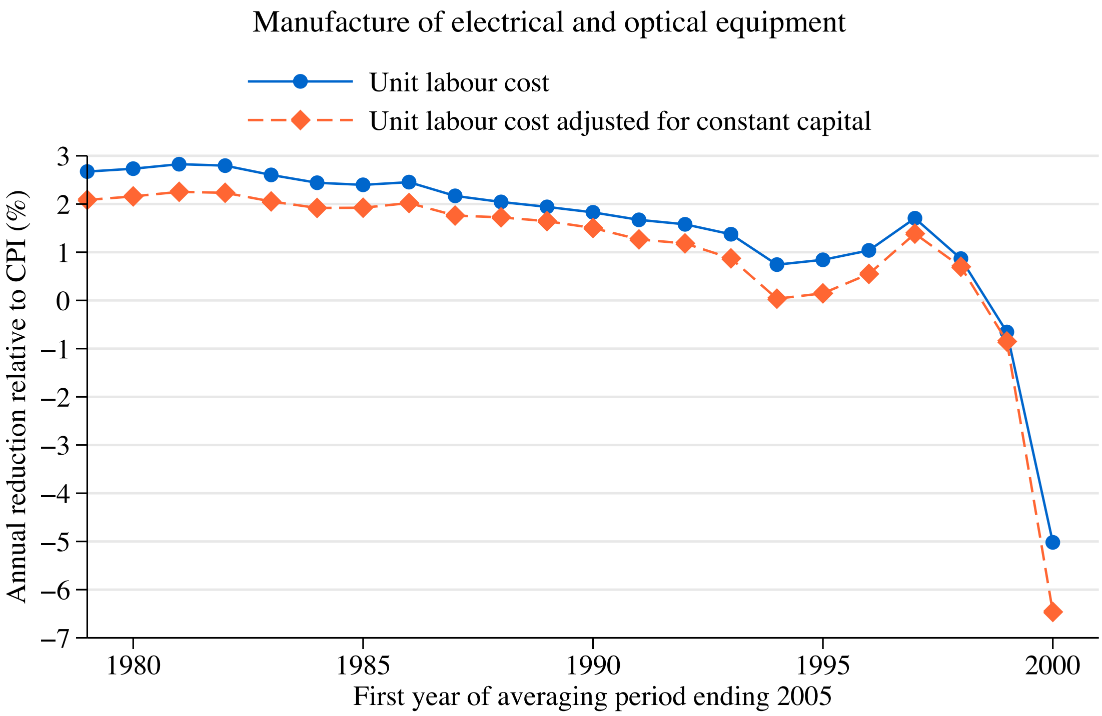
3.28 The manufacture of textiles has been included as a comparator as it did not meet any of our conditions required for omission. That is to say, the nature of the activity or the inputs or outputs were not deemed to be very different from those involved in operating expenditure for a gas transmission network.



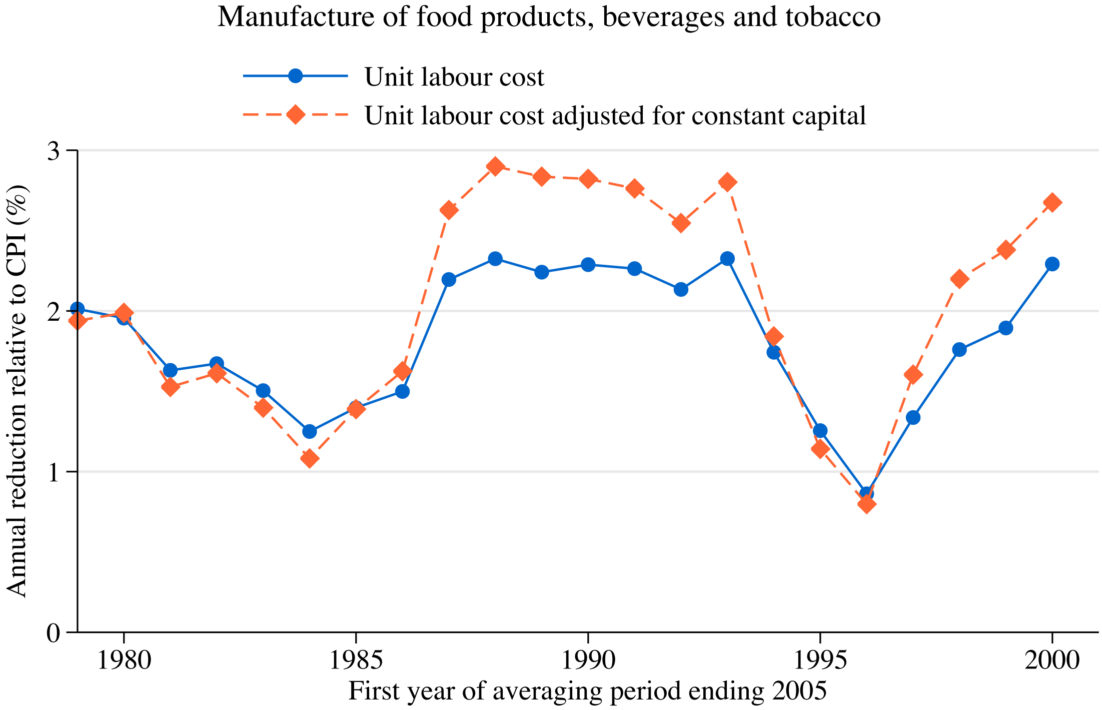
3.29 The manufacture of rubber and plastics, like the manufacture of chemicals, is a process industry involving management of fluids in vessels and pipes. It also involves asset management and health and safety responsibilities. These features are similar to the activities involved in operating a gas transmission network.



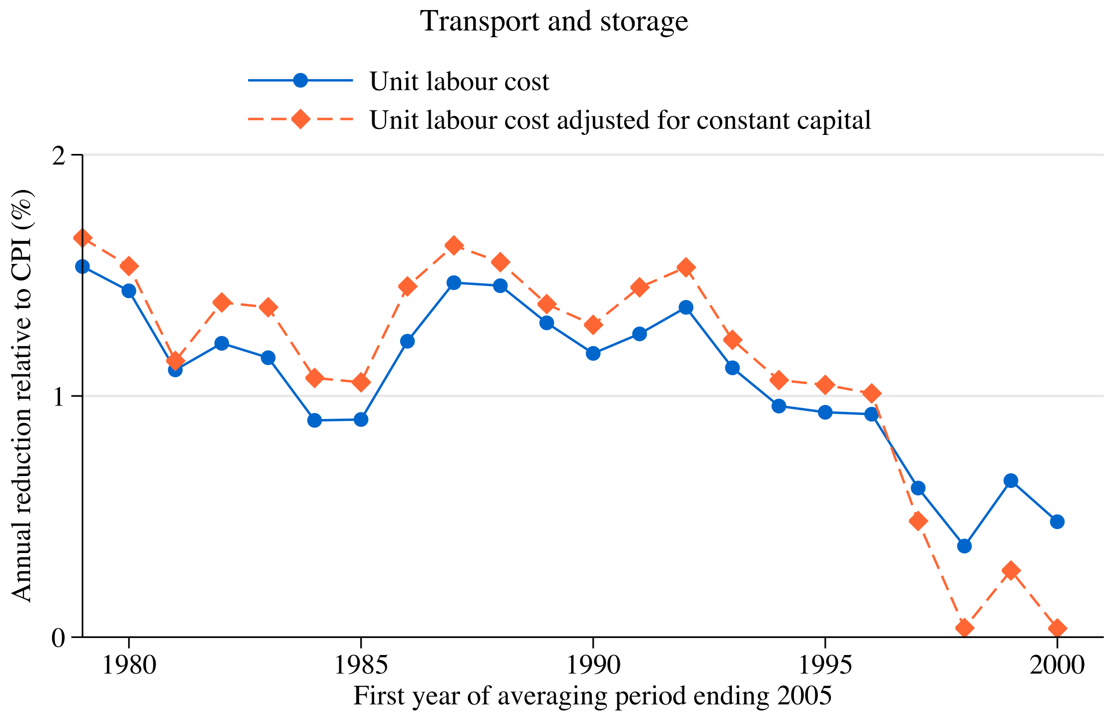
3.30 Manufacture of electrical and optical equipment involves large factories with similar asset management and health and responsibilities to the activities of GTS and its supply chain.



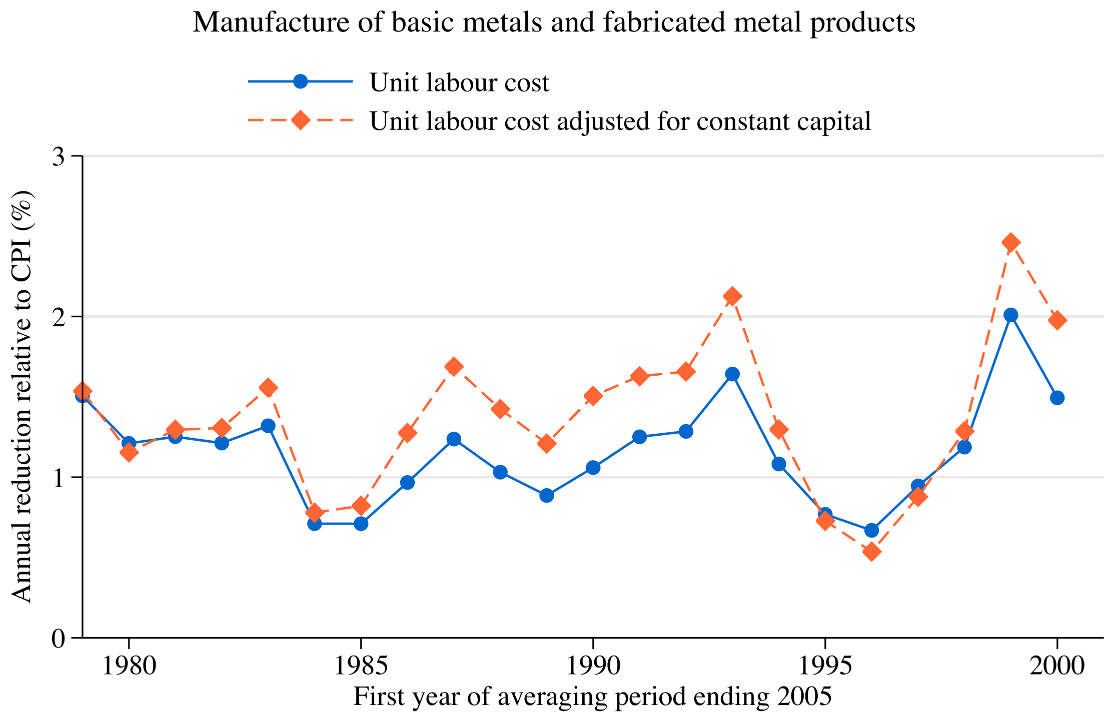
3.31 The manufacture of food products is a process industry involving asset management and health and safety responsibilities. These features are similar in nature to the activities involved in operating a gas transmission network.



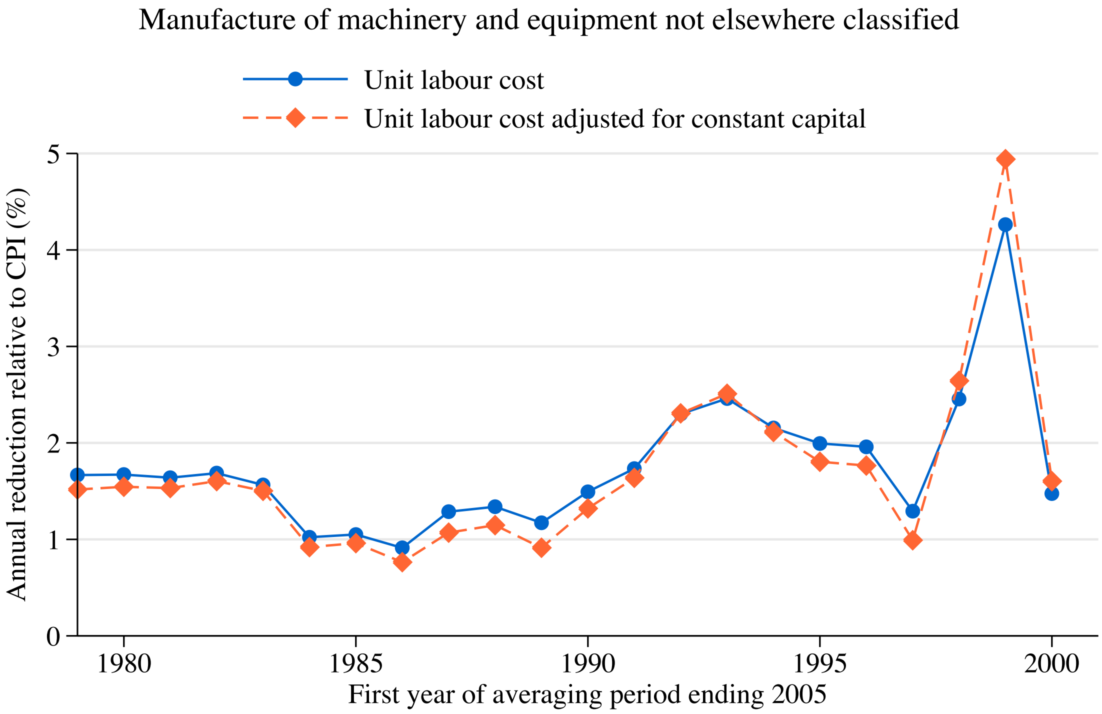
3.32 The transport and storage sector involves a similar geographical spread of activities as a gas transmission network. There are also similar asset management and health and safety responsibilities associated with maintaining and operating a transport network such as a railway.



3.33 The manufacture of basic metals has been included as a comparator as it did not meet any of our conditions required for omission. It also involves asset management and health and safety responsibilities.

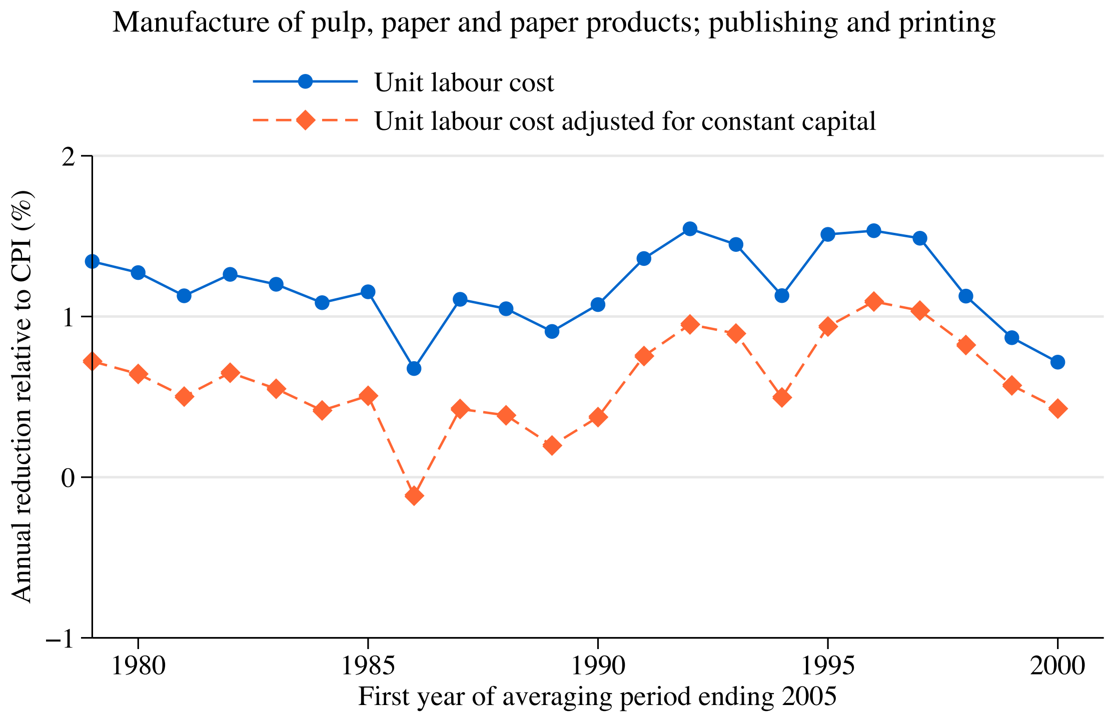


3.34 The manufacture of machinery and equipment is another sector that has been included as a comparator as we found no reasonable basis to omit it. It is a sector that involves asset management and health and safety responsibilities similar to those involved in operating a gas transmission network and its supply chain.

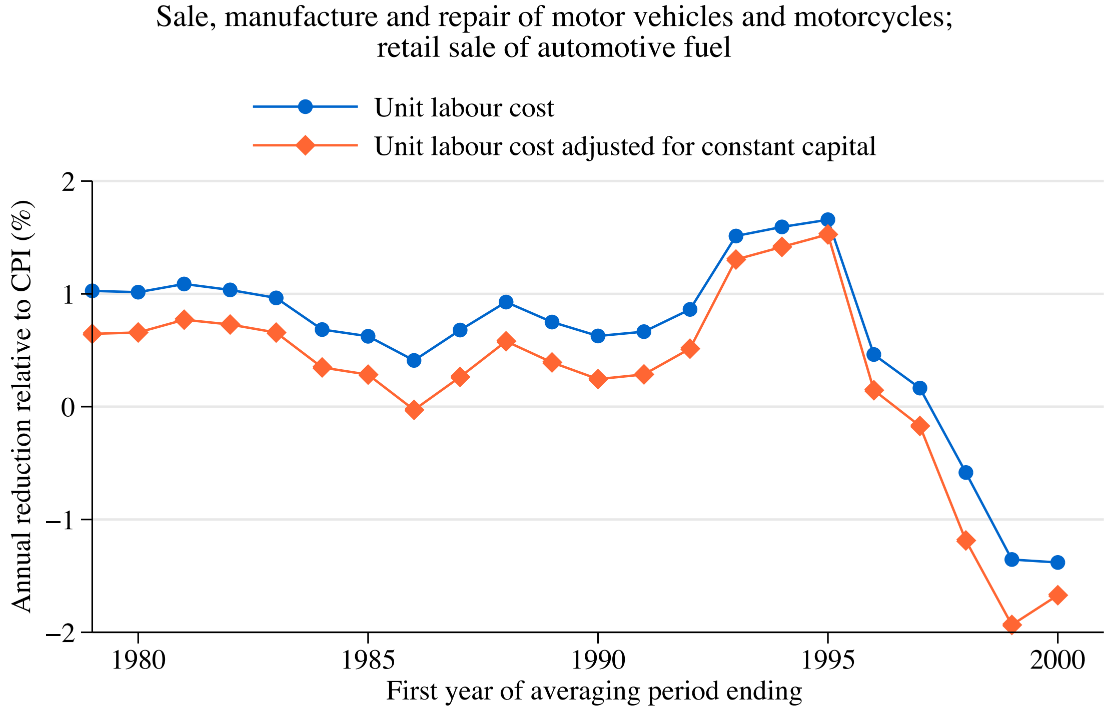


3.35 The manufacture of wood and wood products sector has also been included as a comparator as we found no reasonable basis to omit it. Similar asset management and health and safety responsibilities are likely to be present.

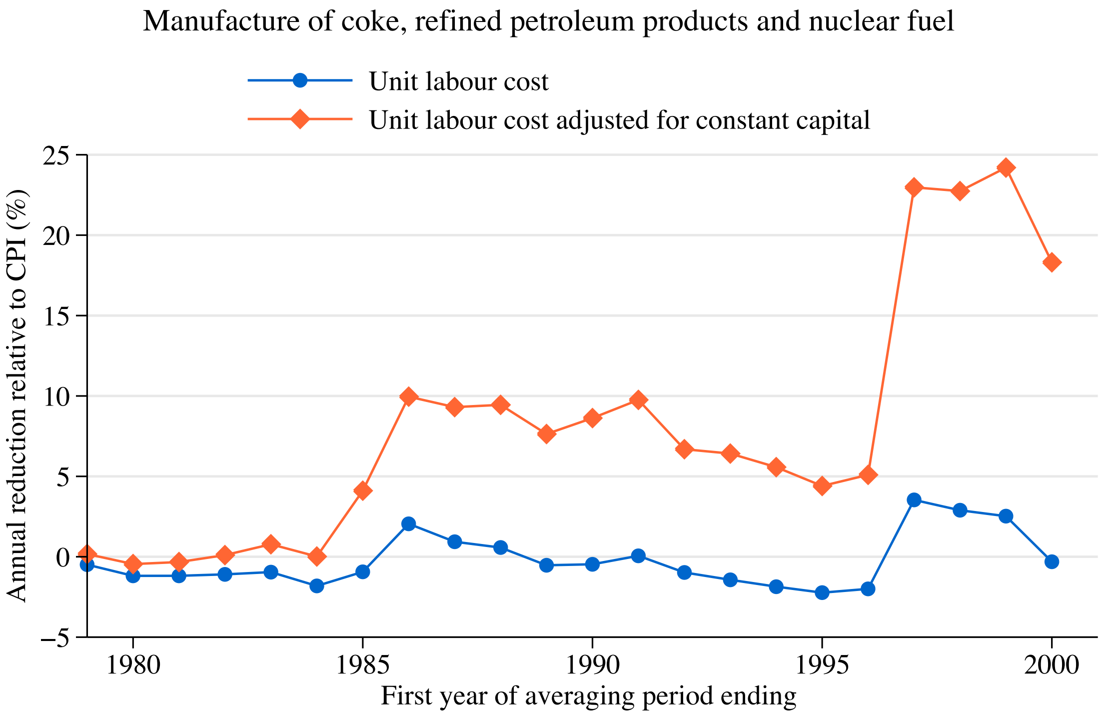
3.36 The manufacture of pulp and paper involves large plants with similar asset management and health and safety responsibilities to those involved in operating a gas transmission network.



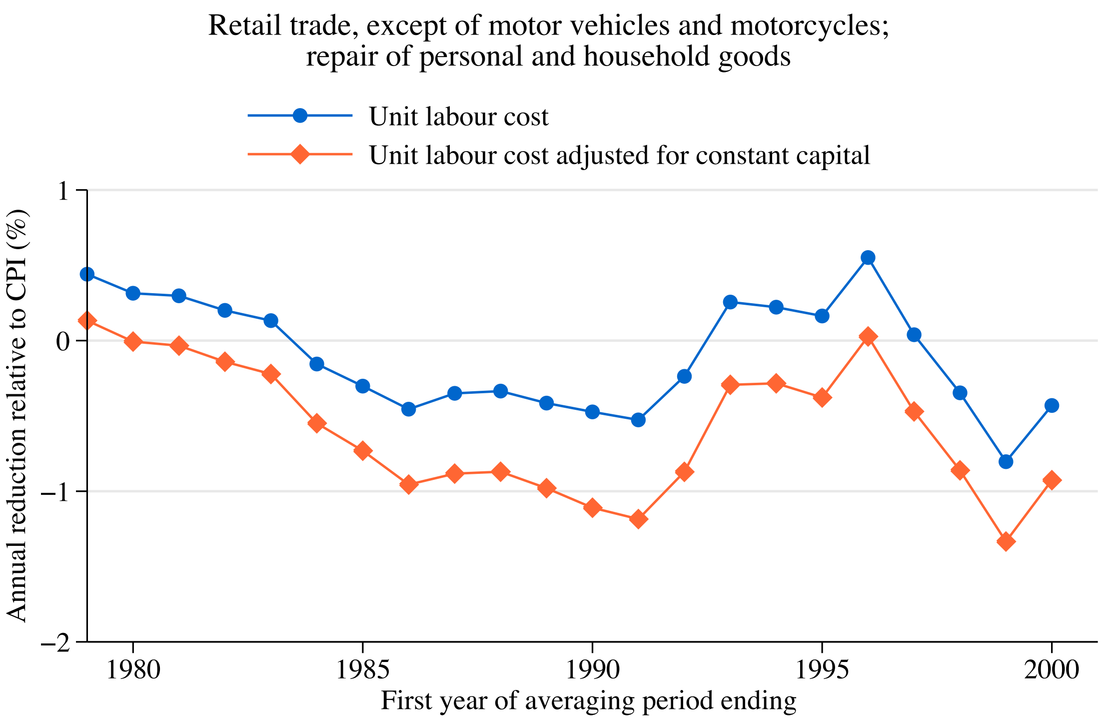
3.37 The maintenance activities undertaken as part of the repair and maintenance of motor vehicles and motorcycles involve a similar level of skilled labour and technology as the operation and maintenance of a gas transmission network.



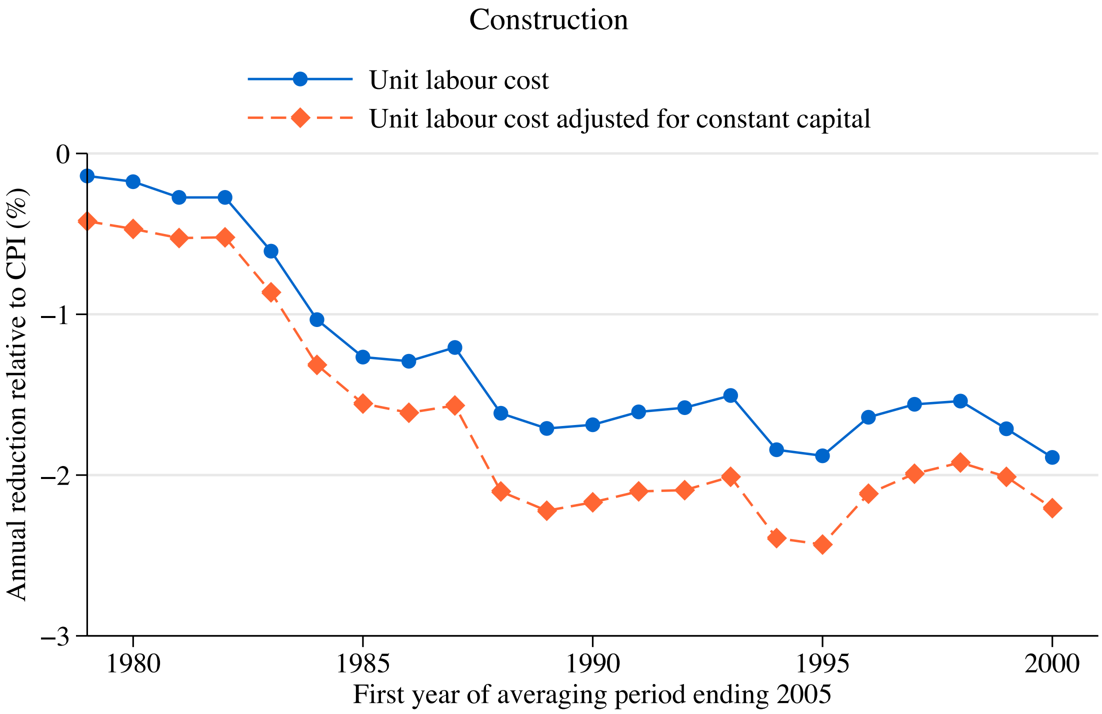
3.38 The manufacture of coke, refined petroleum products and nuclear fuel is another sector involves large plants with similar asset management and health and safety responsibilities to those involved in operating a gas transmission network.



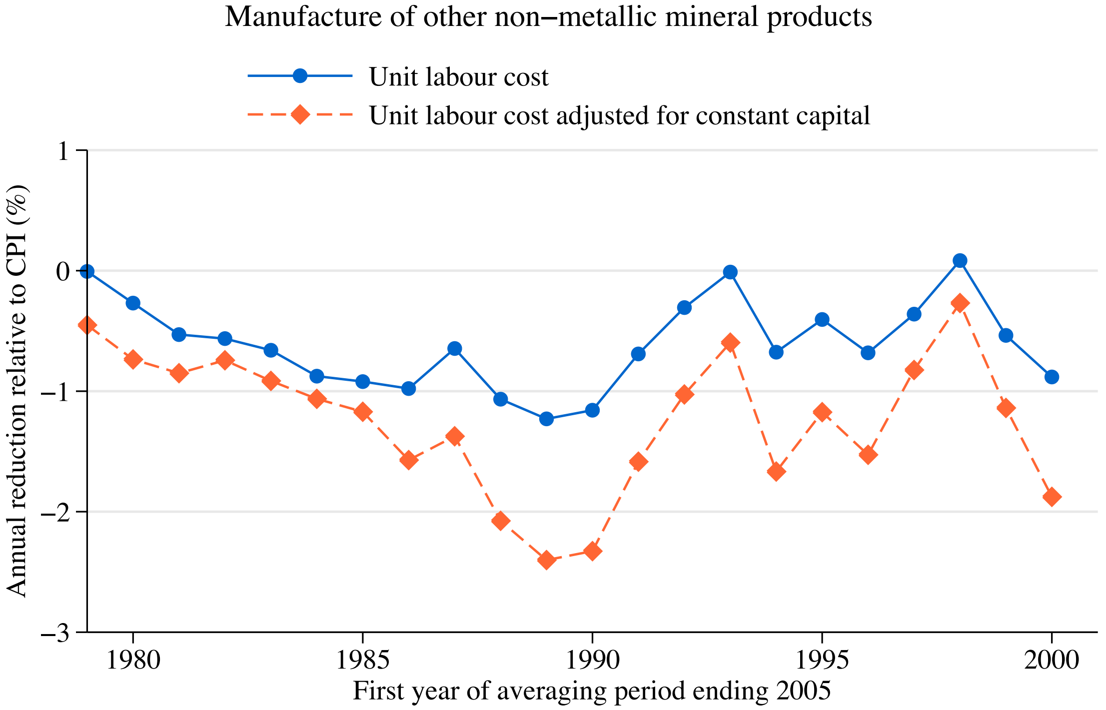
3.39 The retail trade sector involves a similar geographical spread of activities as gas transmission network and its supply chain. It also includes management of operations, contracts, suppliers and customers which have similarities to the activities involved in providing a gas transmission network.



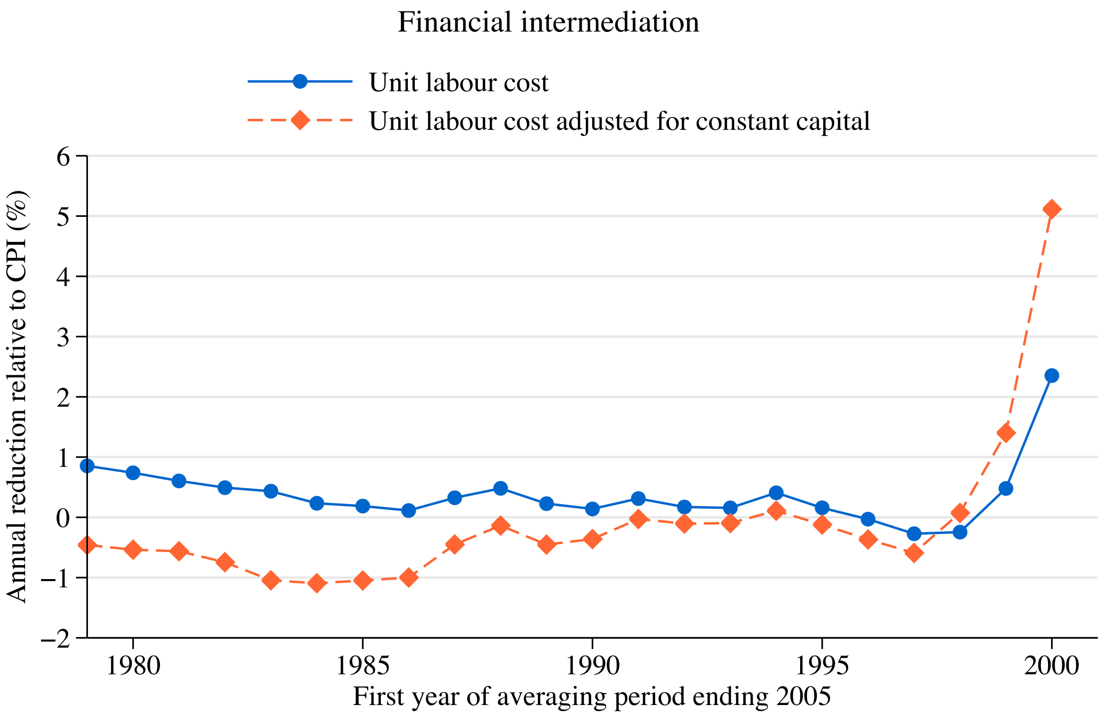
3.40 The construction sector shares a number of similarities with a gas transmission network and its supply chain. These include similar asset management and health and safety responsibilities as well as the management of operations, contracts and suppliers.



3.41 The manufacture of other non-metallic mineral products (such as glass) has also been included as a comparator as we found no reasonable basis to omit it. Similar asset management and health and safety responsibilities are likely to be present.

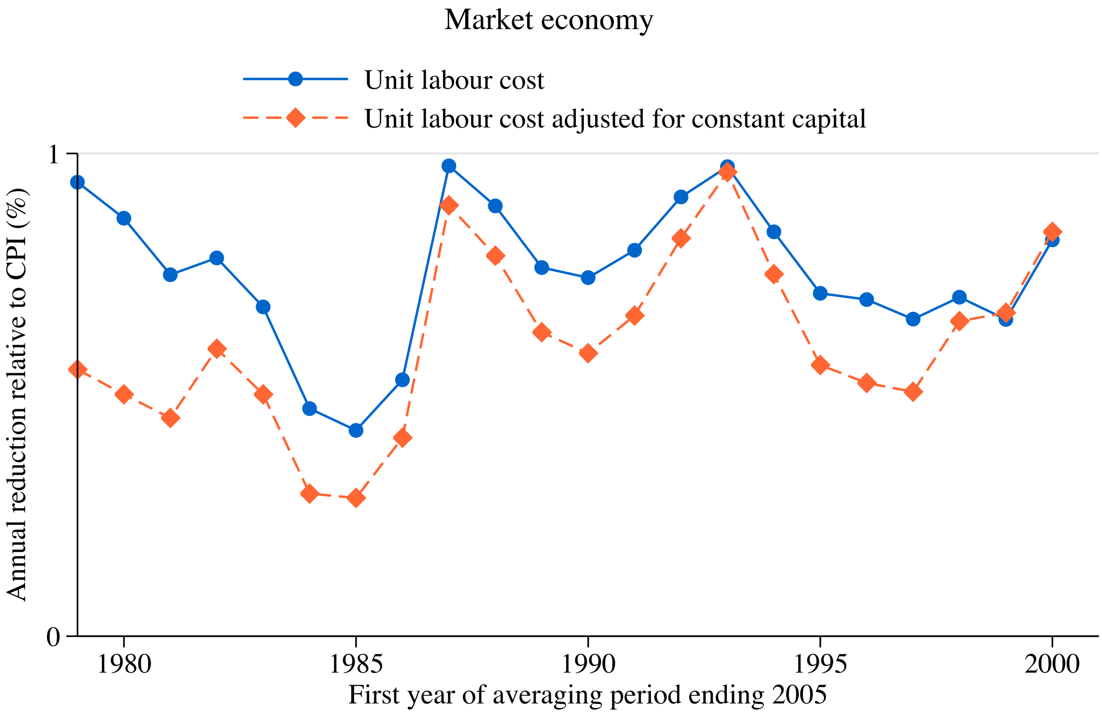


3.42 Financial intermediation has similarities to some administrative functions carried out in operating a gas transmission network such as shipper account management, data management and data audit.

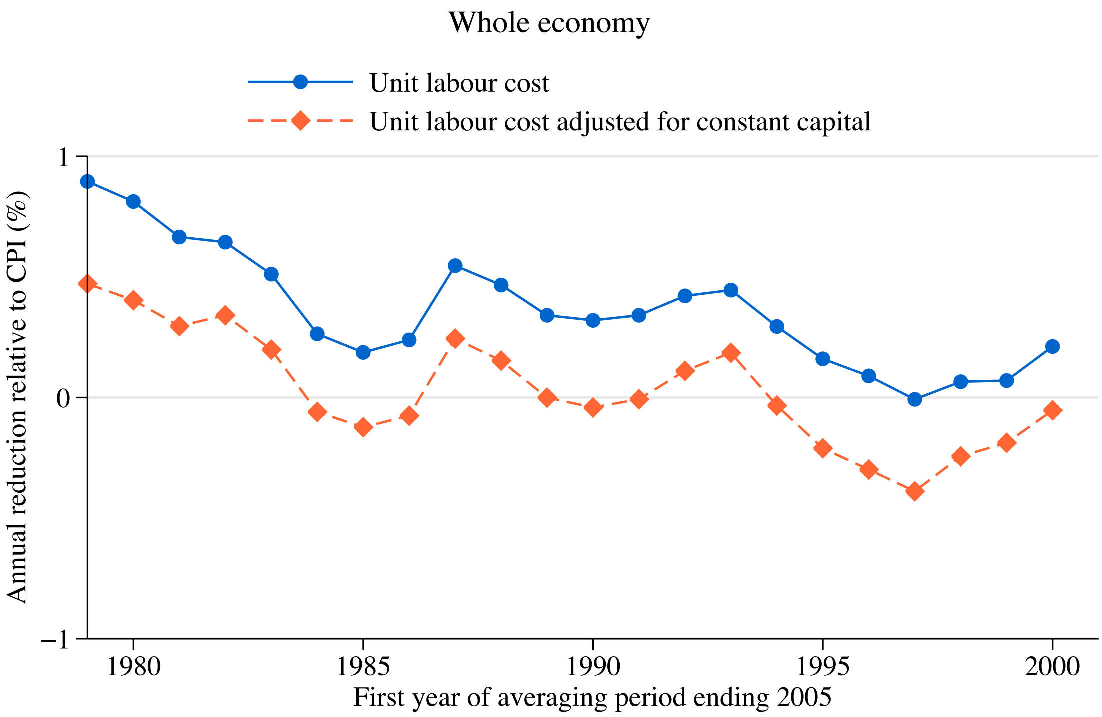


Whole-economy aggregates

3.43 The market economy sector in the EU KLEMS database includes all industries except health, education, government (public administration and defence) and real estate.



3.44 The whole economy sector includes all industries in the EU KLEMS database.



Sectors not included in table 1

3.45 We have omitted sectors from the data presented in table 1 in section 1 if either of the following conditions is met:

(a) there are data for a more disaggregated sector within the database; or

(b) the nature of the activities or the inputs and outputs are very different from those involved in operating expenditure for a gas transmission network.

3.46 We now discuss the reasons behind the exclusion of some sectors on the basis of the second condition above.

3.47 The management of telecommunications networks (which are the bigger part of the post and telecommunications sector) is quite different from the management of a utility network: it is far more capital intensive and involves less routine inspection and maintenance tasks. Furthermore there might be economies of scale (particularly in terms of the use of capital) even at the sector level, as some of the infrastructure is not duplicated and the ordinary expectation that firms operate at around the efficient scale does not apply. Similar structural and regulatory changes as in the electricity, gas and water sector might also have affected the data. Overall it is difficult to see anything of relevance to the activities of operating a gas transmission network in the data from post and telecommunications.

3.48 Productivity data for sectors that are largely government controlled are often affected by output measurement issues: for large parts of the health, education and government sectors, it is difficult to construct a genuine output measure and the data are sometimes based on measures such as the number of teacher-hours, for which productivity growth is inherently limited. Such an approach does not fully recognise the improvements in productivity that might exist in these sectors. Quality adjustments can also be difficult to implement. For these reasons we have omitted the sectors.

3.49 Data for some service sectors, e.g. hotels and restaurants, show a negative rate of both labour and multifactor productivity growth according to the EU KLEMS data for the Netherlands (see the data in Appendix C). We have disregarded the sectors affected, both because of the implausibility of worsening total factor productivity over time (an apparent “unlearning” of better technologies or management techniques), and because we do not see any particular similarities between the sectors and the operation of a gas transmission network.

3.50 In some sectors, capacity utilisation is an important determinant of productivity. When output is at capacity, output per unit of input is typically high and low otherwise. A sector particularly prone to such an effect is the mining and quarrying sector where output and productivity are determined by commodity price changes and the difficulty of extracting the relevant natural resources. Measured productivity in such sectors is therefore not primarily determined by changes to working practices or technologies. There is therefore a risk that productivity or unit costs measures in such sectors will be affected by factors that have no connection to trends for operating expenditure of a gas transmission network operator. We have therefore excluded the mining and quarrying sector.

3.51 We have also excluded the electricity, gas and water supply sectors from our selection of comparators. There are two main reasons why these data are not suitable for our purposes:

(a) Many of the prices in the electricity, gas and water supply sectors are regulated rather than set by competition in the market. This affects the use of value added productivity measures: Government policy choices and regulatory decisions will affect the share of value added in gross output, and therefore the "volume of value added". There is therefore a risk that productivity and unit cost estimates in these regulated sectors might not be comparable with measures in unregulated sectors, or with measures that relate to operating expenditure for a gas transmission network — in both cases the result of technical and economic processes in markets (including markets for labour) rather than the result of a political or regulatory process.

(b) A large proportion of the data for electricity, gas and water supply is accounted for by electricity generation, which is quite different from operating a gas distribution network. In particular, data for the energy sector will include a large amount of capital in the inputs. But we are interested in operating expenditure for a gas transmission network, i.e. something which is not a capital-intensive activity — we are not trying to estimate any notion of total costs for the overall capital-intensive activity of providing a gas network.

Review of inflation measures and other productivity and unit cost data

3.52 The remainder of this section compares the EU KLEMS productivity figures and input price trends with those from other sources.

Consumer prices

3.53 Table 2 below shows the "inflation" and "CPI" figures from CBS, the national statistics office for the Netherlands, averaged over the periods 1997–2004 and 1979–2004. The differences between the two data series are minor.

Table 2 Inflation in the Netherlands

Averaging period	Inflation	CPI
1997–2004	2.5%	2.5%
1979–2004	2.7%	2.7%

Source: Reckon LLP analysis of published CBS data.

3.54 This indicates that inflation has been quite stable through the period for which we have macroeconomic data, and that the two consumer price indices are essentially the same.

Labour price growth

3.55 Table 3 shows labour price indicators for various sources and sectors over the period 1995–2004. All these growth rates are relative to CPI (from CBS).

Table 3 Labour input price growths relative to CPI (1997–2004)

Sector	Eurostat labour cost index	Eurostat labour cost per month	Eurostat labour cost per month	CBS labour cost per hour	EU KLEMS implied labour price index
Mining and quarrying	1.1%	2.1%	1.2%	2.5%	1.6%
Total manufacturing	1.3%	0.6%	0.0%	2.0%	1.2%
Electricity, gas and water supply	2.0%	2.1%	1.5%	2.2%	2.3%
Construction	1.9%	2.3%	1.2%	2.1%	2.1%
Wholesale and retail trade	1.4%	1.7%	1.2%	2.4%	1.7%
Hotels and restaurants	0.9%	1.3%	0.9%	2.3%	1.0%
Transport and storage and communication	1.2%	1.2%	1.5%	1.4%	1.2%
Financial intermediation	3.0%	3.0%	2.5%	4.3%	2.8%
Real estate, renting and business activities	2.4%	2.6%	2.3%	3.5%	2.1%
Total industry and services	1.8%	1.7%	1.1%	2.5%	1.8%

Source: Reckon LLP analysis of published data from sources shown.

3.56 As might be expected, there are some differences between the data sources, but nothing which would cause us to be concerned about the reliability of the EU KLEMS data.

3.57 Table 4, derived from the EU KLEMS database combined with CPI data from CBS, shows variations in labour price trends between sectors, using the longest averaging period permitted by the EU KLEMS data.

Table 4 Labour input price trends by sector (1979–2004 or 1979–2005)

Sector	Labour price growth	Labour price growth relative to CPI
Agriculture, hunting, forestry and fishing	2.8%	0.1%
Mining and quarrying	3.6%	0.9%
Manufacture of food products, beverages and tobacco	3.7%	0.9%
Manufacture of textiles, textile products, clothing and footwear	3.2%	0.5%
Manufacture of wood and wood products	3.8%	1.1%
Manufacture of pulp, paper and paper products; publishing and printing	4.0%	1.2%
Manufacture of coke, refined petroleum products and nuclear fuel	1.1%	-1.6%

Sector	Labour price growth	Labour price growth relative to CPI
Manufacture of chemicals, chemical products and man-made fibres	3.3%	0.6%
Manufacture of rubber and plastic products	2.4%	-0.3%
Manufacture of other non-metallic mineral products	2.9%	0.2%
Manufacture of basic metals and fabricated metal products	3.4%	0.6%
Manufacture of machinery and equipment not elsewhere classified	3.8%	1.0%
Manufacture of electrical and optical equipment	3.0%	0.3%
Manufacture of transport equipment	3.1%	0.4%
Manufacturing not elsewhere classified, including recycling	2.8%	0.1%
Electricity, gas and water supply	2.2%	-0.5%
Construction	2.6%	-0.2%
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	3.1%	0.4%
Wholesale trade and commission trade, except of motor vehicles and motorcycles	2.9%	0.2%
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	3.7%	0.9%
Hotels and restaurants	2.8%	0.1%
Transport and storage	2.8%	0.1%
Post and telecommunications	2.7%	-0.1%
Financial intermediation	4.0%	1.3%
Real estate activities	5.3%	2.5%
Renting of machinery and equipment; research; consultancy; other business activities	1.6%	-1.1%
Public administration and defence; compulsory social security	2.7%	0.0%
Education	2.4%	-0.3%
Health and social work	2.8%	0.1%
Other community, social and personal service activities	6.3%	3.6%
Manufacture of chemical, rubber, plastic and fuel products	3.0%	0.3%
Trade	3.2%	0.5%
Manufacturing	3.4%	0.6%
Wholesale and retail trade	3.2%	0.5%
Transport and storage and communication	2.8%	0.1%
Finance, insurance, real estate and business services	2.6%	-0.1%
Real estate, renting and business activities	2.0%	-0.8%
Public admin, education and health	2.6%	-0.1%
Community social and personal service activities	2.6%	-0.1%
Distribution	3.1%	0.4%
Electrical machinery, post and communication services	2.9%	0.2%
Finance and business, except real estate	2.4%	-0.3%
Goods producing, excluding electrical machinery	3.0%	0.3%
Market economy	3.0%	0.3%

Sector	Labour price growth	Labour price growth relative to CPI
Market services, excluding post and telecommunications	3.0%	0.3%
Consumer manufacturing	3.3%	0.6%
Manufacturing, excluding electrical	3.4%	0.6%
Intermediate manufacturing	3.4%	0.6%
Manufacture of non-high-tech investment goods	3.5%	0.8%
Non-market services	2.7%	0.0%
Other production	2.6%	-0.1%
Personal services	4.4%	1.6%
Whole economy	3.0%	0.2%

Source: Reckon LLP analysis of published EU KLEMS and CBS data.

Comparison with OECD productivity data

3.58 We downloaded data for the Netherlands from the OECD's multi-factor productivity data (available from http://stats.oecd.org/WBOS/). For the Netherlands, this provides data on annual growth in multi-factor productivity for the whole economy from 1985 to 2005. The OECD's definition of multi-factor productivity uses GDP as its output measure, and labour and capital as the relevant inputs. It therefore appears to be the same as our measure of total factor productivity based on value added for the whole economy.

3.59 Over the period 1985 to 2005 average growth (in logs) of MFP from the OECD data is 0.8 per cent. Over the same period the EU KLEMS database have average TFP growth of 0.5 per cent for the whole economy. More in line with the OECD figure is the average TFP growth for the "market economy" (essentially the whole economy excluding government), which is also 0.8 per cent. The input growth numbers are also similar between the OECD figures and the EU KLEMS market economy sector, as shown in table 5.

Table 5 Average growth rates from the OECD productivity database and EU KLEMS (1985–2005)

Variable	OECD whole economy	EU KLEMS market economy
Labour input	1.4%	1.6%
Capital input	3.2%	3.2%
Output	2.7%	2.9%

Source: Reckon LLP analysis of published data from sources shown.

3.60 Input growth figures are mislabelled in the OECD database. The variables labelled as labour and capital input growth are actually the contribution of the factors to MFP growth. From these figures and the share of labour in total factor costs it was possible to calculate the input growth figures given in the table above.

3.61 Given the strong similarities between the OECD figures and those for the market economy it suggests that the OECD figures are based on extrapolations from something similar to the market economy aggregate in EU KLEMS.

Comparison with Eurostat unit labour costs data

3.62 Eurostat provides data on real unit labour cost growth, which is defined as the ratio of whole economy labour compensation (in nominal terms) to GDP (in nominal terms). As discussed in appendix B, to make these data comparable to the unit labour cost data that we have derived from EU KLEMS, the growth in the GDP deflator must be added to the Eurostat figures.

3.63 The GDP deflator data from Eurostat for the Netherlands only enables annual growth comparisons to be made for 2004 and 2005. The table below compares the reductions in unit labour costs for these years using EU KLEMS unit labour cost data and the Eurostat real unit labour cost series combined with the GDP deflator. Both measures are relative to CPI.

Table 6 Annual reductions in unit labour costs relative to CPI

Year	Reduction in unit labour costs using EU KLEMS data	Reduction in unit labour costs using Eurostat data
2004	1.0%	0.9%
2005	1.9%	2.1%

Source: Reckon LLP analysis of published data from sources shown and CPI data from CBS.

APPENDIX A: PRECEDENTS AND LITERATURE

A.1 This section presents the findings of our review of regulatory precedents in Western European and the results from our review of the relevant literature.

Regulatory decisions

A.2 Table 7 provides an overview of the regulatory decisions reviewed in this section.

Table 7 Overview of regulatory decisions reviewed in this section

Price control	Decision (%)	Comment
Italy: gas network (2005)	2	Allowed operating costs trend relative to inflation (with incentive scheme related to actual expenditure in the previous year)
Italy: electricity distribution and transmission (2003)	Distribution: 3.5 Transmission: 2.5	Allowed operating costs trend relative to inflation (with incentive scheme related to actual expenditure in the previous year)
Portugal: electricity transmission and distribution (2005)	Between 0.2 and 4.9	Trend in different components of revenue relative to inflation
UK: electricity distribution (2004)	1.5	Allowed controllable operating expenditure trend relative to RPI
England and Wales: water and sewerage (2004)	Water: 0.3 Sewerage: 0.5	Allowed operating expenditure trend relative to RPI
UK: Electricity and gas transmission (2006)	1.5	Allowed operating expenditure trend relative to RPI
France: electricity transmission (2005)	3	Wages and external purchase costs only (in nominal terms)
France: gas transport (2006)	GRTgaz: 2.4 TIGF: 4	Real operating expenditure reductions
Germany: energy networks (2007)	First regulatory period (2009–2013): 1.25 Second regulatory period (2014–2018): 1.5	Price limits relative to inflation
Spain: gas transmission (2002)	N/A	Prices indexed by 85% of the chosen inflation index
The Netherlands: electricity transmission (2007)	2	Indexation of revenue requirements relative to CPI
The Netherlands: electricity distribution (2006)	Historical reduction relative to CPI in total economic costs over 2003–2005	

Source: Reckon LLP survey of published regulatory decisions.

Relevance of precedents

A.3 Whilst these precedents may be considered informative, we have not found a robust way of bringing them together into a consistent basis.

A.4 This is for the following reasons:

(a) Studies which express their results in terms of partial productivity measures or total factor productivity would need to be combined with input price trends or forecasts to give figures comparable with operating expenditure relative to CPI. We have not produced such forecasts on a basis that would be consistent with the inputs used in these different studies. We do not know of a robust basis to choose particular input price inflation assumptions to combine with productivity measures.

(b) Some studies, particularly those involving total factor productivity, consider network assets as part of their capital inputs. The activities under examination (network financing, renewal and expansion) are then different from the activities giving rise to GTS's operating expenditure. We do not know of a robust way of inferring anything about operating expenditure from such productivity measures.

(c) Some of the studies focused on expenditure relate to the UK and to costs relative to the UK retail prices index (RPI), which is significantly different from the Eurostat-harmonised CPI and from the Netherlands CPI. These differences frequently amount to nearly 1 per cent a year and we do not know of a robust way of addressing this discrepancy.

Italy: gas network price controls

A.5 We consider here the second regulatory period of the Italian gas network price control. This runs from 1 October 2005 to 30 September 2009.

A.6 The key document setting the tariffs for the second regulatory period is Delibera 166/05 dated 29 July 2005 by Autorità per l'energia elettrica e il gas (Autorità).[2] This has since been modified by a number of subsequent revisions, the most recent being by Delibera 277/07 dated 31 October 2007.

A.7 In very broad terms, the Autorità estimates the level of allowed revenue for the first year of the regulatory period and proceeds to split this between a revenue component associated with capacity and one associated with commodity. In the current regulatory period, this split was 70 per cent and 30 per cent respectively. For subsequent years, the Autorità updates the allowed revenue for both of these components to reflect inflation and productivity gains. We proceed to spell out more carefully the assumptions and mechanics underlying this procedure.

Setting allowed revenue for first year

A.8 The Autorità defines allowed revenue for the first gas year as the sum of:

(a) return on capital, set to 6.7 per cent real pre tax of net invested capital;

(b) amortisation; and

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[2] Autorità (2005) Criteri per la determinazione delle tariffe per il trasporto e il dispacciamento del gas naturale, Deliberazione 166/05.

(c) operating costs.

A.9 Operating costs include all operating expenditure and expenditure of a general nature that can be attributed to the transportation activity actually carried out in 2004, and that have been adequately audited. They include in particular:

(a) labour costs;

(b) cost of purchase of materials for consumption;

(c) costs of compression and push and of losses in the network;

(d) costs of sub-contractors; and

(e) other provisions/accruals (excluding amortisation), provided these were not incurred due to accounting rules alone.

A.10 For firms that do not have approved tariffs for 2004/2005, the operating costs were those they submitted to the Autorità.

A.11 For those firms that do have tariffs approved for the gas year 2004/2005, the last year of the previous regulatory period, the operating costs that will be allowed for the gas year 2005/2006 will be calculated according to:

$$COR_{2005} = COE_{2004} + 50\% * \left[COR_{2001} * \prod_{j=02}^{04} (1 + I_j - X) * (1 + I_{05} - \overline{X}) + COR^{NI}_{2001-2004} - COE_{2004} \right]$$

where

COR_{2005}	Allowed operating costs for the gas year 2005/2006
COE_{2004}	Operating costs actually incurred in accounting year 2004
COR_{2001}	Allowed operating costs for the gas year 2001/2002, the first year of the first regulatory period
I	Annual inflation rate relevant to the update of the tariff price cap
X	Productivity gains set for the first regulatory period, set to 2 per cent
$\overline{X}$	Productivity gains set for the first regulatory period, set to 2 per cent
$COE^{NI}_{2001-2004}$	Operating costs relating to new investments carried out in the period including 2001 and 2004, defined to be 1.2 per cent of the value of these same investments

A.12 For businesses with approved tariffs for the year 2004/2005, the Autorità has applied article 11,11.9 of deliberazione 120/01 which foresaw that the value of accepted operating costs for the first year of the second regulatory period would be set allowing the companies to receive at least half of the productivity gains made in excess of those that had been set as a target. Following consultation, the Autorità settled on setting this sharing to 50 per cent.

A.13 Costs associated with balancing the network are recovered separately.

Updating revenue

A.14 The recoverable revenues RT in the year 2005/2006 are split into a commodity, RT^E and a capacity component, RT^C, the first accounting for 30 per cent of RT and the second for the remaining 70 per cent.

A.15 The Autorità distinguishes two elements of the component RT^C linked to capacity: one element is associated with the net return on capital, and the second element is related to operating costs and amortisation. Each of these elements is further broken down into an element associated with the national network and one associated with the regional network. The split of operating costs and amortisation between regional and national network is done in proportion to the operating costs and amortisation of the two networks. These components are labelled RT^N_{co+amm} and RT^R_{co+amm}.

A.16 Productivity gains are applied to these two components alone. In passing we note that this was not the case in the first regulatory period, where the productivity gains applied to a component that included costs of capital. The productivity gains are applied as follows:

$$RT^N_{co+amm,t} = RT^N_{co+amm,t-1} * (1 + I_{t-1} - RP + Y + Q + W)$$

$$RT^R_{co+amm,t} = RT^R_{co+amm,t-1} * (1 + I_{t-1} - RP + Y + Q + W)$$

where

I_{t-1} is the annual average rate of change in relation to the previous 12 months of the consumer price index, as published by Istat.

RP is the annual productivity gain, set to 2 per cent.

Y, Q, W are parameters that take into account of costs due to unforeseen events, costs relating to making up for quality in relation to certain standards and due to new activities relating to demand management and efficient use of resources. By default, the Autorità sets the value of these parameters at 0.

A.17 We have found no information within published documents that discloses how the 2 per cent productivity gain is arrived at, other than a comment that it was based on an analysis of data which showed that there was scope for productivity improvements.

A.18 The commodity tariff, RT^E, is updated on basis of inflation in previous 12 months and a productivity gain associated with the transport of the commodity, fixed at 3.5

per cent. This productivity gain figure was set on the basis of the assumption of an annual growth rate in the amount of transported energy of around 3 per cent per year.

A.19 Again, we have seen no clear account of how this productivity gain was arrive at. We note, though, that in a consultation document put out in May 2005, the Autorità proposed that it would form a view on the productivity gain associated with transport of the commodity on the basis of:

(a) the forecast costs in the light of the growing demand for gas in the near future, and of the plans for the expansion of the network;

(b) the gains made by the transportation operators in the previous regulatory period;

(c) an analysis of the productivity gains set by other European regulators and of the relative levels of efficient costs in line with best practice; and

(d) improvements in the use of capital, i.e. a more efficient use of the existing network as well as a reduction in unit costs due to increase in the volume transported.

A.20 In the first regulatory period, the annual productivity gain relating to capacity was set at 2 per cent; that relating to the commodity element of charges was set at 4.5 per cent.

Italy: electricity transmission and distribution

A.21 We outline here the assumptions of the Autorità on the efficiency gains of the transmission and distribution operators in electricity sector in Italy, and how these assumptions feed through to the setting of the operators' allowed revenues and tariffs.

A.22 We focus on the second and third regulatory period. These covered the period 1 January 2004 – 31 December 2007 and 1 January 2008 – 31 December 2011, although, in fact, the rules and tariffs defined for each of these regulatory periods came into force with a six-month delay on both occasions.

A.23 There are a number of common elements across the two regulatory periods with respect to the regulation of transmission and distribution. In both periods, the Autorità defines a set of tariffs and a value for the individual components that make up the different tariffs for the first year of that regulatory period, and these components are subsequently updated on an annual basis. Different components contribute to define the tariff for transmission and for distribution. For both transmission and distribution, the Autorità sets, in essence, price caps of the relevant operators.

A.24 We now consider the two regulatory periods in turn.

The second regulatory period: 1 January 2004 – 31 December 2007

A.25 As noted, Autorità defined a set of tariffs and the value of components making up these tariffs for the first year of the regulatory period. These were subsequently updated on an annual basis.

A.26 The tariffs set in the first year of the regulatory period were based on operators' allowed expenditure, which, in turn, were determined by the Autorità on the basis of regulatory annual accounts and of operators' responses to information requests by the Autorita.

A.27 The expenditure allowed by the Autorità covered:

(a) operating expenditure, namely costs of external resources, including labour and purchase of materials;

(b) amortisation of fixed assets; and

(c) a return on capital.

A.28 In relation to operating costs, the Autorità defined the costs allowed for 2004, the first year of the regulatory period as the sum of:[3]

(a) the actual expenditure incurred in 2001, the first year of the first regulatory period, updated to 2004 by applying inflation and the relevant factor reflecting productivity gains during the first regulatory period and productivity gains foreseen for the second regulatory period; and

(b) the share of the efficiency gains ("maggiori recuperi") to be attributed to operators. This share is calculated as half of the difference between the average allowed unit expenditure in 2001 and the average actual unit expenditure in 2001, indexed by an "inflation minus X" factor from 2001 to 2004. If the difference is negative (spending in excess of allowances) then the share of the efficiency gains retained by the operator is zero.

A.29 On the basis of the allowed costs calculated, the Autorità determined the value of a set of tariff components for the first year of the regulatory period. This was done in line with the criteria that had been used in the first regulatory period.

A.30 For distribution and transmission, the Autorità updated those components of tariffs that were associated with operating costs (including amortisation) by taking into account the inflation rate and expected productivity gains.

A.31 The inflation rate used for this purpose — and for the purpose of determining the level of operating expenditure allowed for 2004, the first year of the regulatory period — is defined as the average annual, relating to the previous 12 months, of consumer prices for the families of workers and employees. This is prepared by Istat, the national statistical office. This inflation rate is denoted by Foi.

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[3] Autorità (2004) Relazione Tecnica, deliberazione 5/04, Parte III.

A.32 The annual productivity gains were set at 3.5 per cent for distribution and at 2.5 per cent for transmission.

The third regulatory period 1 January 2008 – 31 December 2011

A.33 The rules defining the setting of tariffs in the third regulatory period are, to large extent, common to those that applied in the second regulatory period. As with the second regulatory period, the Autorità proceeded at the end of 2007/beginning of 2008 to estimate the value of the various components contributing to defining the tariff for transmission and for distribution in the first year of the regulatory period, and to define the parameters describing how these components were to evolve in the subsequent two years.

A.34 In relation to computing the value of allowed costs for the first year — which, in turn, form the basis for computing the value of the various components for that same year — we note that the Autorità followed a similar rule to that outlined above but that it used 2006 as the base year to determine the allowed operating expenditure in 2008.

A.35 For the third regulatory period, the Autorità fixed the productivity gain to be used in updating those components of tariffs associated with operating costs at 2.3 per cent and at 1.9 per cent for distribution.

Sources for productivity and expenditure trend estimates

A.36 We have found very limited insight amongst published documents on how the estimates for the productivity gains were arrived at. A technical document accompanying deliberazione 5/04 notes that these productivity gains take into account the "effect on the labour costs of the revised national collective contract signed in 2003". The Autorità also considers that these levels are consistent with the demands made on operators for improvement in the continuity of electric service.

A.37 We note that in the first regulatory period, productivity gains had been set at 4 per cent, for both transmission and distribution, and that this had been applied across all allowed revenue, i.e. operating expenditure (including amortisation) and return on capital.

A.38 Some of the components of the tariffs for transmission and for distribution can also be updated annually by the Autorità to reflect costs associated with unpredictable and exceptional events, and to reflect costs associated with demand management and efficient use of resources.

A.39 In relation to the tariffs and the components of the tariffs associated with return on capital, we note that the Autorità reviewed these on an annual basis in order to take account of the revaluation of fixed assets, through the application of a relevant deflator and to take account of new investments carried out in the previous year.

Portugal: electricity transmission and distribution

A.40 The document "Regulamento Tarifário" ("Tariff Regulation") published by ERSE initially in August 2005, and subsequently revised in June 2007, sets out the regulations for the setting of tariffs and prices in the electricity sector in Portugal for the regulatory period 2006–2008.

A.41 According to this document, electricity distribution is regulated by the setting of a maximum price that is indexed to inflation and that reflects efficiency gains over the regulatory period.

A.42 Regulation of the tariffs for electricity transmission is not subject to considerations of efficiency gains.

A.43 The rest of the discussion applies only to electricity distribution. In mainland Portugal, distribution is carried out by EDP Distribuição.

A.44 Article 81 of the "Tariff Regulation" defines the allowed revenue for the distribution service in each of the three years of the 2006–2008 regulatory period. The regulation sets separate revenue limits for high and medium voltages (effective voltage between phases above 1kV) and for low voltage (up to 1kV). The revenue limit for each voltage level is given by the sum of the following components:

(a) a fixed component of distribution revenue;

(b) a variable component defined as the product of an allowed revenue per kWh and predicted electricity delivered by the distribution system of the voltage type;

(c) expenditure relating to the "Plan to support restructuring" associated with distribution and allowed by ERSE, for the voltage type; and

(d) an adjustment to revenues relating to distribution in that voltage type two years before.

A.45 The adjustment of revenues relating to distribution two years before is made up of four components. One of these components is defined as the difference between the revenue actually collected two years before and the revenue allowed for that year; its inclusion ensures that the operator repays any revenue collected in excess of the allowed revenue that had been allowed two years before. The other three components of the adjustment element refer to incentives provided, or expenditure incurred, two years before, to reduce distribution losses, to improve the quality of service in medium voltage and to carry out projects improving the environment that have been approved by ERSE. For these components interest at 0.5 per cent above three-month EURIBOR is included.

A.46 The fixed and the variable components of the allowed revenue were set in the first year of the regulatory period and are defined in Article 81 of the "Tariff Regulation" to evolve in the subsequent two years by CPI–X to reflect inflation and efficiency gains.

A.47 The values of the fixed and of the variable component for 2006, the first year of the regulatory period were published by ERSE in December 2005.[4] ERSE also defined the value of the parameters governing the evolution of these two components for the subsequent two years of the regulatory period: these are reproduced in table 8.

Table 8 Parameters fixing the evolution of allowed distribution revenues

		2007	2008
X(fixed component)	High/medium voltage	0.8 per cent	0.5 per cent
	Low voltage	0.2 per cent	0.5 per cent
X(variable component)	High/medium voltage	4.9 per cent	4.5 per cent
	Low voltage	4.2 per cent	4.2 per cent

Source: ERSE (2005) Tarifas e Preços para a Energia Eléctrica e Outros Serviços em 2006 e Parâmetros para o Período de Regulação 2006–2008, pages 191–192.

A.48 The values of the parameters reported in table 8 do not apply to operating costs alone. Rather, and in line with the "tariff regulation", these parameters apply to constituent elements of the allowed revenue in accordance with the above formulae. These, in turn, reflect controllable operating expenditure, non-controllable operating expenditure such as amortisation and concession license, and the return on capital.

A.49 It follows that the value of these parameters reflect the efficiency gains that ERSE had set on the controllable expenditure as well as the predicted trend of non-controllable operating expenditure, of the return on capital and of the growth in energy consumed. We turn now to outline the assumptions relating to the efficiency gains in controllable operating expenditure that were one of the ingredients in ERSE's calculation of X factors given above.

A.50 The efficiency gains that ERSE imposed on EDP Distribuição with respect to its controllable operating expenditure were set at 20 per cent over the three-year regulatory period, and they were spread out of this period as follows: a 10 per cent gain in the first year, 2006, and 5 per cent gains in each of the subsequent two years, 2007 and 2008. The level of controllable operating expenditure to serve as the basis for the gains in the first year were, essentially, the forecast for 2006 submitted by EDP Distribuição to ERSE in 2005.

A.51 In addition to the above efficiency gains, ERSE also considered that there would be an additional 1 per cent per year reduction in controllable operating expenditure due to technological progress.

A.52 ERSE carried out separate strands of analysis in arriving at (a) the 20 per cent efficiency gain associated directly with EDP Distribuição and (b) the 1 per cent efficiency gain associated with technological progress. We consider both briefly in turn.

[4] ERSE (2005) Tarifas e Preços para a Energia Eléctrica e Outros Serviços em 2006 e Parâmetros para o Período de Regulação 2006-2008.

A.53 Both figures, put forward by ERSE at the outset of the regulatory period in its December 2005 document "Tarifas e Preços para a Energia Eléctrica e Outros Serviços em 2006 e Parâmetros para o Período de Regulação 2006–2008", can be traced back to a series of three studies published in November 2005 under the collective title of "Parâmetros de Regulação na Actividade de Distribuição de Energia Eléctrica" which examined the efficiency of EDP Distribuição, analysed the trend in the costs of this operator and studied a number of scenarios defined with respect to, amongst other parameters, the level and profile of efficiency gain to be imposed on the operator over the three years of the regulatory period.

A.54 One of these studies, entitled "Metas de Eficiência Para a Actividade de Distribuição de Energia Eléctrica", presents analysis on the efficiency of the 14 regional areas that make up the network of EDP Distribuição in mainland Portugal, as well as of its 41 units (smaller constituent areas of the network). The study draws on stochastic frontier analysis and presents a series of models that seek to describe the cost function of the regional areas, and the production function of the smaller units; all models have a log-log functional form and assume the disturbance term associated with inefficiency has a half normal distribution. The analysis is based on data provided by EDP Distribuição for the years 2003 and 2004. The expenditure category examined in the analysis relate to direct expenditure of units — so that there is no allocation of common costs across units — and account for around 70 to 80 per cent of all controllable operating expenditure.

A.55 ERSE concludes from its analysis that the direct costs of EDP Distribuição's areas are 20 to 30 per cent above the level considered efficient. On the basis of this, ERSE notes that there are two extreme scenarios that could be considered:

(a) require a 20 per cent reduction on 70 per cent of the controllable operating expenditure; or

(b) require a 20 per cent reduction on all controllable operating expenditure.

A.56 ERSE notes that given the significant financial implications of whatever efficiency targets are set it is critical that the results of its analysis be credible. It notes that the various SFA models examined yielded consistent result but that there are other methods that could have been considered to estimate a frontier, naming data envelopment analysis as an example.

A.57 On the basis of published documents, we have not found a similar amount of analytical effort put in by ERSE to determine the 1 per cent efficiency gain associated with technological progress or with the frontier shift to use ERSE's terms. The discussion of this issue appears to be limited to a presentation in "Parâmetros de Regulação na Actividade de Distribuição de Energia Eléctrica Para o Período 2006–2008" — the third in the set of three studies by ERSE on the efficiency of EDP Distribuição referred to above — of the 1.5 per cent value used by Ofgem for 2005–2010, and of the values used by DTe for 2002–2004 (2 per cent) and for 2005 (1.5 per cent). In that same document ERSE chooses to consider two hypotheses: a 1 per cent a year shift in the frontier, and no shift at all.

A.58 In the conclusion to that document, ERSE selects a scenario where 1 per cent hypothesis is assumed. No analysis is provided to support that choice.

United Kingdom

A.59 In 2004 Ofwat and Ofgem set price controls for the water and electricity distribution sectors respectively. Both of these reviews adopted essentially the same approach to setting industry-wide expenditure assumptions.

A.60 In each case, the determination was primarily based on the business plan submissions made by companies deemed to be at the "frontier".

A.61 Ofwat set a continuing efficiency assumption of 0.3 per cent for the water service and 0.5 per cent for the sewerage service, despite deciding that the scope for efficiency improvements was higher (double). Ofwat terms the element included in price limits as a "stick" and the element not included as a "carrot".

A.62 Ofgem included a 1.5 per cent frontier-shift assumption in price limits which was taken from a company submission without any adjustment.

A.63 The figures quoted above related to annual changes in expenditure (excluding the effect of volume changes) relative to the UK retail prices index (RPI).

A.64 Both Ofwat and Ofgem employed consultants to provide relevant evidence on the issue but the reports were only used as a cross-check to the figures derived from the business plans.

A.65 In the 2006 review of electricity and gas transmission price controls, Ofgem applied operating expenditure reductions (relative to RPI) of 1.5 per cent, plus specific identifiable savings; the 1.5 per cent figure was said to be "consistent with the assumption used itself by one of the companies".

A.66 Operating expenditure projections have a relatively small effect on revenues for these companies compared to the effect of capital expenditure and rate of return projections; the operating expenditure reduction projections did not appear to be the subject of a major debate.

A.67 In the 2007 review of gas distribution price controls, Ofgem used a "frontier shift" productivity growth assumption of 2.5 per cent a year, from which an input price growth assumption of about 1 per cent a year (relative to RPI) was deducted (this was a combination of different figures for different categories of inputs).

A.68 In addition to this trend, the forecasts for some companies were based on an element of "catch-up" improvement calculated on the basis of comparisons between companies.

France

A.69 The French price control regime for energy networks is based on building blocks and a regulatory asset value. Operating expenditure reductions (relative to inflation) are usually assumed in setting price controls; they are labelled as productivity improvements, but are not productivity improvements in the sense used in this report since the figure is expressed as being "in real terms" or "in nominal terms" and no adjustment appears to be made for input prices.

A.70 In the 2005 decision on electricity transmission price controls, the assumed reduction in operating expenditure is expressed as 3 per cent, in nominal terms, applied to wages and external purchase costs only. This reduction appears to be applied in the calculation of prices throughout the two years of the price control period.

A.71 In the 2006 decision on gas transport price controls (there are two networks, GRTgaz and TIGF), the assumed real operating expenditure reductions were 2.4 per cent a year for GRTgaz and 4 per cent a year for TIGF. This is said to be based on figures put forward by the companies.

Germany

A.72 A new regulatory regime for energy networks is being established in Germany. This is modelled very closely on the approach in Bernstein and Sappington (1998), and will not involve the use of building blocks and regulatory asset values.

A.73 Prices for each company will be indexed by a general X factor and a company-specific factor to be calculated on the basis of comparisons between companies. These indexation factors apply to different components of costs, determined by the extent to which they can be considered to be under the control of the companies.

A.74 The general X factor was written in primary legislation. It is 1.25 per cent a year for the first regulatory period and 1.5 per cent a year for the second regulatory period. After that the regulator Bundesnetzagentur is to determine the figure based on research. The figures written in legislation were the result of a political decision informed by calculations of total factor productivity and input price differentials between the energy sector and the economy as a whole; the source data were taken from the German National Statistics office.

Spain

A.75 The description below focuses on the regulatory regime for gas transmission in Spain that was in place over the period 2002–2007. (At the time of writing, we did not find any final decision relating to a successor regime.)

A.76 Gas transport operators in Spain have a maximum allowed revenue set yearly which is to reflect costs. Allowed expenditure, both operating and capital, are updated annually by applying a factor set to the product of IPH and *f*, to use the notation in the relevant legislation. IPH is defined as the arithmetic average of the change in the consumer price index ("IPC") and the change in the index of industrial prices ("IPRI"). The factor *f* is defined as an "efficiency index". The value of this index is set annually and, according to Orden ECO/301/2002, and the subsequent updates of this, it is not to be above 0.85. For each of the years in the period 2002 to 2007, *f* has been set at 0.85. This implies that 85 per cent of IPH inflation is carried through into price limits. For example, if IPH inflation is 2 per cent a year then allowed costs increase by 1.7 per cent a year.

A.77 Until 2007, a single number was calculated for the allowed revenue covering the activities of LNG regasification, storage and transport. For 2007, the activity of transportation was considered separately.

The Netherlands

A.78 This section summarises the approach to productivity issues taken in recent price control decisions by DTe.

A.79 In the January 2007 method decision for electricity transmission, DTe based its estimate of the X factor on a calculation of revenue requirements in 2010 (the last year of the price control period): the X factor provided a glidepath from current revenues to the 2010 figure. A "frontier shift" was set at 2 per cent a year based on the total factor productivity estimates (not net of the whole economy) estimated in Europe Economics's 2006 report to DTe. This "frontier shift" was then applied as part of the calculation of 2010 revenue requirements, by treating it as a rate of reduction in total allowed revenues relative to CPI. This adjustment was applied to 2005 cost estimates which had been based from the company's 2005 cost base, with downwards adjustments to parts of the cost base based primarily on international comparisons.

A.80 In the October 2006 method decision for electricity distribution, DTe used the reduction relative to CPI in total economic costs (including amortisation and return on capital) over 2003–2005 and for all companies taken together as the basis for future annual reductions in allowed revenues relative to CPI for each company over 2007–2009. The change in costs between 2003 and 2005 was calculated using a lower cost of capital in 2005 than in 2003 (based on new cost of capital evidence collected for the review), so that part of the past cost reduction used as the basis for future reductions was attributable to that assumed change in input prices rather than productivity by itself.

A.81 In the November 2005 amended method decision for gas distribution, DTe used a reduction of 1 per cent a year for a weighted average tariff relative to CPI, combined with company-specific "catch-up" factors (determined separately for small and large customer groups) which applied immediately. We cannot find a source for the 1 per cent a year figure.

A.82 Some authors have argued that the comparison that is needed is with the difference between comparable sectors and the whole economy. The use of a differential with the whole economy is essentially a way of taking account of input prices, in cases where the index used in the regulatory formula can be taken as equivalent to a whole economy output price index. This hypothesis may not be reliably satisfied in the case for CPI (a consumer price index that includes many imported goods) and the Dutch economy (which produces more than goods for Dutch consumers). Our analysis in this report makes no use of differences with the whole economy to take account of input prices.

Estimates in other reports

A.83 This section briefly reviews the estimates of productivity improvement or cost reduction that have been cited in regulatory and academic reports.

A.84 Table 9 below has a list of estimates in a number reports submitted by utility regulators in Western Europe, their basis and their sources.

Table 9 Recent reports submitted to Western European utility regulators

Report	Estimate (%)	What it refers to	Where it came from
Europe Economics 2006 for DTe	0.75–1.75	Future TFP growth relative to the economy as a whole for TenneT.	Authors' estimates.
Reckon LLP 2007 for Ofgem	0.1–4.8 for the comparator sectors highlighted	Past capital-adjusted labour productivity growth based on value added for various sectors.	Calculations using the EU KLEMS database for all sectors for which data are available. Data for a short list of comparators agreed with Ofgem were highlighted in the summary.
Europe Economics March 2003 for Ofwat	0.8–1.4	TFP (probably based on value added) relative to the economy as a whole.	Authors' estimates based on calculations from the NISEC02 database for a weighted average of comparator sectors.
NERA 2004 report for Water UK	–1.1	Reduction in unit costs relative to RPI	TFP in the water sector relative to the whole economy, taken from other studies, combined with estimated differences in input price trends between the whole economy and the water sector.
First Economics 2007 for GB gas distribution networks	–1.8 to –2.1	Annual percentage reduction in total opex relative to RPI	Authors' estimate based on calculations of trends in comparator sector retail prices relative to RPI.
CEPA 2003 for Ofgem	4.2	TFP growth for GB electricity distribution	Calculations using regulatory accounts data.
	2.4	TFP growth for England Wales electricity transmission	Calculations using regulatory accounts data.
	3.4	TFP growth for UK utilities	Calculations using NISEC02 database.
	0.2	TFP growth for Norwegian electricity distribution	Calculations using data from the Norwegian regulator.
	1.2	TFP growth for German utilities	Calculations using NISEC02 database.
	2.2	TFP growth for US electricity distribution	Calculations using data from FERC.
	7.7	Reduction in unit expenditure relative	Calculations using regulatory accounts data.

		to RPI for GB electricity distribution	
	4.9	Reduction in unit expenditure relative to RPI for England Wales electricity transmission	Calculations using regulatory accounts data.
	9.0	Labour productivity growth for UK utilities	Calculations using NISEC02 database.
	1.6	Reduction in unit expenditure (probably in real terms) for Norwegian electricity distribution	Calculations using data from the Norwegian regulator.
	4.7	Labour productivity growth for German utilities	Calculations using NISEC02 database.
	0.5	Reduction in unit expenditure (probably in real terms) for US electricity distribution	Calculations using data from FERC.
LECG 2005 report for Postcom	2.75–3.25	Reduction in unit operating expenditure relative to RPI	Authors' estimates.
LEK and Oxera 2005 report for ORR	2–8	Reduction in unit operation, maintenance and renewals expenditure relative to RPI.	Authors' estimates.

Source: Reckon LLP survey of published reports cited.

A.85 Table 10 lists some other estimates that we have found in the literature.

Table 10 Other estimates in the literature

Report	Estimate (%)	Comment
IFO 2006 working paper on the X-factor for the German electricity industry	X factor: 2.15	X factor applied to prices relative to RPI
Giannakis, Jamasb and Pollitt 2003 paper on benchmarking and incentive regulation of quality of service in UK electricity distribution	Productivity change: 1.384 for opex 1.203 for totex Boundary shift: 1.534 for opex	UK electricity distribution (1991/1992 to 1998/1999) Average Malmquist productivity indices

Report	Estimate (%)	Comment
	1.193 for totex	
Abbot 2005 study on the productivity and efficiency of the Australian electricity supply industry	TFP:2.5	Australian State electricity sectors (1969 to 1999) TFP from Malmquist indices
Hattori, Jamasb and Pollitt study comparing UK and Japanese electricity distribution performance 1985–1998	Average Malmquist index: 2.5 Frontier shift: 2.9	UK Electricity distributors (1985/1986 to 1997/1998) Approach modelled TOTEX
Tilley and Weyman-Jones 1999 report on productivity and efficiency change in electricity distribution	TFP: 6.3	England and Wales Electricity distributors (1990/1991 to 1997/1998) TFP from Malmquist indices
Ontario Energy Board 1999 report on productivity of electric distributors in Ontario	TFP (gross output measure): 0.87	Ontario electricity distributors (1988 to 1997)
London Economics 1999 report for Independent Pricing and Regulatory Tribunal of New South Wales on efficiency and benchmarking of the NSW distribution businesses	TFP: –6.4 to 4.1 Frontier shift: –1.1 to 0.3	NSW distribution businesses (1995/1996 to 1997/1998) Malmquist TFP indices
	TFP: 3.5 Frontier shift: 3.9	England and Wales distributors (1990/1991 to 1996/1997) Industry averages from Malmquist TFP indices
	TFP: 0.7 Frontier shift: 2.3	United States distributors (1994 to 1996) Industry averages from Malmquist TFP indices
	TFP: 1.4 Frontier shift: –1.3	New Zealand distributors (1994/1995 to 1996/1997) Industry averages from Malmquist TFP indices
NERA 1997 working paper on price cap plans for electricity distribution companies	TFP: 1.86	United States electricity distribution (1972 to 1994)

Source: Reckon LLP survey of published articles cited.

A.86 One notable feature of the data reported in several of the reports listed in table 10 is that the “frontier shift” sometimes implies faster productivity growth than the industry average. This is shown as a negative “catch-up” figure in some studies.

A.87 What this feature of the data in fact implies is that, in the periods where frontier shift was faster than average productivity growth (or unit cost reduction), the dispersion of productivity or unit cost levels between companies increased (so that the average and the frontier moved away from each other).

A.88 A possible interpretation for such a divergence of performance in a set of regulated companies would be that initially upon inception of incentive regulation and that poor performers only catch up later. During the initial period, frontier shift would exceed average productivity growth. In the latter period, average productivity growth would exceed frontier shift. The explanation that is sometimes given is that frontier firms are typically better managed and more flexible and respond faster to new regulatory incentives.

A.89 The fact that frontier shift exceeds average productivity growth does not necessarily imply that the catch-up relationship between differences in productivity is reversed. It is possible for the rate of frontier shift to be higher than average productivity growth whilst the productivity growth of companies at or near the frontier is lower than average productivity growth, since the identity of the companies defining the frontier can change from year to year and companies which have a particularly high increase in productivity due to ordinary random fluctuations are more likely to be setting the frontier in the future than companies which do not. Thus, the negative "catch-up" figures in some studies do not indicate a reversal of catch-up in its normal meaning in connection with comparative analysis.

Debate on productivity measures and estimation methods

A.90 This section reviews previous published papers and studies relating to the estimation of productivity growth in regulated industries. It starts by discussing aspects of a debate about the relationship between "X factors" and productivity. It then reviews the sources and relevance to GTS of estimates in recent reports for regulators and regulated companies.

Bernstein and Sappington (1998) Setting the X factor in price cap regulation plans

A.91 Bernstein and Sappington (1998) sets out an approach for computing X in price cap regulation.

A.92 They show that imposing a zero profit condition on the regulated firm implies that output price growth is equal to the difference between input price growth and the firm-level TFP growth. They go on to show how this relationship can be applied to price cap regulation.

A.93 They consider an economy with a single regulated industry (a single firm or several firms operating under similar circumstances). They also stipulate that the prices set by the regulator have no effect on the prices in the rest of the economy. They call this the "benchmark" setting.

A.94 They then extend the firm-level relation between growth in input prices, output prices and TFP to the whole economy and find that a similar relationship exists between whole economy output price growth, whole economy input price growth, whole economy TFP growth and profit levels.

A.95 They combine the two sets of relationships to obtain the classic formulation of price cap regulation that the growth in output prices of the regulated firm should be set equal to the growth in output prices in the whole economy, less an X factor.

A.96 When profits, both in the regulated industry and in the rest of the economy, are assumed to be zero, they show X to be equal to the sum of:

(a) the difference between the growth rates of industry level TFP and whole economy TFP, and

(b) the difference between the growth rates of whole economy input prices and industry-level input prices.

A.97 They describe the adjustments to be made to X when only a subset of the regulated firm's output is subject to price cap regulation. The magnitude of the adjustment:

(a) depends negatively on the fraction of the firm's revenues accounted for by price-capped services;

(b) is zero when the price of capped and uncapped services increase at the same rate; and

(c) should be negative when the prices of uncapped services are rising less rapidly than is necessary to ensure zero profitability overall for given overall productivity and input price growth rates.

A.98 They then describe the adjustment that needs to be made to relax the assumption that the output price of the regulated industry does not affect the overall economy output price growth. Their adjustment reduces the sensitivity of output price growth in the regulated industry to the output price growth in the whole economy, but only in the case where some of the outputs of the regulated industry are intermediate goods.

A.99 They go on to describe some of the ways in which the effects of "structural changes" to the regulated industry, for example by the introduction of a new regulatory regime, or by a sudden increase in competitive pressures could be accommodated in the price setting process.

Swinand (2003) An empirical examination of the theory and practice of how to set X

A.100 This paper, published by the consultancy London Economics and with similarities to London Economics (2003) (report for Ofwat), reviews the various interpretations of X and its past application by regulators in the US and in Europe.

A.101 It examines the validity of the US method of determining X as a "productivity offset" as in Bernstein and Sappington (1999), and draws the conclusion that this approach could lead to an upward bias in the price cap.

A.102 It points out that the "productivity offset" approach relies on the ability to estimate the economy-wide output price inflation. The author asserts that the RPI published by the ONS differs significantly from the difference between economy-wide input price growth and the economy-wide TFP growth. He then states that if the observed RPI were to exceed the theoretical RPI, the price cap would be biased upwards.

A.103 The author then attempts to demonstrate the existence of the bias using data from the UK.

A.104 He begins by looking at the relationship between RPI and PPI as published by the ONS and TFP growth in the economy. He finds that the observed RPI exceeds the theoretical RPI, which he computes as PPI minus TFP, by annual average of 2.18 per cent over the period 1975 to 2000. If price caps were set based on the "productivity offset" X, an equivalent upward bias would have affected the set prices.

A.105 We are not convinced by the use of PPI data as a measure of input price growth in the economy. This is because the relevant input prices should correspond to the inputs for the measure of output. If the TFP was computed using value added as a measure of output, the appropriate measure would be labour and capital price growth and not PPI as labour and capital are in inputs for value added. Even if the TFP was computed using gross output, the PPI alone would be an inadequate proxy for labour and capital price growth.

A.106 The author then uses ONS's unit labour cost index as a measure of input price growth. Again, this is not an appropriate measure since the unit labour cost is calculated by dividing average wages and salaries by output per worker. Consequently, the unit labour cost index minus TFP would be expected to exceed RPI by a number equal to the labour productivity growth. Unsurprisingly, the author finds an upward bias of approximately 2 per cent — a reasonable figure for labour productivity growth.

A.107 The author constructs two composite input price indices using labour cost indices, PPI and cost of capital measures based on gross capital formation in the economy. Our criticism of the use of the labour cost index and the PPI applies to these composite indices as well.

A.108 The author then goes on to construct an alternative definition of X as the economy-wide TFP minus real input price growth. As far as we can tell, this is actually equivalent to the Bersnstein and Sappington formulation: no bias has been added or removed. The only difference is that Swinand's mistakes in testing the relationship between whole-economy input prices, whole-economy output prices and whole-economy total factor productivity prevents him from using that identity. As a result, he cannot rely on assumptions about input price differentials, and instead his approach would require direct estimation of the absolute value of the input price growth (relative to whichever price index is chosen to index regulated prices) and of the total factor productivity growth for the regulated company. This would be useful if Swinand had a method for estimating these parameters. The 2003 paper does not disclose any such method.

A.109 In London Economics (2003),[5] this method was put into effect as follows:

[5] London Economics (2003) PR04 Scope for Efficiency Studies, report to Ofwat, page 134.

> We also estimate the differential between input prices in the industry and RPI to be zero — it is our understanding that these is consistent with the business plans in the industry.
>
> [Footnote:] We stress that a rigorous measurement of input prices was outside the scope of this study. In addition, we showed previously in this chapter that for a number of time periods and measures of input prices, input prices have tended to lag behind the RPI in the UK. Therefore, if anything, attempts at refining our input price growth measure relative to RPI, we feel would lead to a larger bias between the two Xs.

A.110 As far as we can tell, these assumptions and claims do not have a basis other than the incorrect interpretation of ONS data as discussed above. It would not be surprising if business plans in the industry had made reference to the same concept of unit labour cost (per unit of output). It seems to us that this mistake invalidates the specific method proposed by Swinand/London Economics. Without that mistaken assumption about input prices the method adds nothing to Bernstein and Sappington (1998).

NERA (2004) Estimating OPEX and CAPEX efficiency (report for Water UK)

A.111 NERA's paper for Water UK aims to compute a US-style X factor[6] for the UK water and sewerage industry. The paper computes the X factor as the sum of;

(a) the difference between the growth rates of water industry TFP and whole economy TFP; and

(b) the difference between the growth rates of whole economy input prices and water industry input prices.

A.112 NERA begin by looking at the baseline estimates of water and sewerage TFP growth (without quality and privatisation adjustments) produced by London Economics, CEPA, Europe Economics and Saal and Parker which report a range of baseline TFP estimates from –0.6 per cent to 0.53 per cent. NERA choose to adopt the mid-point of this range (0 per cent) as their estimate of baseline TFP growth.

A.113 They then go on to discuss the London Economics and CEPA approaches to adjusting output for quality. NERA find that these approaches are reasonable and uses the mid-point of London Economics's (0.7 per cent) and CEPA's (0.3 per cent) estimates and use 0.5 per cent as their TFP adjustment for quality. To estimate the privatisation effect, they first examine the approaches taken by London Economics and Europe Economics and conclude that these approaches do not provide conclusive results. They then argue that NERA's own estimate of baseline TFP, being based on data from 1990 to 2000, would already contain an embedded privatisation effect. They say that this privatisation effect is diminishing and that there is considerable uncertainty surrounding this issue. They take the view that the privatisation effect would be minimal, if at all during the next review period. Taking account of this uncertainty NERA decide to make a "conservative" downward adjustment of -0.1 per cent to their baseline TFP estimate. The basis for this adjustment is unclear. As a result, NERA's estimate of water and sewerage TFP growth is 0.4 per cent.

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[6] Bernstein and Sappington (1998) Setting the X factor in price cap regulation plans.

A.114 NERA then estimate the economy-wide TFP growth rate using the NISEC02 dataset and find that the growth rate is 1.4 per cent over the period 1974–99. They also report the estimates used by Europe Economics and CEPA in their studies — both are 1.3 per cent. NERA uses 1.3 per cent as the economy-wide TFP growth figure.

A.115 NERA then estimate future input price growth for water and sewerage. They divide OPEX inputs into labour, power, materials and Government charges. Labour price growth is estimated based on the UK average earnings forecast reported by Oxford Economic Forecasting (2004). NERA settle for a central estimate of 4.4 per cent for nominal labour price growth, calculated as the average of OEF forecasts for the years 2004–2008. Power (electricity) nominal price growth is expected to be 8.7 per cent over the period 2005–2010, combining forecasts by OXERA for real electricity price growth and Treasury forecasts of RPI growth.

A.116 NERA then estimates future price growth of input materials using historic PPI data. They compute a weighted average of past PPI growth for electrical machinery and equipment and chemicals and chemical products. The relative weighting of 4:1 is calculated based on NERA estimates of their relative share in OPEX. A linear trend is used to extrapolate this weighted average and they estimate that real prices of input materials would decrease by 2 per cent and the nominal price would increase by 0.5 per cent.

A.117 NERA acknowledge that Government charges (LA and EA) are difficult to forecast and therefore assume that these would rise in line with RPI. As a result, they assume that nominal Government charges would grow at 2.5 per cent a year.

A.118 A weighted average of component input price growth rates is used to compute the overall input price growth in the water and sewerage industry. Weights are assigned based on the relative average expenditures on each input within opex based on data from all companies' June returns. This gives an estimate of 3.4 per cent.

A.119 NERA make forecasts of CAPEX input price growth based on DTI forecasts and other published commentary of growth in the construction industry. They choose a forecast of 3.4 per cent a year.

A.120 OPEX and CAPEX input prices are averaged using a weight of 60 per cent for CAPEX and 40 per cent for OPEX giving an overall estimate of 3.4 per cent for aggregate future input price growth.

A.121 A similar approach is used to estimate whole economy input price growth. Labour price growth for the economy is estimated based on OEF forecasts, materials input prices are estimated based on OEF manufacturing PPI forecasts. Capital price growth is estimated using a combination of construction prices indices and manufacturing output prices as a proxy for capital price index.

A.122 All of these individual whole economy input price trends are aggregated by assigning weights derived by NERA using data from the UK national accounts. As a result, NERA estimates that future input price growth in the economy would be 3.2 per cent.

A.123 Table 11 sets out the weighting used by NERA.

Table 11 Weights for input price components

Factor inputs	National accounts source used by NERA	NERA weight	NERA – Nominal input price growth forecast
Labour	Total compensation of employees	56 per cent	4.4 per cent
Capital	Gross Capital Formation	17 per cent	Weighted average of 3.4 and 0.8 per cent (weight 3.3:1)
Other factors of production – Materials and fuel	Estimated as a residual fraction of GDP (GDP – labour + capital)	27 per cent	2 per cent
Total output	GDP	100 per cent	

Source: Reckon LLP analysis of published NERA report.

A.124 Finally all of these estimates are combined using the postulated relationship between X, TFP growth and input price growth. They state that X equals the water and sewerage TFP relative to the economy-wide TFP minus water input price growth relative to economy-wide input price growth. They estimate that real unit costs in the water and sewerage sector will increase by 1.1 per cent a year.

A.125 NERA do not estimate separate capex and opex change forecasts. They argue that their estimates of overall costs are likely to be more robust than separate estimates of opex and capex as the available evidence on capital and non-capital PFPs is poor.

A.126 We disagree with the method adopted by NERA to compute economy-wide input cost trends, for the following reasons.

A.127 First, the economy-wide TFP measure used by NERA (whether taken from NIESR, Europe Economics or CEPA) is a value-added measure. Consequently, it is incorrect to include any input costs other than labour and capital in the calculation of economy-wide input cost growth. These costs would only be included if we were to use a gross output measure of TFP.

A.128 Second, gross capital formation is not an appropriate measure of the cost of capital used. It reflects the investments made in the year, not the contribution of capital to value added. Gross operating surplus would seem to be a better measure.

A.129 Third, NERA assumes that the GDP less total compensation of employees less gross capital formation ("the residual fraction") is the cost of other factors of production (materials and fuel). This is wrong because the two numbers form parts of different measures of GDP (income and expenditure methods respectively) and cannot be lumped together. In fact, a large part of the residual labelled materials and fuel by NERA is VAT and excise duties, which are included in the income calculation alongside compensation of employees.

A.130 To demonstrate the importance of these errors, table 12 shows estimated weights for economy-wide input costs using data from the UK national accounts for 2000.

Table 12 Actual input price weights

Factor inputs	UK national accounts data source [ONS Blue Book reference code]	Economy-wide value in 2000 in £ billion	Input weight in gross output measure	Input weight in value added measure
Labour	Compensation of employees [HAEA]	532	0.30	0.64
Capital	Gross total operating surplus [ABNF] *plus* Mixed income [QWLT]	298	0.17	0.36
Materials and fuel	Intermediate consumption at basic prices [NQAJ]	932	0.53	Not applicable
Total gross output at basic prices	Calculated as HAEA + ABNF + QWLT + NQAJ	1,762	1.00	Not applicable
Total value added	Calculated as HAEA + ABNF + QWLT	831	0.47	1.00
Total GDP	Including VAT and other taxes [YBHA]	959	Not applicable	Not applicable

Source: Reckon LLP analysis of published ONS data.

Conclusion on this debate

A.131 Some of the papers debating estimation methods reviewed above are affected by significant errors. Others, in particular Bernstein and Sappington, did contribute to the analysis of expenditure and productivity trends, although their methods do not lend themselves to a direct application for the questions addressed in this report. These contributions are taken into account in our definitions of productivity and unit cost measures (see appendix B).

APPENDIX B: DEFINITIONS, SOURCES AND METHODS

General conventions and definitions

B.1 This section specifies conventions used in this report and defines a number of productivity measures and other variables and concepts used in productivity measurement.

B.2 A number of the productivity growth measures presented in this section rely on standard formulae within the academic literature. The EU KLEMS methodology paper provides these standard formulae.[7]

Use of logarithms in growth rates

B.3 Except where otherwise specified, we use natural logarithms for the measures of rates of change that we have calculated. For example, if a variable X changes from 105 to 110 then its growth $g(X)$ will be defined as ln(110/105) = 4.65%.

B.4 This convention enables growth rates over a period to be calculated as a simple arithmetic average of the annual growth rates.

B.5 To convert a logarithmic growth rate into an annual rate of reduction, the conversion formula is:

$$[\text{percentage rate of reduction}] = 100 * (1 - \exp(-g))$$

B.6 For example, a productivity rate of 4.65 per cent in terms of logarithms, if applied to an input volume with a first-year value of 100 (and constant output), implies a rate of reduction of 4.54 per cent a year, calculated as 1 – 100*exp(–0.0465).

B.7 A different conversion formula needs to be used if rates of reduction are used in a CPI–X formula. If g is a logarithmic rate of growth measured relative to CPI, and if *CPI* denotes percentage growth of the consumer prices index, then the conversion formula is:

$$[\text{Value of X in CPI–X}] = (100 + CPI) * (1 - \exp(-g))$$

Description of averaging periods

B.8 The macroeconomic data that we use are taken from the national accounts, which are based on calendar years.

B.9 Unless otherwise specified we measure growth rates in logarithms as straightforward averages of the annual change in logarithms.

[7] Timmer, Marcel et al. (2007) EU KLEMS Growth and Productivity Accounts, Version 1.0, Part I Methodology.

B.10 For example, when we refer to growth over the period 1973–1998, we mean growth measured from the year 1973 to the year 1998, i.e. a period spanning a total of 26 years.

B.11 If the source data are expressed as rates of growth, then the growth over 1973–1998 is the average in logarithms of 25 annual growth rates, the first one being growth from 1973 to 1974. If the source data are expressed as index numbers, then the growth over 1973–1998 is calculated using the index numbers for 1973 and 1998.

B.12 This average logarithmic growth rate can be converted into a compound annual growth rate by exponentiating it and deducting 1.

Gross output

B.13 Gross output relates to the goods or services produced by a firm or sector. For a firm, the value of gross output is its turnover.

Labour

B.14 Labour refers to human work in production activities. The value of labour comprises the wages and social security contributions of employees, and the estimated labour element of the profits of self-employed people.

Intermediate inputs

B.15 Intermediate inputs are all the inputs other than labour that are consumed by the production process (not inputs that are merely used without being consumed: these are capital). Intermediate inputs are comprised of energy, materials and services.

B.16 For a firm, the combined value of labour and intermediate inputs is its operating expenditure (operating cost less amortisation charges).

Capital

B.17 Capital (meaning the services from capital) represents the contribution to the production process made by durable assets.

B.18 The value of the capital input is value added less labour compensation. For a firm, the value of the capital input is essentially its cashflow from operations: that is to say, earnings before interest, amortisation and taxes on profit. This will not normally correspond to any accounting measure of profit, or to any combination of capital expenditure, renewals expenditure, the estimated cost of capital or amortisation.

Value added

B.19 Value added is defined as gross output less intermediate inputs.

B.20 Provided that all nationally produced natural resources (such as energy or materials) are treated as the output of a sector (e.g. mining), then the aggregate of value added over the economy, plus VAT and other taxes, is the gross domestic product (output measure of GDP). This is the total output from the economy seen as a whole, including exports, net of imports, measured in purchasers (tax-inclusive) prices.

B.21 Value added is also the sum of the value of labour and the value of capital, which on aggregate over the economy can be reconciled with the income measure of GDP as wages plus rents plus profits plus VAT and other taxes.

B.22 At the level of an individual firm, this notion of value added is not a significant accounting measure.

Productivity

B.23 All the measures outlined above are in financial terms. To estimate productivity growth, it is necessary to convert them into volume terms. This can be done in two ways:

(a) Applying notional constant prices to the underlying volume data. For example, the change in the volume of labour input can be calculated from a weighted average of changes in hours worked by different types of labour (e.g. by skill level) in which the weights are shares of value (i.e. proportions of total labour cost).

(b) Using a suitable deflator to convert values into volumes. For example, value added volumes for the whole economy can be calculated from GDP in current prices by using the GDP deflator to convert it into constant prices (i.e. volumes).

B.24 The EU KLEMS methodology paper provides a good discussion of the methods it used to calculate the volume series reported in its database.[8]

B.25 Productivity growth is the difference between input volume growth and output volume growth in a production process, and is defined to be positive when the relevant output grows faster than the relevant input.

B.26 The output measures that can be used for sector-level measures of productivity growth are gross output and value added. The input measures can be any combination of labour, capital, and, if the chosen output measure is gross output, intermediate inputs or its component parts (energy, materials, services). But these intermediate inputs are not relevant inputs if output is measured as value added since their contribution to production has already been netted off the value added output measure.

B.27 Combining several input measures gives multi-factor productivity measures. If all relevant inputs are included then the term total factor productivity is used. Total factor productivity can thus be measured using value added or gross output as the output measure.

B.28 For the economy as a whole, measurements usually focus on value added measures rather than gross output measures, since gross output aggregated over the economy as

[8] Timmer, Marcel et al. (2007) EU KLEMS Growth and Productivity Accounts, Version 1.0, Part I Methodology.

a whole has little economic significance. The headline productivity measures on the value added basis are labour productivity (i.e. economic growth relative to changes in volume of labour) and total factor productivity (i.e. economic growth relative to the combined change in volume of labour and capital).

Unit costs

B.29 The term unit costs when applied to an input or a category of inputs is potentially ambiguous: it might refer to the cost per unit of input, or to the price of that input per unit of output.

B.30 The latter definition is the usual one in respect of inputs identified by accounting category: for example, unit operating expenditure means operating expenditure per unit of output.

B.31 To ensure consistency in the use of terminology, and in line with the terminology used in national statistics (see the discussion of unit labour costs later in this section), we always define unit costs as costs per unit of output. We use the term input prices if we want to refer to a cost per unit of input.

Labour productivity growth based on value added

Definition and methods

B.32 Labour productivity growth based on value added is defined as the increase in value added at constant prices relative to the increase (or decrease) in the volume of labour input used.

$$g(LP_{VA}) = g(VA) - g(L)$$

where

$g(LP_{VA})$ is the increase in labour productivity based on value added

$g(L)$ is the increase in the amount of labour used

$g(VA)$ is the increase in value added at constant prices

B.33 When information is available on different types of labour (e.g. by qualification level), the change in the volume of labour input is calculated as a weighted average in which the weights are shares of value (i.e. proportions of total labour cost).

B.34 Where information is available on values and volumes of gross outputs and intermediate inputs, rather than on value added at constant prices, a proxy measure for the increase in value added at constant prices is given by the following formula:[9]

[9] Equation 10′ in Section 3 of Timmer, Marcel et al. (2007) EU KLEMS Growth and Productivity Accounts, Version 1.0, Part I Methodology.

$$g(VA) = [g(GO) - (1 - shareVA_{GO}) * g(II)] / shareVA_{GO}$$

where

$g(GO)$ is the increase in volume of gross output

$g(II)$ is the increase in volume of intermediate inputs

$shareVA_{GO}$ is the proportion of the value of gross output that is accounted for by value added

B.35 Both value added and labour are additive between sectors of the economy. This means that labour productivity growth based on value added can be calculated for individual sectors, and averaged up to groups of sectors or the economy as a whole without a risk of double counting or similar errors.

Data availability

B.36 Labour productivity data are available from EU KLEMS, broken down by country and by sector. The EU KLEMS data appear to incorporate the work previously published by the University of Groningen.

B.37 The OECD also publishes labour productivity data, but this relates to each national economy as a whole with no breakdown by sector.

B.38 No labour productivity data as such are likely to be available for GTS, due to the lack of reliable information on staff numbers and hours used by the regulated transmission business.

Unit labour costs and real unit labour costs

Definition and methods

B.39 Unit labour costs are defined as the costs of labour per unit of output. This is equivalent to a wage index divided by a labour productivity measure.

B.40 This measure is reported as an index in nominal terms by the national statistics offices in some countries, including the US and the UK.

B.41 Eurostat does not publish such unit labour cost data. Instead, it collects information on a measure called real unit labour costs. This differs from unit labour costs by the use of nominal GDP instead of GDP at constant prices as the output measure.

B.42 Thus, real unit labour cost is simply the ratio of whole economy labour compensation (in nominal terms) to GDP (in nominal terms). If the proportion of GDP accounted for by VAT and other taxes (which are included in the income-based measure of GDP alongside the value of labour and capital) is constant, then the change in real unit labour costs is the same as the change in the share of labour in value added.

B.43 The difference in the growth of unit labour costs and real unit labour costs is the GDP deflator — as the only difference is the use of GDP in market prices in one case and GDP in constant prices in the other.

B.44 Over the long run, the trend real unit labour costs is likely to be flat, reflecting the observation that the labour share of value is fairly stable. However in the short term there are noticeable fluctuations in real unit labour costs.

Possible use in regulating GTS

B.45 A unit labour cost measure based on labour productivity and expressed relative to the CPI is a possible element of the estimation of reasonable trends in operating expenditure for GTS as part of the price control review.

B.46 The use of the CPI as a reference point (instead of, say, the GDP deflator used in Eurostat's unit labour cost measure) simply reflects the likely use of that index in the price control regime given precedence in other regulated Dutch entities. It has no particular economic significance.

B.47 Using unit labour cost trends would not capture the whole of operating expenditure: in particular, it would omit any element of expenditure that cannot be analysed as a cost of labour (either labour used directly by GTS or labour used by its suppliers). The main exclusions would be:

(a) natural resources costs, mainly the cost of any gas used to provide transportation services;

(b) any land or asset rentals under operational leases; and

(c) the costs of imported materials (other than imports whose price is constrained by competition with domestic production driven by similar wage and productivity trends as those implied in the unit labour cost measure).

B.48 Another issue with the use of labour productivity and unit labour costs data is the need to establish whether the productivity figure used takes proper account of the investment for which revenues are being allowed to GTS. This is addressed by the capital adjusted measures of labour productivity, to which we now turn.

Adjustment for constant services from capital

Labour productivity adjusted for constant services from capital

B.49 Labour productivity growth based on value added and adjusted for constant output and constant services from capital is defined as the decrease in the volume of labour input used that would have been achieved if both the volume of services from capital and the amount of value added at constant prices had been held constant.

B.50 The adjustment is therefore intended to remove changes in labour productivity that are attributable to economies of scale or to changes in the capital employed.

B.51 Making the adjustment requires information on output growth, economies of scale, capital input growth and the marginal rate of substitution between labour and capital input.

B.52 As regards macroeconomic data, we assume that, at the sector or whole economy level, there are generally no economies of scale as enterprises are deemed to be operating at a reasonably efficient scale and volume growth can arise from changes in the number of producers just as much as from changes in the scale of production. Thus the only adjustment to be made is for capital input growth and capital-labour marginal substitution.

B.53 The standard assumption for the marginal rate of substitution is to assume that, on average over a sector or the whole economy, the mix of inputs is reasonably efficient, such that the shares of values of different inputs provide a proxy for marginal rates of substitution. For example, if value added is one third capital and two thirds labour, then the expectation is that an increase of capital employed of 1 per cent would permit a reduction in labour employed of 0.5 per cent, leaving the total cost constant.

B.54 This assumed marginal rate of substitution underpins the standard formula for total factor productivity based on value added:[10]

$$g(TFP_{VA}) = g(VA) - shareK_{VA} * g(K) - shareL_{VA} * g(L)$$

where

$g(TFP_{VA})$ is the increase in total factor productivity based on value added

$g(VA)$ is the increase in value added at constant prices

$g(K)$ is the growth in the volume of services from capital

$g(L)$ is the growth in the volume of labour

$shareL_{VA}$ is the share of value added which is accounted for by labour

$shareK_{VA}$ is the share of value added which is accounted for by capital

B.55 The effect of using the assumed marginal rates of substitution in the definition of total factor productivity is that $g(TFP_{VA})$ is expected to be the same for all combinations of increases in labour and capital growth that can be achieved by substituting between these two inputs. Labour productivity growth adjusted for constant services from capital and constant output is therefore obtained by setting $g(K)$ and $g(VA)$ to zero in the above formula. This gives:

$$-g(L) = g(TFP_{VA}) / shareL_{VA}$$

[10] Equation 8 in Section 3 of Timmer, Marcel et al. (2007) EU KLEMS Growth and Productivity Accounts, Version 1.0, Part I Methodology.

and since we know that $g(LP_{VA}) = g(VA) - g(L)$ and that in this case $g(VA) = 0$, the equation can be rewritten as follows:

$$g(LP_{VAadj}) = g(TFP_{VA}) / shareL_{VA}$$

where

$g(LP_{VAadj})$ is labour productivity growth adjusted for constant capital

$g(TFP_{VA})$ is the increase in total factor productivity based on value added

$shareL_{VA}$ is the share of value added which is accounted for by labour

B.56 The above equations are equivalent to the following formulae:

$$g(LP_{VAadj}) = g(LP_{VA}) + (1 - shareL_{VA}) / shareL_{VA} * g(KP_{VA})$$

where

$$g(KP_{VA}) = g(VA) - g(K)$$

B.57 The term $g(KP_{VA})$ is the increase in capital productivity based on value added. This alternative formulation shows how labour productivity data is being estimated to take account of the changes in capital productivity. It also indicates a likelihood of serious inaccuracy if the share of value attributable to labour is small, as any inaccuracies in the measurement of capital volumes are then scaled up in calculating the adjusted labour productivity figure.

Data availability

B.58 Using EU KLEMS data, we can calculate labour productivity growth adjusted for constant services from capital using the method outlined above for a variety of sectors and periods.

B.59 We have not seen data for GTS that would enable the calculation of labour productivity growth adjusted for constant services from capital. In our experience, data availability for utility companies does not normally permit such calculations.

Unit labour costs adjusted for constant services from capital

B.60 In the same way as the labour productivity can be combined with a wage index to determine a unit labour cost index, we can construct a unit labour cost index adjusted for constant services from capital on the basis of the adjusted labour productivity measure described above.

B.61 If used within a CPI–X price control regime, it would be natural to express these unit labour costs relative to the CPI, rather than in nominal terms or relative to a GDP deflator measure.

Application to operating expenditure

B.62 Using labour productivity adjusted for constant output and constant services from capital, instead of labour productivity, enables comparisons to be made between companies or sectors which have experienced different levels of investment in better assets, and (if information on economies of scale is available) different rates of output growth.

B.63 This means that a figure derived from comparator sectors can be used in the regulation of GTS provided that other aspects of the price control (in particular any allowances for capital expenditure or for returns on such expenditure) would enable GTS to maintain the capability of its asset base and to meet additional output requirements, but no more.

B.64 Whilst the appropriate allowances for asset renewal and demand growth will be a matter of debate, we think that it is most transparent to conduct this debate on the basis of a clear baseline of constant output and constant services from capital. Explicit adjustments can then be made any planned deviation from this notional baseline, for example:

(a) Further reductions in operating expenditure may be expected if the amount of planned capital expenditure would allow older (but still working) assets to be replaced with newer technology with lower maintenance requirements.

(b) Increases (or lower reductions) in operating expenditure may be expected if additional capital expenditure is scheduled to create new assets to meet demand growth: these assets would need to be operated and maintained.

B.65 Other points noted in the discussion on labour productivity based above will also apply to labour productivity adjusted for constant output and constant services from capital. This means that the measure of expenditure will need to exclude:

(a) natural resources costs, mainly the cost of any gas used to provide transportation services;

(b) any land or asset rentals under operational leases; and

(c) the costs of imported materials (other than imports whose price is constrained by competition with domestic production driven by similar wage and productivity trends as those implied in the unit labour cost measure).

B.66 Given that the productivity trends do not apply to these items, separate assumptions will be required for them in price limits.

Total factor productivity based on value added

B.67 Total factor productivity based on value added was defined above as a step in the calculation of labour productivity growth adjusted for constant capital. Definitions, methods and data availability are as above in respect of macroeconomic studies.

B.68 There is a risk that the concept of total factor productivity based on value added cannot usefully be applied to data from utility companies. This is because the assumption underpinning the concept that a marginal rate of substitution between capital and labour can be inferred from the shares of value added accounted for by capital and labour might be invalid in the case of a utility company whose main outputs and allowable revenues are constrained by a regulatory regime based on the public interest and fairness to investors (rather than freely adjusted to maximise economic returns as assumed in other sectors or, as an approximation, for the economy as a whole).

Labour and intermediate inputs productivity growth based on gross output

Definition and methods

B.69 Labour and intermediates productivity growth based on gross output is defined as the increase in gross output at constant prices relative to the increase (or decrease) in the volume of labour and intermediate inputs used:

$$g(LIIP_{GO}) = g(GO) - shareL_{LII} * g(L) - shareII_{LII} * g(II)$$

where

$g(LIIP_{GO})$ is the increase in labour and intermediates productivity growth based on gross output

$g(GO)$ is the increase in gross output at constant prices

$g(L)$ is the increase in the amount of labour used

$g(II)$ is the increase in the amount of intermediate inputs used

$shareL_{LII}$ is the share (by value) of labour in the aggregate of labour and intermediate inputs

$shareII_{LII}$ is the share (by value) of intermediate inputs in the aggregate of labour and intermediate inputs

B.70 Whilst gross output and the various inputs are in a sense additive, aggregating them across the economy makes little sense: total gross output across the economy is not a meaningful measure of economic output, since it depends on the size of the reporting units and the extent of vertical integration reflected in the data.

B.71 Macroeconomic data for this measure can be distorted when there is a change in the level of vertical integration, whether in economic reality or merely in the way that data are submitted or processed for the national accounts. For example, in the gas sector, separation of network and commodity activities will have led to a sharp increase in both gross output and in intermediate inputs, as the transmission service previously produced in house by an integrated company is now identified and priced as gross output and as intermediate inputs in the national accounts.

B.72 At the level of an individual firm, labour and intermediate inputs productivity based on gross output seems the most natural measure of operating productivity. It relates specifically to the part of the production process under the control of the firm, and to the trend in operating expenditure relative to input prices. For example, operating leases are recognised as part of the services supplied to the company, in line with their accounting treatment as operating expenditure. (In the measures based on value added, outlined above, these services are netted off output rather than treated as inputs.)

B.73 Labour and intermediate inputs productivity growth can be adjusted for an assumption of constant services from capital in a similar way as labour productivity based on value added. The relevant formula is:

$$g(LIIP_{GOadj}) = g(GO) - shareL_{LII} * g(L) - shareII_{LII} * g(II)$$

$$g(LIIP_{GOadj}) = g(LIIP_{GO}) + shareK_{GO} /(1 - shareK_{GO}) * g(KP_{GO})$$

where

$$g(KP_{GO}) = g(GO) - g(K)$$

$shareK_{GO}$ is the share (by value) of gross output attributable to capital

Data availability

B.74 EU KLEMS provides the relevant data for a variety of countries, sectors and years.

B.75 In our work for Ofgem, we briefly considered the UK data and agreed with Ofgem not to investigate it further on the grounds that it had oddities in several of the sectors of interest.

Possible use in regulating GTS

B.76 If it is was possible to make a reasonable determination of a rate of labour and intermediate inputs productivity applicable to GTS and of a weighted average rate of input price growth for the labour, energy, materials and services used by GTS for operational purposes, then combining these figures would provide a basis for estimating changes in operating expenditure for regulatory purposes.

B.77 As above, the adjustment for constant capital can be used to address concerns about the effect of new or improved assets on operating expenditure. The concerns expressed above about elements of operating expenditure such as operating lease charges would vanish, since such elements are taken into account as part of intermediate inputs.

B.78 Against these advantages of measures based on gross output, the difficulties in establishing reasonable comparisons are more significant in the case of measures based on gross output than in the case of measures based on value added, because:

(a) Productivity growth measured on a gross output basis depends on the industrial organisation of the sector. Value added is not affected by this.

(b) The relevant input price trends for gross output measures include price trends for the various intermediate inputs. There is no reasonable basis to assume that, for example, trends in the price of things as disparate and non substitutable as gas, paint, plant hire and consultancy services follow the same trends or that the particular mix of inputs used by GTS follows a trend inferred from an economy-wide aggregate. This issue does not arise in the case of measures based on value added, because it is plausible to expect that labour mobility between sectors means that there is likely to be a degree of competitive constraint between wages across the economy, such that a broad brush assessment of wage trends in the economy is a reasonable proxy of wage trends in GTS's supply chain.

Total factor productivity based on gross output

Definition and methods

B.79 Using the same data as above, it is possible to define a concept of total factor productivity based on gross output as:[11]

$$g(TFP_{GO}) = g(GO) - shareK_{GO} * g(K) - shareL_{GO} * g(L) - shareII_{GO} * g(II)$$

B.80 For the same reasons as outlined above, this measure is dependent on the level of vertical integration, and the whole economy figure has no significance for growth accounting or macroeconomics.

Data availability

B.81 EU KLEMS data provides a basis for calculating total factor productivity growth based on gross output for a variety of sectors and periods.

Possible use in regulating GTS

B.82 The concept of total factor productivity based on gross output would provide a basis for estimating changes in total revenues per unit of output for regulatory purposes if it was possible to make a reasonable determination of:

(a) the rate of growth in total factor productivity based on gross output that is applicable to GTS over the price control period; and

(b) a weighted average rate of input price growth for the capital, labour, energy, materials and services used by GTS.

B.83 However, we are unable to identify a robust basis for either of these. Comparisons of gross output measures of total factor productivity between sectors of the economy are vulnerable to the claim that they do not control for differing degrees of vertical

[11] Equation 3 in Section 3 of Timmer, Marcel et al. (2007) EU KLEMS Growth and Productivity Accounts, Version 1.0, Part I Methodology.

integration in different industries. Comparisons of input prices for materials seem to require a complex analysis of different categories of materials, as there is limited substitutability across the economy as a whole. Comparisons of input prices for capital between GTS and other sectors seem difficult to reconcile with a process of regulatory determination of the cost of capital and a regulatory asset value for GTS. The assumption implicit in the use of total factor productivity that the shares of value attributable to different inputs are an indicator of marginal rates of substitution between inputs may also be vulnerable to criticism when the value attributable to capital — i.e. profit — is constrained by a regulatory price control regime.

Worked example of total factor productivity calculations

B.84 The difference between value added and gross output measures of total factor productivity can be significant.

B.85 Take for example a hypothetical construction sector in which the inputs are:

(a) energy, materials and services (50 per cent share of gross output by value),

(b) labour (40 per cent), and

(c) capital (10 per cent).

B.86 Assume that:

(a) gross output (in terms of number of things built) is constant;

(b) energy, materials and services used reduce by 2 per cent (say because more efficient designs are being used); and

(c) all other inputs stay constant.

B.87 The total factor productivity growth using the gross output definition is the growth in gross output (zero in this example) minus the growth in inputs. The growth in inputs is the weighted average growth rate of the individual inputs i.e. –1 per cent (–2%*0.5). This gives a total factor productivity improvement of 1 per cent using the gross output definition.

B.88 Using the value added output definition, total factor productivity improvement is growth in value added minus growth in inputs where the relevant inputs are labour and capital only. Unlike gross output growth, value added growth is not zero in this example. This is because value added is equal to gross output minus intermediate inputs (energy, materials, and services). Gross output is constant while intermediate inputs are reduced by 2 per cent which means that value added increases by 2 per cent. Input growth is zero in this case as labour and capital input is constant. This gives total factor productivity growth of 2 per cent using the value added definition.

B.89 Thus the total factor productivity growth using a value added measure is 2 per cent, against 1 per cent for total factor productivity growth using a gross output measure.

APPENDIX C: RESULTS FOR ALL SECTORS

C.1 The following tables provide results from the EU KLEMS database for the productivity measures described in appendix B.

C.2 Results are provided for all sectors for which relevant data are available, using the longest data averaging period available in each case.

Netherlands: unit labour costs relative to CPI (1979-2004 or 1979-2005)

Annual rates of change are expressed in logarithms. Negative numbers (i.e. increases faster than CPI) are in brackets.

Comparator sector	Data period	Reduction in unit labour costs relative to CPI	Unit labour costs relative to CPI adjusted for constant capital
Agriculture, hunting, forestry and fishing	1979-2005	3.1%	3.1%
Mining and quarrying	1979-2005	(2.7%)	(71.3%)
Manufacture of food products, beverages and tobacco	1979-2005	2.0%	1.9%
Manufacture of textiles, textile products, clothing and footwear	1979-2005	2.7%	2.6%
Manufacture of wood and wood products	1979-2005	1.3%	1.3%
Manufacture of pulp, paper and paper products; publishing and printing	1979-2005	1.3%	0.7%
Manufacture of coke, refined petroleum products and nuclear fuel	1979-2005	(0.5%)	0.2%
Manufacture of chemicals, chemical products and man-made fibres	1979-2005	3.5%	6.3%
Manufacture of rubber and plastic products	1979-2005	2.6%	2.4%
Manufacture of other non-metallic mineral products	1979-2005	(0.0%)	(0.5%)
Manufacture of basic metals and fabricated metal products	1979-2005	1.5%	1.5%
Manufacture of machinery and equipment not elsewhere classified	1979-2005	1.7%	1.5%
Manufacture of electrical and optical equipment	1979-2005	2.7%	2.1%
Manufacture of transport equipment	1979-2005	3.9%	4.7%
Manufacturing not elsewhere classified, including recycling	1979-2005	0.8%	0.8%
Electricity, gas and water supply	1979-2005	2.7%	3.4%
Construction	1979-2005	(0.1%)	(0.4%)
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	1979-2005	1.0%	0.6%
Wholesale trade and commission trade, except of motor vehicles and motorcycles	1979-2005	3.0%	3.6%
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	1979-2005	0.4%	0.1%
Hotels and restaurants	1979-2005	(0.7%)	(1.1%)
Transport and storage	1979-2005	1.5%	1.7%
Post and telecommunications	1979-2005	5.7%	7.0%
Financial intermediation	1979-2005	0.9%	(0.5%)
Real estate activities	1979-2005	(0.3%)	9.0%
Renting of machinery and equipment; research; consultancy; other business activities	1979-2005	0.3%	(0.5%)
Public administration and defence; compulsory social security	1979-2005	1.4%	0.8%
Education	1979-2005	(0.1%)	(0.5%)
Health and social work	1979-2005	(0.7%)	(0.9%)
Other community, social and personal service activities	1979-2005	(6.6%)	(14.7%)

Netherlands: unit labour costs relative to CPI (1979-2004 or 1979-2005)

Annual rates of change are expressed in logarithms. Negative numbers (i.e. increases faster than CPI) are in brackets.

Comparator sector	Data period	Reduction in unit labour costs relative to CPI	Unit labour costs relative to CPI adjusted for constant capital
Manufacture of chemical, rubber, plastic and fuel products	1979-2004	2.6%	4.0%
Trade	1979-2005	1.9%	2.0%
Manufacturing	1979-2004	2.0%	2.0%
Wholesale and retail trade	1979-2004	1.5%	1.4%
Transport and storage and communication	1979-2004	2.7%	2.9%
Finance, insurance, real estate and business services	1979-2004	(0.1%)	(1.0%)
Real estate, renting and business activities	1979-2004	(0.1%)	0.1%
Public admin, education and health	1979-2005	0.4%	(0.1%)
Community social and personal service activities	1979-2004	(0.0%)	(0.6%)
Distribution	1979-2005	1.8%	1.9%
Electrical machinery, post and communication services	1979-2005	5.0%	4.6%
Finance and business, except real estate	1979-2005	0.4%	(0.5%)
Goods producing, excluding electrical machinery	1979-2005	1.3%	1.0%
Market economy	1979-2005	0.9%	0.6%
Market services, excluding post and telecommunications	1979-2005	0.4%	(0.1%)
Consumer manufacturing	1979-2005	1.7%	1.6%
Manufacturing, excluding electrical	1979-2005	1.9%	2.0%
Intermediate manufacturing	1979-2005	1.9%	2.1%
Manufacture of non-high-tech investment goods	1979-2005	2.4%	2.5%
Non-market services	1979-2005	0.8%	0.0%
Other production	1979-2005	0.6%	(0.1%)
Personal services	1979-2005	(4.0%)	(6.6%)
Whole economy	1979-2005	0.9%	0.5%

Netherlands: Productivity measures based on value added (1979-2004 or 1979-2005)

Annual rates of change are expressed in logarithms. Negative numbers are in brackets.

Comparator sector	Data period	Total factor productivity	Labour productivity	Labour productivity adjusted for constant capital
Agriculture, hunting, forestry and fishing	1979-2005	2.8%	3.2%	3.2%
Mining and quarrying	1979-2005	(1.9%)	(1.9%)	(70.5%)
Manufacture of food products, beverages and tobacco	1979-2005	1.6%	2.9%	2.8%
Manufacture of textiles, textile products, clothing and footwear	1979-2005	2.5%	3.2%	3.1%
Manufacture of wood and wood products	1979-2005	1.8%	2.3%	2.3%
Manufacture of pulp, paper and paper products; publishing and printing	1979-2005	1.4%	2.5%	1.9%
Manufacture of coke, refined petroleum products and nuclear fuel	1979-2005	(2.1%)	(2.1%)	(1.4%)
Manufacture of chemicals, chemical products and man-made fibres	1979-2005	3.1%	4.1%	6.8%
Manufacture of rubber and plastic products	1979-2005	1.6%	2.3%	2.2%
Manufacture of other non-metallic mineral products	1979-2005	(0.2%)	0.2%	(0.3%)
Manufacture of basic metals and fabricated metal products	1979-2005	1.5%	2.1%	2.1%
Manufacture of machinery and equipment not elsewhere classified	1979-2005	2.0%	2.7%	2.5%
Manufacture of electrical and optical equipment	1979-2005	1.9%	2.9%	2.3%
Manufacture of transport equipment	1979-2005	3.8%	4.2%	4.9%
Manufacturing not elsewhere classified, including recycling	1979-2005	0.7%	0.9%	0.8%
Electricity, gas and water supply	1979-2005	0.9%	2.1%	2.8%
Construction	1979-2005	(0.5%)	(0.3%)	(0.6%)
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	1979-2005	0.7%	1.3%	0.9%
Wholesale trade and commission trade, except of motor vehicles and motorcycles	1979-2005	2.6%	3.2%	3.8%
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	1979-2005	0.9%	1.3%	1.0%
Hotels and restaurants	1979-2005	(0.9%)	(0.7%)	(1.1%)
Transport and storage	1979-2005	1.2%	1.6%	1.7%
Post and telecommunications	1979-2005	3.2%	5.6%	6.9%
Financial intermediation	1979-2005	0.3%	2.0%	0.7%
Real estate activities	1979-2005	0.9%	2.2%	11.4%
Renting of machinery and equipment; research; consultancy; other business activities	1979-2005	(1.5%)	(0.8%)	(1.6%)
Public administration and defence; compulsory social security	1979-2005	0.6%	1.5%	0.8%
Education	1979-2005	(0.7%)	(0.4%)	(0.8%)
Health and social work	1979-2005	(0.7%)	(0.7%)	(0.9%)
Other community, social and personal service activities	1979-2005	(3.6%)	(3.1%)	(11.2%)

Netherlands: Productivity measures based on value added (1979-2004 or 1979-2005)

Annual rates of change are expressed in logarithms. Negative numbers are in brackets.

Comparator sector	Data period	Total factor productivity	Labour productivity	Labour productivity adjusted for constant capital
Manufacture of chemical, rubber, plastic and fuel products	1979-2004	2.0%	2.9%	4.3%
Trade	1979-2005	1.8%	2.4%	2.4%
Manufacturing	1979-2004	1.8%	2.7%	2.6%
Wholesale and retail trade	1979-2004	1.5%	2.0%	2.0%
Transport and storage and communication	1979-2004	1.9%	2.8%	3.0%
Finance, insurance, real estate and business services	1979-2004	(0.6%)	(0.2%)	(1.2%)
Real estate, renting and business activities	1979-2004	(0.4%)	(0.8%)	(0.7%)
Public admin, education and health	1979-2005	(0.2%)	0.3%	(0.2%)
Community social and personal service activities	1979-2004	(0.5%)	(0.1%)	(0.7%)
Distribution	1979-2005	1.7%	2.2%	2.2%
Electrical machinery, post and communication services	1979-2005	2.9%	5.1%	4.7%
Finance and business, except real estate	1979-2005	(0.6%)	0.1%	(0.8%)
Goods producing, excluding electrical machinery	1979-2005	0.8%	1.6%	1.3%
Market economy	1979-2005	0.6%	1.2%	0.8%
Market services, excluding post and telecommunications	1979-2005	0.1%	0.7%	0.2%
Consumer manufacturing	1979-2005	1.5%	2.3%	2.2%
Manufacturing, excluding electrical	1979-2005	1.7%	2.5%	2.6%
Intermediate manufacturing	1979-2005	1.6%	2.5%	2.7%
Manufacture of non-high-tech investment goods	1979-2005	2.6%	3.2%	3.3%
Non-market services	1979-2005	0.1%	0.8%	0.0%
Other production	1979-2005	(0.1%)	0.6%	(0.2%)
Personal services	1979-2005	(2.8%)	(2.4%)	(5.1%)
Whole economy	1979-2005	0.4%	1.1%	0.7%

Netherlands: Productivity measures based on gross output (1979-2004)

Annual rates of change are expressed in logarithms. Negative numbers are in brackets.

Comparator sector	Data period	Total factor productivity	Labour and intermediate inputs productivity	Labour and intermediate inputs productivity adjusted for constant capital
Agriculture, hunting, forestry and fishing	1979-2004	1.2%	1.5%	1.5%
Mining and quarrying	1979-2004	(1.3%)	(0.8%)	(9.1%)
Manufacture of food products, beverages and tobacco	1979-2004	(0.0%)	0.5%	0.4%
Manufacture of textiles, textile products, clothing and footwear	1979-2004	(0.9%)	0.9%	0.8%
Manufacture of wood and wood products	1979-2004	5.1%	0.3%	0.2%
Manufacture of pulp, paper and paper products; publishing and printing	1979-2004	4.7%	0.8%	0.6%
Manufacture of coke, refined petroleum products and nuclear fuel	1979-2004	(17.8%)	0.3%	0.3%
Manufacture of chemicals, chemical products and man-made fibres	1979-2004	(0.3%)	0.8%	1.0%
Manufacture of rubber and plastic products	1979-2004	6.6%	0.6%	0.5%
Manufacture of other non-metallic mineral products	1979-2004	4.1%	0.0%	(0.1%)
Manufacture of basic metals and fabricated metal products	1979-2004	3.4%	0.5%	0.4%
Manufacture of machinery and equipment not elsewhere classified	1979-2004	6.4%	0.6%	0.6%
Manufacture of electrical and optical equipment	1979-2004	3.8%	0.6%	0.5%
Manufacture of transport equipment	1979-2004	5.7%	0.9%	1.0%
Manufacturing not elsewhere classified, including recycling	1979-2004	3.6%	0.2%	0.2%
Electricity, gas and water supply	1979-2004	0.3%	0.4%	0.4%
Construction	1979-2004	(0.1%)	(0.0%)	(0.1%)
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	1979-2004	0.4%	0.9%	0.8%
Wholesale trade and commission trade, except of motor vehicles and motorcycles	1979-2004	0.9%	1.1%	1.2%
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	1979-2004	0.7%	0.9%	0.8%
Hotels and restaurants	1979-2004	(0.4%)	(0.1%)	(0.3%)
Transport and storage	1979-2004	0.6%	0.8%	0.7%
Post and telecommunications	1979-2004	1.5%	1.8%	2.1%
Financial intermediation	1979-2004	0.3%	1.3%	0.5%
Real estate activities	1979-2004	1.6%	2.0%	4.7%
Renting of machinery and equipment; research; consultancy; other business activities	1979-2004	0.3%	0.8%	0.5%
Public administration and defence; compulsory social security	1979-2004	0.5%	1.0%	0.5%
Education	1979-2004	(0.1%)	0.2%	(0.1%)
Health and social work	1979-2004	(0.5%)	(0.3%)	(0.7%)
Other community, social and personal service activities	1979-2004	(1.9%)	(1.4%)	(1.9%)

Netherlands: Productivity measures based on gross output (1979-2004)

Annual rates of change are expressed in logarithms. Negative numbers are in brackets.

Comparator sector	Data period	Total factor productivity	Labour and intermediate inputs productivity	Labour and intermediate inputs productivity adjusted for constant capital
Manufacture of chemical, rubber, plastic and fuel products	1979-2004		0.7%	0.7%
Trade	1979-2004		1.1%	1.0%
Manufacturing	1979-2004		0.6%	0.6%
Wholesale and retail trade	1979-2004		1.1%	1.0%
Transport and storage and communication	1979-2004		1.2%	1.2%
Finance, insurance, real estate and business services	1979-2004		1.0%	1.0%
Real estate, renting and business activities	1979-2004		0.9%	1.2%
Public admin, education and health	1979-2004		0.4%	(0.0%)
Community social and personal service activities	1979-2004		0.1%	(0.3%)
Distribution	1979-2004		1.0%	0.9%
Electrical machinery, post and communication services	1979-2004		1.4%	1.2%
Finance and business, except real estate	1979-2004		0.9%	0.5%
Goods producing, excluding electrical machinery	1979-2004		0.5%	0.4%
Market economy	1979-2004		0.6%	0.4%
Market services, excluding post and telecommunications	1979-2004		0.6%	0.3%
Consumer manufacturing	1979-2004		0.5%	0.4%
Manufacturing, excluding electrical	1979-2004		0.6%	0.6%
Intermediate manufacturing	1979-2004		0.7%	0.6%
Manufacture of non-high-tech investment goods	1979-2004		0.8%	0.8%
Non-market services	1979-2004		0.9%	0.4%
Other production	1979-2004		0.5%	0.1%
Personal services	1979-2004		(1.0%)	(1.3%)
Whole economy	1979-2004		0.7%	0.4%