Research into Productivity Growth in Electricity Transmission and Other Sectors
A Report for DTe

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EXECUTIVE SUMMARY

Europe Economics was commissioned by DTe to take stock of available evidence on productivity growth in electricity transmission and other utilities. The purpose was to provide advice on the likely efficiency frontier shift in the Dutch electricity transmission operator TenneT.

We have reviewed evidence on productivity growth in utilities including electricity transmission in a number of countries. We have considered measures of total and partial factor productivity at both the utility and national economy levels and comment on how measures of frontier shift have been used by regulators. In principle TFP is preferable to partial (PFP) measures but it is necessary to apply estimation techniques which separate out frontier shift from other influences.

We found a wide range of relevant studies of utility productivity relating to the electricity, gas and water sectors in the UK, Italy, Australia, New Zealand and the US. The read across from one sector or country study to another cannot be exact but in our view there is an adequate range of estimates available to allow a judgement to be made about the likely potential for efficiency improvements in the Netherlands electricity transmission network.

A number of techniques have been used to estimate TFP and PFP with varied success in deriving estimates of frontier shift. Estimates of TFP growth representing movements in the efficiency frontier for network utilities mostly fall in the range of 1 to 2 per cent per annum. However there is evidence that in circumstances where strong incentive based regulation has been applied higher rates of growth have been achieved in the range 1.5 to 2.5 per cent and with some higher estimates.

We also considered macroeconomic estimates of productivity for European countries, including the Netherlands, and the US. There is a considerable variation between countries. TFP in the Netherlands has been low in recent years. This is possibly a reflection of labour market conditions. The extent to which utility TFP exceeds the underlying national productivity growth is an important factor in incorporating frontier shift into price control. In the UK utilities have out-performed relative to the UK economy by 0.5 to 2.0 per cent. This represents an upper and lower bound for likely frontier shift for TenneT.

Out-performance by TenneT may be affected by the same factors that contribute to low TFP in the Dutch economy as a whole. But the utility's frontier shift will also be driven by other factors, including incentive regulation. Efficiency gains demonstrated by other utilities suggest that TenneT should be able to achieve improvements above the economy-wide level of TFP.

It is our view that on the basis of comparison with other network businesses TenneT should be expected to achieve TFP growth of 0.75 – 1.75 per cent over and above the underlying productivity growth in the economy as a whole. Given underlying productivity growth in the Netherlands of approximately 0,5% per annum,, the total expected productivity growth for TenneT would be 1,25-2,25%. This is within the ranges identified in the studies. This range is put forward as indicating the change associated with a shift in the efficiency frontier. If a firm is operating below the efficiency frontier then there may be potential for additional productivity growth as it

catches up with the efficient level of operation. This study does not include estimates of the potential for 'catch up' increases in productivity in the Netherlands.

1 MEASURING FACTOR PRODUCTIVITY

Total factor and partial factor productivity growth

1.1 Productivity is a measure of the efficiency with which firms turn inputs into outputs. Measures of capital and labour productivity separately identifying the output attributable to each unit of these factors of production (single or partial factor productivity, PFP) can yield useful insights into whether that efficiency has improved either over time or with respect to other firms, sectors or countries. Partial measures of productivity can also be derived at the firm level based on output per unit of operating expenditure (opex) and capital expenditure (capex). The opex based measure, which covers all expenditure other than on capital, is frequently taken into account in setting utility price controls.

1.2 Taken in isolation, partial factor productivity measures can be misleading. For instance, the productivity of labour, i.e. the ratio between the output produced and the quantity of labour used to produce it, can increase over time just because the same workers had more capital to use (i.e., the capital to labour ratio had increased), without any real improvement in the utilisation of labour in the production process. A similar reasoning can of course be extended to opex and capital productivity. Measures that simultaneously take into account all factors of productions should in principle yield a more reliable picture of the true productivity of a firm, sector or country.

1.3 Total factor productivity (TFP), sometimes known as multifactor productivity, does just that, i.e. it provides an overall measure of the efficiency of the production process considering all inputs simultaneously. TFP is usually computed using index number methodologies as the ratio between a basket of outputs and a basket of inputs.

1.4 TFP indices are used to undertake both cross sectional comparisons, i.e. comparing productivity levels across different economic units at a single point in time (for instance, across different firms, such as different electricity distribution companies) and to track TFP growth over time for single economic units. In the latter case, economists talk about TFP growth.

1.5 TFP growth can be described as the difference between the rate of growth of a basket of outputs and the rate of growth of a basket of inputs. As such, TFP growth is a residual, since it measures the increase in output which is not accounted for by the corresponding increase in inputs. Abramovitz (1956) even referred to it as “a measure of our ignorance”. It includes the effects of everything, other than input growth, which can help explain the increase in output.

1.6 While index number techniques for estimating TFP cannot decompose the residual into its constituent parts, econometric methodologies (and non-parametric techniques like data envelopment analysis (DEA)) can and have been used to perform this task. Economic theory has identified many potential factors that can explain TFP growth. These include scale economies, efficiency change, market power and external changes in the economic

environment. There is a large and growing literature which suggests methodologies to provide increasingly accurate estimates of potential TFP growth constituents.

TFP decomposition: technical change component

1.7 Originally, the importance of TFP growth stemmed from the identification of TFP growth with technical change. Technological change is usually understood as a shift in the production possibility frontier of an economy, or in the production or cost function of a group of firms. For example, using the cost function framework as a benchmark[1], technological change can be referred to as a downward shift of the cost function itself, as the same level of output can be realised with lower production costs. However, technical change is just one of the TFP growth's constituents.

1.8 The identification of TFP growth with technological change is valid only under some restrictive assumptions. If these restrictive assumptions do not hold, then TFP growth will be a biased measure of technological change for a particular sector. One of the assumptions that need to hold for TFP growth to be a valid measure of technological change is the existence of constant returns to scale in the product market.

TFP decomposition: the role played by scale economies

1.9 To understand why this is so, consider a firm that operates under positive scale economies (i.e., a 1 per cent increase in output leads to less than 1 per cent increase in costs): if, over the sample period, output growth is positive, then unit costs will tend to fall as a result of positive scale economies, even in the absence of any improvement in technology and/or in organisation. The opposite happens if output growth is negative. This is an important issue to bear in mind when setting the X factor in an RPI – X price control because if positive scale economies are assumed to exist and demand growth is forecast to be positive, then costs will tend to fall even in the absence of any productivity improvement. Only if output growth is zero will scale economies not matter and not be reflected in the residual.

1.10 The traditional growth accounting framework also makes the implicit assumption that firms are technically and economically fully efficient.

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[1] Early econometric studies relied on the so-called primal approach, which was based on the estimation of a production function. However, after the development of duality theory, the estimation of cost functions to measure and decompose TFP growth has become increasingly common.

TFP decomposition: efficiency change

1.11 As far technical efficiency is concerned, a firm is technically efficient if it lies on the production frontier at the industry level. Slightly different definitions of technical efficiency have been proposed in the literature (see Kumbhakar and Lovell, 2000): one of these, proposed by Koopmans, is frequently adopted[2] and identifies an input bundle as technically efficient if, given the output level, no reduction in any input is feasible. Debreu and Farrel linked the Koopmans definition of technical efficiency to isoquants.[3] An input bundle is not technically efficient if it lies above the isoquant, i.e. if the same output level could be produced by radially contracting the input bundle. Therefore, only input bundles lying on the isoquant would be considered technically efficient.

1.12 Economic efficiency is a wider concept than pure technical efficiency, as it considers the possibility that a company could produce its output lying on the industry frontier, but using the wrong input mix, given relative factor prices. In this case, the firm would be characterised by allocative inefficiency.

1.13 To sum up, the literature on technical and economic efficiency allows for the possibility that firms do not produce at full efficiency, either because there is slack in the production process or because, given factor prices, different combinations of inputs should be preferred. Implicit in this literature is the possibility of defining a frontier of efficiency at industry level and of measuring how far a company is from that frontier.

1.14 The efficiency analyses fits well with TFP growth measurement. We noted above that for the residual to measure technical change, or a shift in the efficiency frontier, certain assumptions have to be fulfilled. One is the existence of constant returns to scale (as discussed above); another is the absence of efficiency change, or catching up, over the period. In fact, as unit costs can fall because of output growth and positive scale economies (which in a cost function framework can be understood as a movement along the cost function), they can fall also because some of the inefficient companies are catching up with the efficient industry frontier (which can be understood as a movement of some companies towards the cost frontier). Of course, unit costs can fall also because of technological change (which can be seen as a downward movement of the cost frontier itself).

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2 It is also probably the most useful in the case of regulated network utilities, as the output is largely demand driven and, as such, outside the control of the company.

3 An isoquant is a curve represented by the combination of inputs (for instance, capital and labour) which make the production of a given level of output feasible.

1.15 TFP growth measures computed with index number methodologies are thus likely to provide a biased measure of the likely scope for frontier shift, unless the assumptions of constant returns to scale, no catching up and perfect competition in output markets[4] are all valid or some separate adjustment is made.

TFP decomposition: other relevant factors

1.16 Furthermore, there are some external factors which define the economic environment where firms operate and which are outside the control of the firms. Typical examples are shifts in economic policy, such as liberalisation of the industry or, more likely in the case of a network company, privatisation and/or incentive regulation. There is some evidence in the empirical literature (see Kumbhakar and Vivas, 2005) that important policy shifts can have significant effects in explaining TFP. This is important if empirical evidence related to some firms operating in a one country (country A) is used to estimate the likely scope for frontier shift for a company operating in another country (country B). If regulation in country A is strong, than TFP growth is also likely to be strong, and this "external factor-led" TFP growth component would be added in to the pure technological change component.

1.17 In other words, in transferring the empirical evidence on either TFP growth or technical change to firms operating in another country one should carefully consider the policy framework the companies analysed operated in. For instance, the TFP figures for a country with lax economic regulation could be scaled up to take into account the positive effects on TFP brought about by the incentives provided by incentive regulation. For example, Kumbhakar and Vivas (2005) show for the Spanish banking industry that policy changes were a significant determinant of TFP growth, together with technical change and scale economies. Europe Economics (2003) showed, for a sample of UK sectors, that privatisation and subsequent regulation was a significant explanatory factor of the sectors' TFP out-performance over the whole economy.

Some measurement issues

1.18 Another issue related to the use of empirical evidence for comparing performance between sectors or countries is the definition of the main variables used in TFP growth computations.

1.19 The definition of inputs is relatively straightforward. Capital and labour should be used when net output is used. Alternatively, when gross output is used, labour, capital and

[4] See Nadiri and Nandi (1999).

intermediate inputs are the relevant inputs to consider. As far as the exact definition of inputs is concerned, labour is usually represented by employee figures (sometimes adjusted to reflect hours worked and or skill levels); capital is often represented by the value of the capital stock employed by the company (usually reconstructed using the perpetual inventory method), but in some studies proxies are used to avoid valuation issues. For example in the water sector the mains pipeline length has been used.

1.20 However, the definition of outputs is less clear. For instance, some studies assume that network utilities are single output firms. This is usually represented by the volume of the physical good conveyed over the network (millions of litres of water, kWh of electricity, etc) but also by the number of customers connected to the network. The choice of the variable representing the output can potentially have consequences for the TFP growth figures found in the analysis. For instance, given the quantity of the physical good distributed (i.e. gas, water, electricity) a country with a few very large users could have lower TFP than a country with many small users, if output were proxied by the number of customers. Furthermore, two firms delivering the same quantity of good, but with a different customer composition could display different TFP growth figures if the dynamics of the customer composition changes over time.

1.21 Furthermore, some utilities are vertically integrated, while others are not. This is important, as vertically integrated utilities are characterized by production processes which cannot be defined only in terms of network managements, but also involve "production" activities, such as generation of electricity or extraction and treatment of water. While the empirical studies in the electricity industry generally distinguish between generation and network activities this is not the case in the water industry, which is usually analysed as a vertically integrated entity.

1.22 Changes in the quality of output over time can also affect the measurement of TFP. If capital expenditure is directed at quality improvements, a particular issue in the water sector, failure to adjust for this can lead to under-estimation of TFP and can affect cross-sector comparisons.

Reliability of estimates

1.23 In general, the reliability of a good empirical work depends on the use of good quality data. If the empirical analysis is undertaken as a component of a price setting review by an industry regulator (as most of the evidence discussed in this report) or using data collected by a regulator, we can be usually reasonably confident on the reliability of the results, as the quality of the data should have in principle been closely scrutinised by the firm(s) and the regulator.

1.24 Having said that, we noted above that results may be sensitive to the variables used to account for the capital stock, the output variable(s) and the inclusion of a control for quality improvements over the sample period. In most cases it is not, *a priori,* clear how sensitive the estimates are to the use and/or to the omission of different variables. For instance, while in principle network utilities should be analysed as multi-output producers

(see above), it is not clear how and whether the TFP growth results would be substantially affected by ignoring that dimension, i.e. focussing on just, say, the number of customers or the physical volume delivered over the network. In general this would require a detailed knowledge of the firm (industry) which is analysed, in terms of market structure trends and composition, major investments undertaken over the period, etc. which are not often clearly discussed in most studies.

1.25 Finally, the reliability of productivity estimates often relies on the methodology used to compute them. One of the most popular methods is the use of index number techniques. Their main advantage is that they are fairly robust, and, provided good quality data and the right variables are used, they should yield reliable estimates of productivity growth. The main drawback is that they do not yield a decomposition of TFP growth into the effects of scale economies, catching up and frontier shift, unless a researcher is willing to make additional assumptions using information derived from other sources (for instance regarding the existence of scale economies).

1.26 Econometric techniques and data envelopment analysis (DEA) do allow for the decomposition of TFP growth into its constituents (and thus they yield an estimate of frontier shift), but they necessarily rely on the correct specification of the cost or production function estimated as well on issues related to the sample size and the estimation methodology.

2 SECTORAL PRODUCTIVITY

Introduction

2.1 Estimation of total and partial factor productivity (TFP and PFP) has been an important element in incentive based regulatory price reviews in many parts of the world in recent years. A number of techniques have been applied dependent in part on availability of data and on the nature of the sector under consideration. The existence in many countries of local distribution companies for gas, electricity and water means that a considerable amount of information is available for these businesses allowing for intra-country comparisons of performance both on a cross-section and time series basis. Inter-country and inter-sector comparisons are also possible. Transmission networks tend to be national or large regional monopolies and comparisons of performance are more likely only to be between networks in different countries or with other sectors with similar economic features.

2.2 This section reviews studies carried out in recent years for the electricity, gas and water sectors in the United Kingdom, Italy, Australia, New Zealand and the United States. The principal focus is on measures of TFP and PFP although a number of those studies have been carried out alongside estimation of an efficiency frontier for the sector. The efficiency frontier analyses typically allow comparison of firms within the sector at a point in time and provide a means of identifying scope for differential efficiency improvement. They are of less value for inter-country or inter-sector comparison. However certain types of TFP estimate do identify movement in the efficiency frontier and, where available, these are considered in this review.

2.3 Although the broad objectives of these studies have been similar – to establish the productivity performance of the business in the recent past and estimate the potential for future improvement – the techniques and data used differ from case to case and any comparison of the result between studies must be approached with caution. The summaries provided here highlight relevant points of difference.

2.4 Comparisons between sectors and between countries must be treated with particular caution because of the difficulty of adjusting for differences in operating characteristics and national circumstances. For example there are features of the water sector that may make it an appropriate comparator for other capital intensive network businesses. However the pattern of capital expenditure in water may be heavily influenced by requirements to improve the quality of water. Unless this is properly reflected in the construction of the TFP indices the comparison between the sectors will be distorted. Similarly, comparisons between networks in different countries may be affected by the different densities of customers or by different development histories that need to be taken into account. These issues are well recognised in the studies reviewed but the studies also recognise that a considerable degree of judgment is involved in making the appropriate adjustments to the data.

The Electricity Sector

United Kingdom

2.5 As part of the five yearly review of price controls for electricity distribution network operators (DNO) Ofgem commissioned a review of TFP and PFP in the sector together with cross sectoral and international comparisons from Cambridge Economic Policy Associates, CEPA (2003). This is a detailed study which seeks to address known problem areas in the measurement of TFP; in particular it makes adjustments to allow for possible economies of scale and for the impact of quality of service developments.

2.6 CEPA estimated aggregate measures of TFP for all 14 DNOs in Great Britain over the period 1991/2 to 2001/2 with adjustments for quality changes and volume effects.[5] Estimates were also produced for PFP separating operating and capital expenditure. This showed a trend rate of growth of TFP of 4.2 per cent over the period. Growth in PFP using opex was 7.7 per cent and using capex 1.0 per cent. There were some significant year by year variations strongly linked to the introduction of new price controls. Exclusion of 2000/01 as an outlier gave a preferred trend growth in TFP of 3.1 per cent. The growth in TFP for the DNOs was well above the historic rate of growth in TFP for the UK economy as a whole which was estimated at 1.3 per cent.

2.7 TFP and PFP estimates were also prepared for a number of other UK regulated network utilities, electricity transmission, water and sewerage, telecommunications and rail. Both rail and telecommunications were ruled out as useful comparators, telecommunications because of the very different technology and time scales and rail because of different investment profiles. The estimates of TFP and PFP for the water sector were very sensitive to the method adopted for measuring output and adjusting for quality. The estimates for electricity transmission showed trend growth in TFP of 2.4 per cent and in opex PFP of 5 per cent.

2.8 A further level of information was provided by international comparisons. TFP for US electricity distributors was estimated at 2.2 per cent. Unusually the capex based PFP was higher than opex based. This was attributed to low investment in network infrastructure. Estimates for Norway show a very low level of TFP at 0.2 per cent. This could be attributable to quality effects for which no adjustment was made.

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[5] CEPA allowed for economies of scale contributing to the productivity improvement of the DNOs. They estimated that a 1per cent increase in output would increase costs by only 0.85 per cent. This gave a downward adjustment to TFP estimates of around 0.2 – 0.3 percentage points.

2.9 An alternative form of international comparison was provided using aggregate sectoral data rather than individual company statistics. This allowed longer time series and separate time periods to be analysed. TFP for the UK electricity, gas and water sectors over the period 1950 to 1999 was 2.5 per cent compared with 4.4 per cent in France and 1.4 per cent in the US. However in the most recent period, 1990 to 1999, UK performance was significantly better with TFP growth of 3.4 per cent compared with 1.5 per cent in France, 1.2 per cent in Germany and 0.2 per cent in the US. Estimates of labour productivity over the same periods showed a similar pattern.

2.10 Sectoral data were also used to compile a composite estimate of TFP for electricity distribution in the UK equivalent to the 'nature of work' estimates described above for Transco. This indicated TFP of 2.0 per cent, rather lower than the trend rate of 4.2 per cent (3.1 per cent if an outlier is excluded) estimated from company data. However it is possible that this could be a better indicator of future growth if it is assumed that companies in the rest of the economy face more competition and may be operating closer to their efficiency frontier.

2.11 In the last major review of productivity of UK electricity transmission in 2000, Ofgem's consultants compared the performance of the National Grid Company with the UK electricity distribution companies and with other network utilities. Over the previous 10 years NGC's productivity, measured by changes in real unit operating expenditure, had increased at an annual rate of 6.8 per cent compared to 7.7 per cent for the six leading distribution companies. Productivity in gas transmission had increased at an annual rate of 7.5 per cent while the improvement in water and sewerage productivity was lower in the range 3.7 to 4.1 per cent.

2.12 Ofgem commented that in broad terms, the nature of the business for these sectors was comparable and variation in input prices or capital substitution should not create fundamental differences in unit costs. The figure for water and sewerage probably understated efficiency improvements due to additional expenditure on quality improvements whereas the figure for gas probably overstate efficiency gains due to a large increase volumes, which had the effect of boosting performance due to economies of scale

Australia and New Zealand

2.13 In 1999 the Independent Pricing and Regulatory Tribunal (IPART) of New South Wales (NSW) reviewed the efficiency of NSW electricity distributors and commissioned a benchmarking study. This study, London Economics (1999), estimated an efficiency frontier for electricity distribution using a large international sample of distributors and provided comparative measures of TFP.

2.14 The efficiency frontier analysis suggested that the NSW distributors had considerable scope for improving their efficiency with potential input savings of between 13 per cent and 44 per cent. Their trend growth in productivity compared reasonably favourably both with growth in the Australian economy as a whole and with international comparators.

2.15 TFP estimates were prepared using the Malmquist index approach which allows for a distinction to be made between increasing technical efficiency that is a move towards the efficiency frontier, and a shift in the efficiency frontier itself. The results for the NSW distributors (which are subject to data limitations) showed variable growth in TFP from a negative rate up to a maximum of 4 per cent. Almost all of the growth was attributable to technical efficiency improvements rather than any frontier shift.

2.16 International comparisons were made using data for the UK, US and New Zealand. Analysis of the performance of the 12 distributors in England and Wales over the period 1990-91 to 1996-97 suggested an average increase in TFP of 3.5 per cent over the period almost all of which was attributable to frontier shift. The best practice distributors were improving their efficiency faster than the less efficient companies were catching up. The study identified significant variations both from year to year and between companies.

2.17 In the US between 1994 and 1996 there was an even wider range of TFP growth but with average growth of only 0.7 per cent. There was a 2.3 per cent growth in the element of the index attributable to frontier shift but this was offset by falling technical efficiency in the less well performing companies. In contrast, in New Zealand overall TFP grew by 1.4 per cent a year driven almost entirely by technical efficiency improvements rather than a shift in the efficiency frontier.

2.18 In 2003 the New Zealand Commerce Commission (NZCC) commissioned a study into the productivity of New Zealand's electricity distribution and transmission businesses. This study Meyrick (2003) considered both the aggregate growth in TFP and comparative growth for the individual distribution companies. The NZCC intended to adopt a CPI- X form of price control but wanted to break the X factor into two elements – B attributable to general productivity growth and C attributable catch up efficiency gains. This is similar to the US PUC approach with a productivity element supplemented by a stretch factor.

2.19 Aggregate TFP was estimated separately for distribution and transmission. For distribution output was measured by a composite index of throughput, capacity and customer numbers and for transmission by throughput and capacity. The input indices combined operating expenditure and measures of capital investment based in existing assets.

2.20 Using data for the period 1996 to 2002 TFP for distribution was estimated to have grown at an annual average rate of 3.2 per cent and transmission at a rate of 2.3 per cent. These estimates are similar to the estimates for the UK derived in the CEPA and London Economics studies. Adjusting for TFP growth in the New Zealand economy as a whole the levels of TFP relevant for setting the B factor were 2.6 per cent for distribution and 1.7 per cent for transmission.

The Gas Sector

United Kingdom

2.21 Transco is the owner and operator of the gas transmission and distribution network in Great Britain.[6] Its charges for use of the network are regulated by Ofgem using an RPI-X incentive style of price cap. The pricing regime is reviewed every five years and the most recent review took place in 2001 in order to establish the price controls for the period 2002 – 2007. As part of that review Ofgem commissioned work to establish both a 'bottom up' estimate of an efficient level of costs for Transco's regulated business and a 'top down' estimate of efficiency improvements. The 'top down' study incorporated an analysis of total factor productivity.

2.22 The top down study was carried out by Europe Economics (2001) and adopted a dual approach to identifying the scope for Transco to improve its efficiency:

- Reviewing the achievements of other companies, which like Transco, were previously state-owned and which had been privatised and subjected to an increased degree of competition and/or regulatory incentives; and

- "Nature of work" comparisons, which involved identifying at a relatively high level the broad categories of work which Transco undertook, and then reviewing the productivity improvements made by firms undertaking similar functions in other areas of the economy.

2.23 At one level the first element in this approach is very specific to the UK privatisation experience of the past 20 years. However it may be possible to draw parallels between the impetus for efficiency improvement which resulted from the changed ownership and a similar effect resulting from liberalisation of markets without ownership change and, in the case of network monopolies, the development of incentive based price regulation. More generally, the first part of the study is addressing the issue of where the regulated business stands in relation to an assumed efficient operator and what scope still exists for productivity to catch up with that efficient level. The second part of the study is more concerned with the scope for further efficiency improvement in future once these catch up gains have been fully exploited.

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[6] In 2005 some parts of the distribution network were sold to independent operators.

Cost efficiency

2.24 The comparison with other privatised industries was carried out on the basis of two measures of efficiency – real unit operating expenditure (RUOE) and real unit operating costs (RUOC). RUOC includes depreciation and therefore incorporates a measure of capital. If there are trends of increasing capital intensity within an industry, reductions in RUOE may be higher than those for RUOC since increases in capital intensity will tend to lower operating expenditure but increase capital costs (including depreciation figures).

2.25 Cost reductions since each industry was privatised using these two measures are shown in Tables 2.1 and 2.2 below. We can see that there are some differences between changes in RUOE and RUOC, but that, overall, they seem to draw a similar picture. In particular, we can note that, with the exception of BT, BAA and British Gas/Transco, the other firms/sectors display a slightly sharper reduction in RUOE (which should be interpreted as evidence of capital substitution, i.e. of an increasing trend in capital intensity). However, while for BAA, BT and British Gas/Transco RUOC seem to have declined slightly more than RUOE, the difference between the two measures does not appear to be large.

2.26 For the water industry, the Europe Economics (2001) study did not report figures for the percentage change in RUOC: however, the evidence reported below for the water industry seems to suggest that substantial capital substitution did take place in the water and sewerage industry in England and Wales: we could thus expect lower figures (in absolute terms) for RUOC percentage change for that sector.

Table 2.1: Compound Annual Changes in real unit operating expenditure (%)

BAA	-1.6
BT	-3.7
Railtrack (1)	-7.3
Railtrack (2)	-1.8
Water Services	-2.9
Sewerage services	-3.0
Electricity Transmission	-6.7
Electricity Distribution	-5.6
British Gas/Transco	-8.8

Source: Europe Economics

Table 2.2: Compound Annual Changes in real unit operating cost (%)

BAA	-1.3
BT	-4.0
Railtrack (1)	-6.3
Railtrack (2)	-0.7
Water Services	n/a
Sewerage services	n/a
Electricity Transmission	-4.0
Electricity Distribution	-4.6
British Gas/Transco	-9.4

Source: Europe Economics

2.27 Care needs to taken in interpreting the figures for Transco. The company was privatised in 1985 as part of British Gas and only became an independent company in 1999. However an analysis of separate Transco data from 1992 to 1999 showed efficiency gains of a similar magnitude. The measure of output used for British Gas/Transco was units of gas transported which had doubled over the period. The unit cost reduction will be affected by economies of scale. However, again, separate analysis of Transco data (for a shorter period) using customer numbers as the measure of output showed similar gains.

2.28 Based on this analysis and a wider review of academic studies Europe Economics took the view that there was no evidence of a slow-down in the 'catch-up' improvements being achieved by the privatised industries with many firms continuing to make significant efficiency gains in recent years. The recent restructuring of Transco as an independent network operator should also facilitate further efficiency gains. The study concluded that Transco should still be able to make productivity improvements at a faster rate than the economy-wide trend over the next price control period.

Nature of work comparisons

2.29 For this second stage of analysis Europe Economics derived TFP and labour productivity estimates for industry sectors giving annual percentage productivity changes over the period 1973 – 1995. These showed average annual changes in TFP ranging from 3.06 per cent (transport and communications) to –2.15 per cent (mining and oil refining) and with electricity, gas and water growing at 2.87 per cent. The range for labour productivity ran from 0.45 per cent (non-market services) to 5.37 per cent (mining and oil refining) with electricity, gas and water at 4.96 per cent.

2.30 The nature of Transco's business was reviewed and broken into seven areas of activity and each activity was allocated one or more comparator sectors in the rest of the economy. This allowed weights to be attached to each comparator and a weighted

average for Transco TFP and labour productivity to be derived from the aggregate sectoral estimates.

2.31 On this basis the weighted average annual growth rates derived for Transco for the period 1973 – 1995 were 2.45 per cent for TFP and 3.58 per cent for labour productivity. These can be compared with economy wide figures of 1.73 per cent for TFP and 2.22 per cent for labour productivity. These figures suggested that Transco should be expected to outperform the rest of the economy by 0.7 per cent p.a. before any scope for privatisation or other catch up effects are taken into account.

2.32 These findings are sensitive to the assumptions made about appropriate comparators. Sensitivity analysis carried out as part of the study suggested that Transco's TFP out-performance would lie in the range 0.2 per cent to 1.3 per cent.

Study conclusion

2.33 In its final conclusion the study put most weight on the comparison with other privatised companies and concluded that Transco had scope to reduce its operating costs at a rate of 2 – 4 per cent p.a. from current levels. Allowance for capital substitution would reduce that to 1 – 2 per cent p.a. If Transco was assumed already to be at the efficiency frontier then the further reductions in total costs would be in the range of 0.2 – 1.3 per cent p.a.

Australia and New Zealand

2.34 The New Zealand Commerce Commission commissioned a comparison of the efficiency of gas transmission and distribution networks in Australia and New Zealand as part of its review of the possible introduction of price regulation. This study, Meyrick (2004a), compared ten distribution and seven transmission businesses in Australia and four distribution and one transmission business in New Zealand. Given the small number of comparators, factor productivity analysis was the principal analytical tool used.

2.35 Physical differences between the networks, in particular differences in customer density, make a significant difference to productivity and although some adjustments were made for such factors this was not always possible and the results need to be treated with caution.

2.36 The study was primarily concerned with the relative positions of the New Zealand and Australian businesses using a single year (2003) for comparison. It showed that even after adjusting for network differences the Australian distribution networks were some 21 per cent more efficient than their New Zealand counterparts. The Australian transmission companies were on average 57 per cent more productive than the New Zealand company. Time series values of TFP were estimated for the gas transmission companies. These show considerable year on year fluctuations reflecting changes in the values of both the input and output measures. TFP for NGC (the New Zealand operator) for which the longest time series was available rose by 6 per cent between 1997 and 2000, fell 16 per cent in the next two years and rose by 18 per cent in 2003. These

variations reflect significant changes in operating expenditure between years. Over the period as a whole the average annual increase in TFP was about 0.85 per cent

2.37 A further study, Meyrick (2004b), examined the performance of the NGC's distribution company over a period of years. These estimates suggest that NGC's distribution TFP grew at a 'relatively high' trend annual rate of 2.8 per cent over the period 1997 to 2003.

United States

2.38 TFP estimates are used in rate setting cases before State Public Utilities Commissions (PUC) in cases where the PUC has adopted a performance based regulation (PBR) approach (akin to RPI – X) as an alternative to the cost of service approach traditionally employed. An example is the presentation in 2004 on behalf of the Southern California Gas Company and the San Diego Gas and Electric Company. The companies drew on evidence on TFP for 40 electricity and gas utilities over the period 1992 to 2002. Numbers of customers was used as the output index and an index composed of labour costs, other O&M (operating and maintenance) costs and capital services represented inputs. Over the period considered, average TFP for US gas distributors grew at an annual rate of 1.16 per cent. This was compared with a multi-factor productivity indicator for non-farm businesses calculated by the US Bureau of Labour Statistics which grew at an annual rate of 0.86 per cent.

2.39 The labour productivity of gas distributors showed much greater growth over the period with an annual average of 5.30 per cent but this was offset by a decline in capital productivity leading to the lower figures for TFP when both factors were combined. In addition to looking at TFP a PUC will also consider whether to add a stretch factor to the underlying productivity gain. This would allow for any potential for the utility to catch up with the most efficient operator.

Italy

2.40 Fraquelli and Erbetta (2002) analyse TFP growth using index numbers for a sample of 33 gas distributors in Italy over the period 1994-1999. The firms analysed represented 54 per cent and 47 per cent of the gas volumes and customers in the Italian gas distribution market, respectively. The sample was composed of both small and large distributors and public and private operators. The only output considered was the volume of gas distributed, and the inputs were total employees and other operating costs (defined as the sum of material costs plus third party services and depreciation). The results, reported in

Table 2.3, show that TFP grew at very slow rates, 0.64 per cent on average.[7] The performance of public operators seems to be slightly better that that of private operators (1.27 per cent against -0.94 per cent) probably attributable to efficiency gains realised by public operators in the second half of the 1990s as a consequence of the tighter budget constraints imposed on public firms.

Table 2.3: TFP, gas distribution 1994 – 99; Italy

TFP growth: whole sample	0.64%
TFP growth: small sample	0.22%
TFP growth: public operators	1.27%
TFP growth: private operators	-0.93%

Source: Fraquelli and Erbetta (2002)

Returns to scale

2.41 We have briefly reviewed the available empirical evidence on returns to scale in the gas distribution and transmission industry to assess whether scale economies exist and their extent.

2.42 Ellig and Giberson (1993) find decreasing returns to scale for the largest operators in a sample of Texas gas transmission utilities. Fabbri et al (2000) find approximately constant returns to scale for a sample of Italian gas distributors. Their result is confirmed by Erbetta and Rappuoli (2004) who, using DEA methods, find constant scale economies for a sample of Italian gas distributors (with the exception of the smallest distributors that would operate under increasing returns to scale). Sickles (1991) finds constant returns to scale for a sample of US gas transmission companies. However, Granderson and Linvill (1996) find substantial economies of scale in the transmission sector of the US interstate natural gas industry.

2.43 In general the available empirical evidence does not support the view that there are large un-exhausted scale economies in the gas transmission industry.

[7] This figure is reduced to 0.22 per cent if the distributors displaying large variability in their TFP across years are removed from the sample.

The Water Sector

The empirical evidence

2.44 We have reviewed international evidence on productivity growth in the water and sewerage industries. Most of the academic literature is concerned either with measuring scale and scope economies, or with assessing the relative efficiency between public and private water companies (this is mainly for the US, given their mixed ownership structure of their water industry). Productivity growth in the water industry is an issue that has been barely addressed in the academic literature. However, the 1989 privatisation of the English and Welsh water and sewerage industry has spurred some interest in measuring productivity growth in order to assess the improvements, if any, of the industry performance under private ownership and estimates that can be used in price regulation.

2.45 In the last five years a number of studies have been published, both by academic economists and by (or on behalf of) Ofwat, the economic regulator of the water and sewerage industry in England and Wales.

2.46 Saal and Parker (2001) used index number techniques to measure both labour and total factor productivity for the ten water and sewerage companies operating in England and Wales[8] which account for about 90 per cent of total customers in the industry. The results are reported in Table 2.4. Two indices of labour productivity were considered: one is the usual labour productivity index, computed dividing total output by total employment.[9] The second index, non-capitalised labour productivity, removes from total employment the share of employment attributable to internal capital projects. The second index is more useful as a measure of the efficiency of the day-to-day operations of water companies. The rate of growth of non-capitalized labour productivity was higher in the 1990-99 period than under public ownership, especially after the tightening in regulation following the 1994 price review.

[8] As of 2005, there are 12 additional water only companies in the English and Welsh water industry (they were 30 in 1989)

[9] The output was given by the number of connected customers, and was corrected to take into account the improvements in quality that occurred over the period.

Table 2.4: Water and sewerage labour productivity; England and Wales

	85-90	90-95	95-99	90-99
Labour productivity growth	4.5%	4.8%	6.3%	5.46%
Labour productivity growth (non-capitalised)	4.4%	5.8%	8.2%	6.8%
TFP growth	2.3%	2.1%	1.0%	1.6%

Source: Saal and Parker (2001)

2.47 The strong labour productivity performance can be attributed both to labour shedding and capital deepening. The performance in terms of TFP growth rate has been much more disappointing: as Table 2.4 shows, the TFP growth rate has been 1.6 per cent, lower, albeit not statistically significantly so, than under public ownership. One of the reasons for this poor performance is the possibility that the high investments to raise quality have incurred in a "region" of decreasing marginal returns, i.e. the additional money spent to improve quality did not result in commensurately higher water quality as the latter is already at high levels.

2.48 Some additional evidence is reported in another study by Saal, Parker and Weyman-Jones (2004). They estimated econometrically an input distance function[10] for the ten water and sewerage companies over the period 1985-2000 using stochastic frontier methods. The sample size and the time period was the same as in Saal and Parker (2000). They considered four separate outputs[11], two for the sewerage service (sewage collection and sewage treatment) and two for the water service (water extraction and treatment and water distribution) and three inputs (capital, labour and other operating costs). The estimation of a stochastic frontier input distance function is particularly appealing as it allows total factor productivity growth (computed using a Malmquist index) to be decomposed into technical change (i.e. frontier shift), technical efficiency change and scale economies effect.

2.49 The results reported in Table 2.5 show that, as far as the TFP growth rate is concerned, the figures were similar to those computed with index numbers techniques: in particular, in the 1990-2000 period the TFP average growth rate was 1.64 per cent, not significantly different form the 1.75 per cent in the 1985-1990 period. However, the technical change did increase after privatization to 2.19 per cent over the 1990-2000 period from 1.61 per

[10] Input distance functions measure how much a company is far from the production possibility frontier. In particular, it gives the maximum amount by which an input vector can be radially contracted and still remain feasible for the output vector it is supposed to produced. Input distance functions are usually used to assess the technical efficiency of a set of firms and turn out to be relevant when a multi-output technology is considered. See, for a detailed exposition, Kumbhakar and Lovell (2000).

[11] Outputs are corrected to take into account quality improvements over the period.

cent under public ownership. The divergent behavior between TFP and technical change could be explained by the negative contribution to TFP growth caused by the existence of diseconomies of scale combined with positive output growth which prevailed over the period and by negative efficiency change.

Table 2.5: Water and sewerage, components of TFP; England and Wales

	85-90	90-95	95-00	90-00	85-00
Efficiency change	0.47%	-0.22%	-0.09%	-0.16%	0.05%
Technical change	1.61%	2.43%	1.95%	2.19%	2.00%
Scale effect	-0.34%	-0.45%	-0.34%	-0.39%	-0.37%
TFP growth	1.75%	1.76%	1.53%	1.64%	1.68%

Source : Saal et al (2004)

2.50 The Saal, Parker and Weyman-Jones' study is instructive as it shows the importance of distinguishing between technical change and TFP growth in network industries where economies or diseconomies of scale may exist. In particular, if economies of scale exist in a particular sector (and output increases), TFP growth is likely to over-estimate the scope for frontier shift; on the other hand, if there are diseconomies of scale (and output growth) TFP growth will under-estimate frontier shift.

2.51 Other studies that have recently investigated productivity growth issues in the English and Welsh water industry are a series of reports commissioned by Ofwat for the 2004 price review.

2.52 London Economics (2003) computed TFP growth in the water and sewerage industries using index number techniques for the period 1990-2000. The main differences from Saal and Parker (2000) are that London Economics treated sewerage and water as distinct sectors and considered aggregate data at industry level, while Saal and Parker (2000) relied on company accounting data. Furthermore, London Economics considered as output the gross output, corrected to take into account quality improvements (as in Saal and Parker, 2000) and as inputs capital, intermediate inputs and labour (corrected to take into account skill levels). Finally, the capital stock was adjusted for capacity utilization, using a methodology proposed by Griffith et al. (2002).

2.53 The figures, reported in Table 2.6, show that, once the adjustments to output, labour and capital have been made, the average annual TFP growth rate for the water industry over the 1990-2000 period was 1.20 per cent. This average growth rate is boosted by the strong increase in TFP between 1990-91. Excluding the first year, the average TFP growth rate would fall to 0.31 per cent.

Table 2.6: Comparisons of TFP 1990 - 2000; United Kingdom

TFP growth water	1.20%
TFP growth sewerage	3.76%
TFP growth electricity	0.53%
TFP growth gas	1.40%
Rail transport	1.24%
Coal and Petroleum products	-1.31%
Mining & quarrying	2.85%

Source : London Economics, 2003

2.54 For the sewerage sector, the TFP growth rate over the sample period was 3.76 per cent (after adjusting for capacity utilization). The data used in the study also include refuse disposal and, therefore, the results on sewerage TFP performance should be treated with more care.

2.55 London Economics (2003) also considered TFP growth rates in the 1990-2000 period in certain UK sectors whose economic characteristics (such as capital intensity) were found to be similar to the water and sewerage sectors using cluster analysis techniques. This included the electricity sector. The figures, reported in Table 2.6, show, amongst other things, that the TFP growth rate was 0.53 per cent and 1.40 per cent for the electricity and gas sectors respectively.

2.56 Europe Economics (2003) in its report to Ofwat on the scope for efficiency improvements in the English and Welsh water industry used sector level data to estimate the TFP growth rate for a set of sectors that could be considered as relevant comparators for the water industry, the sewerage industry and the electricity industry respectively. These sectors are reported in Table 2.7. Europe Economics ran regressions for each set of sectors. The TFP out-performance of each sector in each year with respect to the UK economy TFP performance was regressed on a privatization variable (which is intended to capture the effects of privatization on TFP growth), a variable representing the average age of the capital stock (to capture the extent of fixed factors in the short run) and a variable representing the intensity of competition in the sector. The results showed that, after controlling for privatization[12], the long run trend for TFP out-performance was 1.10 per cent, 0.26 per cent, and 0.25 per cent for the comparators of electricity, water and sewerage respectively. Europe Economics also "pooled" the three sets of comparators together and ran a fixed effects regression for each sector included in the analysis. This

[12] The other two variables turned out to be insignificant and therefore excluded from the regression.

indicated that the electricity, gas and water sector outperformed the whole economy TFP growth over the period by 1.4 per cent.

Table 2.7: Comparator sectors for electricity, water and sewerage

Electricity	**Water**	**Sewerage**
Electricity, gas & water	**Electricity, gas & water**	**Electricity, gas & water**
Construction	Chemicals	Chemicals
Transport	Construction	Construction
Communications	Transport	Transport
Machinery	Communications	Communications
Office equipment	Machinery	Machinery
Electrical & optical equipment	Food, drink & tobacco	Coal & Petroleum products
Other transport equipment		Textiles. Clothing & leather
		Food, drink & tobacco

Source: Europe Economics (2003)

2.57 Europe Economics also report that the average TFP growth rate for the sector "electricity, gas and water" in the UK was 2.43 per cent and 3.45 per cent over the periods 1979-89 and 1989-99, respectively. The corresponding TFP growth rates for the market sector as a whole were 1.81 per cent and 1.02 per cent suggesting an out-performance of 0.62 per cent and 2.43 per cent by the utility sector. This is higher than the figure quoted from the previous study which was estimated after adjusting for the effects of privatization.

Conclusions

2.58 In this section we have provided a review of the international empirical evidence on technical change and productivity growth in network industries like electricity and gas transmission and distribution and water and sewerage services.

2.59 While we will draw our conclusions in section five of the report, after reviewing the macroeconomic evidence on labour and total factor productivity growth, it may be useful at this stage to provide some general comments on the importance and reliability of the studies surveyed to assess the scope for productivity growth and frontier shift for TenneT.

2.60 Generally speaking, the large majority of studies discussed above are relevant for TenneT. They all relate to utilities which deliver a service (gas, water, electricity) over a

physical network which involves large fixed and sunk capital costs[13] and with low or no competitive pressure.

2.61 With respect to the "network" nature of the sectors analysed in this report, the evidence we have reported for the English and Welsh water and sewerage services is related to the whole industry. The water and sewerage industries are vertically integrated in the UK: as such, they involve a network component (water distribution and sewerage collection and transportation) and a non-network stage (water abstraction and treatment and sewerage treatment). The non-network stages, especially water and sewerage treatment, involve rather different technologies and input requirements (e.g. chemicals) and it is the water network activities which are more comparable to the electricity and gas distribution and transmission industries.

2.62 Virtually all the evidence discussed in this report derives from studies performed by (or in behalf of) regulators or by academic economists using data on regulated sectors (like the works by Saal et al (2000 and 2005)). This is important because it should ensure that the quality and reliability of data should be reasonably good.

2.63 Nonetheless it is difficult to rank the studies in terms of their reliability and relevance. As the quality of data appears to be reasonably good and the methodologies adopted widely accepted in the economics literature, the quality and relevance of a single study will largely depend on issues like the variables used to proxy for output (especially if the customer density dynamic was significant over the sample period) and the control for quality improvements (if large investments were realised to increase quality over the sample period).[14]

2.64 Most of the studies provide a measure for TFP growth using conventional index number methodologies including both catch-up, frontier shift and other effects. Therefore, using these TFP growth figures to infer the scope for frontier shift alone would require some further assumptions to disentangle the frontier shift component from scale economies effects and possible catching-up. Those studies that have estimated frontier shift separately using econometric or DEA methodologies thus provide more insights as they yield a direct measure of frontier shift. However, econometric and DEA methods are more dependent on the validity of underlying assumptions and, as such, their conclusions might

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[13] There are some exceptions, like the figures reported for BAA, which is obviously not a network industry, or British Telecom, as the technology (as well as the degree of competition in the sector) of a telecommunication network is probably substantially different from the one characterising the electricity, gas and water industries.

[14] For instance, most of the evidence referred to the English and Welsh water and sewerage industry should be viewed with caution given the relevant quality improvements realised since privatisation unless the study does explicitly mention that the output has been corrected for quality,.

be less robust than those provided by index number techniques.[15] This needs to be taken into account in interpreting estimates of frontier shift.

[15] See 1.26 – 1.27 above.

3 MACROECONOMIC MEASURES OF PRODUCTIVITY

EU and US evidence

3.1 This section considers general economic trends in productivity measures for the US and the EU (15) countries, with a special emphasis on the Netherlands. We review the available international empirical evidence on labour and total factor productivity and capital intensity differentials across countries as well as their trend growth rate over the last twenty years.

3.2 The discussion is largely based on a series of papers by Bart van Ark and co-authors (see, for instance, van Ark, 2003, Timmer et al., 2003, O'Mahoney et al, 2003) which provide relevant figures for the US and the EU countries. The main source for data on TFP is the Total Economy growth accounting database at the Groningen Growth & Development Centre (GGDC). Other sources of data are papers by O'Mahoney (2002) and Scarpetta et al. (2000). In what follows we focus on the Netherlands, the US, the EU, the UK, France and Germany.[16]

Labour productivity levels

3.3 GDP per capita is probably the best indicator to measure and compare average standards of living across countries. Table 3.1 reports the real GDP per capita levels in our reference countries in 1950, 1980, 1990 and 2004 relative to the US. With the exception of the UK, the other countries converged towards the US levels up to 1980 (the same trend can be observed for most other EU countries). However, after 1980 this process of convergence was reversed. Again, the UK behaviour is different, as it has closed some of the gap with the US since 1980. In particular, we note that the Netherlands had a GDP per capita which was about 86 per cent of the US level in 1980. In 2004, the figures show that the GDP per capita in Netherlands was just 77.5 per cent of the US level.

[16] For Germany, the data shown in the tables reported in this section, and referred to the years before German reunification, are to be interpreted as referred to West Germany, unless a separate figure for West Germany is separately shown.

Table 3.1: Indices of GDP per capita

	US=100			
	1950	**1980**	**1990**	**2004**
US	100	100	100	100
Netherlands	67.9	86.1	80.9	77.5
UK	78.8	75.6	76.9	78.1
Germany			78.7	70.3
West Germany	48.9	90.3		
France	57.8	85.3	81.8	75.1

Source: Groningen Growth and Development Centre

3.4 However, GDP per capita, though interesting per se, is not the most useful indicator of a country's productivity as it can reflect differences between countries in terms of labour force participation, unemployment rates, working age population and number of hours worked. GDP per worker and GDP per hour worked are more the relevant concepts to analyse.

3.5 Table 3.2 shows the difference in labour productivity, measured as GDP per hour worked, between the US and the EU, in different years. There are differences between countries but the gap between the US and the EU is not great, although in the second half of the 1990s the gap it had started to widen. As far the Netherlands is concerned, labour productivity has been consistently higher than in the US and the EU average, although the margin of advantage has been falling over the past decade.

Table 3.2: Labour Productivity indices (gdp/hour)

	US = 100				
	1980	**1990**	**1995**	**2000**	**2002**
US	100	100	100	100	100
EU	85	89	96	94	92
Netherlands	108	114	115	108	105
UK	72	78	85	85	84
Germany	96	89	103	103	103
France	94	108	110	106	106

Source: van Ark (2003)

Labour productivity growth

3.6 Table 3.3 shows the labour productivity growth in terms of GDP per worker over selected time periods. The figures show than on average, EU country GDP per worker continued to converge towards US levels, but that this convergence process slowed down and changed "direction". Since the second half of the 1990's, GDP per worker has been rising faster in the US than in the EU. This reflects a combination of a slowdown of many EU countries and acceleration by the US.

3.7 The Netherlands has seen relatively low and declining rates of labour productivity growth well below the EU average in all the selected periods.

3.8 This diverging trend of GDP per worker between the US and the EU is often attributed to the large investments in Information and Communications Technology (ICT) in the US and to the externalities generated across the whole economy.

Table 3.3: Average growth in labour productivity (gdp/hour)

	per cent per annum			
	80-90	**90-95**	**95-00**	**00-02**
US	1.4	1.1	2.0	1.7
EU	2.3	2.6	1.5	0.8
Netherlands	1.9	1.4	0.6	0.3
UK	2.2	3.0	1.8	1.1
Germany	2.5	4.0	2.2	1.3
France	2.9	1.4	1.3	1.7

Source: van Ark (2003)

Capital intensity and TFP levels

3.9 Labour productivity only gives a partial picture of relative performance across countries and time because, as discussed earlier in this report, it is influenced by the capital/ labour ratio, i.e. by the relative capital intensity of the economy. Total factor productivity is therefore a more useful measure. It can be shown that labour and total factor productivity are intimately related, as TFP growth can be derived from labour productivity growth by subtracting the growth in capital per worker weighted by the income share of capital. [17][18] This relationship shows that labour productivity may grow either because TFP grows or because the capital intensity of the economy grows, or both.

[17] This decomposition is strictly valid only under certain circumstances such as constant returns to scale and perfect competition.

[18] This relation can be expressed as; $\Delta TFP = \Delta LP - (\frac{\dot{K}}{K} - \frac{\dot{L}}{L})(1-\alpha_L)$, where α_L is the income share of labour, ΔTFP is the rate of growth of TFP, ΔLP is the rate of growth of labour productivity and $(\frac{\dot{K}}{K} - \frac{\dot{L}}{L})$ is the rate of growth of capital per worker. See, among the others (Romer, 2001).

3.10 Table 3.4 shows the capital intensity (capital per hour worked) in a selected number of years, expressed with reference to the US levels. We can see that France, the Netherlands and Germany all have levels of capital stock per hour worked above the US level while the UK levels are well below those in the US. In the second half of the 1990s the capital per hour worked fell in all these countries, relative to the US.

Table 3.4: Capital per hour worked

	US=100			
	1980	**1990**	**1995**	**2000**
Netherlands	103	127	123	115
UK	66	71	73	65
Germany	113	129	141	131
France	99	126	125	103

Source: O'Mahoney et al (2003).

3.11 Table 3.5 shows relative TFP levels in 1999: the US achieved TFP levels 12 per cent higher than the EU. Within the EU, the Netherlands' TFP levels are 13 per cent higher than the EU average.

Table 3.5: TFP levels in 1999

	EU=100
US	112
EU	100
Netherlands	113
UK	99
Germany	101
France	104

Source: O'Mahoney, (2002)

3.12 Table 3.6 shows average TFP growth rates over selected time periods. The picture is similar to that shown above for labour productivity: TFP growth was faster for the EU in the 1980s and in the first half of the1990s, but with US TFP growing significantly faster in the following ten years.

Table 3.6: Average growth in TFP

	80-90 (%)	**90-95 (%)**	**95-00 (%)**	**00-04 (%)**
US	0.6	0.5	1.1	1.7
EU	1.1	1.2	0.9	0.4
Netherlands	1.1	0.6	0.6	0.2
UK	1.2	1.6	1.1	1.5

Germany	1.5	1.8	1.3	0.6
France	1.4	0.0	1.4	0.5

Source: Groningen Growth and Development Centre

3.13 As far the Netherlands is concerned, TFP was growing at a pace consistent with the EU average in the 1980s, but in the following 15 years the growth rate has lagged behind the growth in both the EU and the US. Nonetheless, as Table 3.5 showed, in 1999 the absolute level of TFP in the Netherlands remained very high.

Evidence from manufacturing, market services and other sectors

3.14 O'Mahoney et al (2003) report evidence on labour productivity levels (measured as value added per hour worked) in manufacturing, relative to the US. This is shown in Table 3.7. The picture we can draw from this work is consistent with the evidence we have reported so far. In manufacturing, EU countries' labour productivity converged towards the US levels in the 1980's-early 1990s, when a number of countries achieved productivity higher than the US levels (the Netherlands was one of these countries). However, by the end of the 1990s the convergence process reversed in many EU countries and labour productivity in manufacturing (relative to the US) fell below the values of the 1980s for the EU as a whole.

Table 3.7: Labour productivity levels in manufacturing (value added/hour)

	US=100		
	79-81	**94-96**	**99-01**
	(%)	**(%)**	**(%)**
US	100	100	100
EU	85	88	80
Netherlands	94	110	99
UK	63	82	75
Germany	100	93	83
France	104	104	102

Source: O'Mahoney et al (2003)

3.15 The picture for the Netherlands is broadly similar to the EU as a whole. There was a fast increase in labour productivity in the 1980s and a sharp fall in the second half of the 1990s. However, the divergence from the US has been less sharp than for the EU as a whole.

3.16 Table 3.8 shows the value added per worker in 1995 and 1999 for the market services sector only (see O'Mahoney, 2002). The difference between the US and the EU is significant and appears to be increasing. EU value added per worker in 1999 was just 81 per cent of the US corresponding figure. The Netherlands figure was just 64 per cent, based on value added per worker. Unfortunately, we do not have a figure for value added per hour worked. As the number of hours worked is lower in the Netherlands than in the

US, it is likely that expressing labour productivity in terms of value added per hour worked would yield a much better performance for the Netherlands.

Table 3.8: Labour productivity values in market services (value added per worker)

	EU=100	
	1995	**1999**
US	107	123
EU	100	100
Netherlands	91	79
UK	81	85
Germany	97	98
France	105	104

Source: O'Mahoney (2002)

3.17 Furthermore, the gap seems to be widening. Estimates in O'Mahoney (2002) indicate that while the growth in the US in the 1995-99 period was 4.63 per cent, the EU figure is just 1.01 per cent, and the Netherlands figure is -2.64 per cent Some of the sub-sectors included in the category of market services are intensive users of ICT, which could explain the poor EU performance. We note that, for some EU countries, the growth rate in GDP per worker has been at fairly high levels, al though still lower than in the US.

3.18 O' Mahoney et al. (2003) report data on labour productivity growth and its determinants for the EU, individual member states and the US at a detailed level of disaggregation. We have reviewed the data for the EU, the US, the UK, the Netherlands, France and Germany.

3.19 The sector which is most relevant to this study is "electricity, gas and water supply". The results for both labour and total factor productivity growth are reported in Table3.9.

Table 3.9: **Productivity in Electricity, Gas and Water**

	Per cent per annum					
	Labour productivity growth			**TFP growth**		
	79-90	**90-95**	**95-01**	**79-90**	**90-95**	**95-01**
US	1.12	1.81	2.32	-0.36	0.67	0.22
Netherlands	2.39	1.85	4.5	1.11	-0.27	-0.83
UK	5.21	5.19	11.08	3.7	-1.76	4.43
Germany	0.86	3.53	6.38	-0.61	1.21	2.76
France	5.39	2.24	3.72	3.92	2.05	2.62

Source: O'Mahoney et al (2003)

3.20 The sectoral figures for both TFP and LP growth are interesting per se, but it is important to link this to the productivity performance in the economy as a whole when considering RPI – x types of price control. Productivity growth at the economy wide level is already reflected in the RPI index, the regulated company should only be required to increase its

prices at less than RPI if its TFP growth is forecast to be higher than the one characterising the country as a whole.[19]

3.21 Unfortunately, we have not been able to find an economy wide figure that matched exactly the 1979-90, 1990-95 and 1995-01 periods reported in Table 3.9. However, the data reported in Table 3.3 and 3.6 above show economy-wide figures for TFP and LP growth over the 1980-90, 1990-95 and 1995-00 period, which should not be materially different if calculated for the 1979-90, 1990-95 and 1995-01 periods. Therefore, in Table 3.10 we report the data of Table 3.9 "net of" economy wide TFP and LP figures as shown in Table 3.3 and 3.6 above.

Table 3.10: **Productivity in Electricity, Gas and Water**

	Per cent per annum					
	Labour productivity growth out-performance			TFP growth out-performance		
	79-90	**90-95**	**95-01**	**79-90**	**90-95**	**95-01**
US	-0.28	0.71	0.32	-0.96	0.17	-0.88
Netherlands	0.49	0.45	3.9	0.01	-0.87	-1.43
UK	3.01	2.19	9.28	2.5	-3.36	3.33
Germany	-1.64	-0.47	4.18	-2.11	-0.59	1.46
France	2.49	0.84	2.42	2.52	2.05	1.22

Source: Europe Economics

3.22 Labour productivity growth in this sector over the 1995-2001 period has increased in the Netherlands at an average rate of 4.5 per cent compared to 2.39 per cent in the 1979-90 period and 1.85 per cent in the 1990-95 period (see Table 3.9). Table 3.10 shows that labour productivity growth for the sector in the Netherlands has always out-performed the labour productivity in the economy as a whole, but this out-performance sharply increased in the 1995-01 period.

3.23 Tables 3.9 and 3.10 show a similar picture for France. Labour productivity growth in this sector in the period 1995-2001 was 3.72 per cent; significantly lower than the 5.39 per cent of the 1979-90 period but slightly higher than the 2.24 per cent of the 1990-95 period. Furthermore, French labour productivity growth in the sector consistently out-performed the economy-wide figure in all three periods (with a lower performance in the 1990-95 period.

[19] Bernstein and Sappington (1999) set out this principle in the context of US utility regulation. It has been suggested by Swinand (2003) that this approach may bias final prices upwards.

3.24 In Germany, labour productivity in the "electricity, gas and water supply sector" rose consistently over the sample period, from 0.86 per cent in 1979-90, to 3.53 per cent in 1990-95 to 6.38 per cent in 1995-2001. However, when compared to the total economy figures, we see that only in the last period did the sector out-perform the total economy. This reflects both an increase in sector productivity and of a slowdown in the rate of growth in the economy as a whole.

3.25 The UK labour productivity growth in this sector has, throughout the period reviewed, always been stronger than in Germany, France and the Netherlands (5.21 per cent and 5.19 per cent in 1979-90 and 1990-95, respectively) but this difference increased significantly in the 1995-01 period, to reach a growth rate of 11.08 per cent, probably reflecting the liberalisation in network utilities which took place at the beginning of the 1990s and which is known to have brought significant gains in efficiency and productivity in the second half of the 1990s (after the first price reviews for water and electricity). The figures show a very similar picture for the labour productivity out-performance, with the labour productivity growth rate consistently higher than the economy as a whole, especially in the 1995-01 period.

3.26 The US figures are smaller in this sector than the countries surveyed above. Labour productivity growth was just 1.12 per cent, 1.81 per cent and 2.32 per cent in 1979-90, 1990-95 and 1995-2001, respectively. The correction for the labour productivity growth in the economy shown in Table 3.9 displays a similar picture.

A summary and implications for the Netherlands

The macroeconomic evidence

3.27 In this section we have reviewed empirical evidence on labour and total factor productivity growth for the Netherlands and other major countries (US, UK, France and Germany) at macroeconomic level and for some specific sectors. The evidence related to the economy as a whole is the most significant, especially because it is the relevant one to consider when computing the X factor in the RPI-X style of regulation (see paragraph 3.20 above).

3.28 The figures reported above consistently show a productivity slowdown over the period in the Netherlands and most other EU countries. As argued by van Ark (2003) the productivity slowdown is in part a worldwide problem, in part an European problem and in part a typical Dutch problem

3.29 As far as labour productivity growth is concerned (and focussing on the figures for the total economy), it has often been argued that one of the causes for this poor performance is the increase in labour force participation and in employment which occurred during the 1990s: the consequent increase in the share of unskilled workers in total employment would have caused labour productivity growth to fall. However, the empirical evidence (CPB, 1997, 1998, cited in van Ark, 2003) finds little support for the hypothesis that the

increase participation to the labour market of unskilled workers is the major factor responsible for the slowdown in productivity growth.

3.30 Furthermore, evidence reported in van Ark (2003) and O'Mahoney (2003) shows that, for the Netherlands, the labour productivity slowdown was more intense in a few industries such as agriculture, manufacturing, financial services and other community, social and person services, while sectors like distributive trades, communication and business services displayed quite robust (and increasing) labour productivity growth.

3.31 This evidence suggests the need to look elsewhere for additional explanations of the labour productivity growth slowdown. Van Ark (2003) uses labour productivity growth accounting methodologies to look at the determinants of labour productivity growth: he decomposes labour productivity growth into components due to growth in ICT capital, non-ICT capital, skills (as a proxy for intangible capital) plus a residual (which can be interpreted as TFP growth) and compares the resulting figures over time and with the US. His figures show, for the US, the increased importance of ICT capital formation and TFP growth in accounting for labour productivity growth in the economy as a whole over the 1979-2001 period. In particular, TFP growth and ICT capital formation increased over time especially in the ICT producing and ICT-using sectors of the economy.

3.32 By way of contrast, in the Netherlands, the ICT capital formation did increase over the sample period, but "the effect [on output] is considerably smaller than in the United States".

3.33 The less important role played by ICT in the Netherlands and Europe in driving productivity growth is further discussed by van Ark at the light of future developments of productivity growth. In fact, as new investment in a general purpose technology (like ICT) may require time to display its effects, it is possible that the Netherlands is simply lagging behind the US in benefiting from this investment. If this hypothesis is true - and there is some evidence supporting it (like similar rates in ICT capital formation between the Netherlands and the US) - then it would be reasonable to expect an increase in productivity growth for the Netherlands in the next years.

3.34 However, it is also possible that there is something in the economic environment (labour and product market rigidities, for instance) that limits the impact of ICT investment in the EU compared to the US.

3.35 O'Mahoney et al. (2003) argue that although ICT capital formation grew in the EU and the US at similar rates, its share in total investment has always remained smaller in the EU and that there does not seem to be evidence of the EU starting closing the gap.

3.36 Furthermore, the reasonably good productivity performance in non-ICT sectors could indeed suggest that ICT is not as important as in the US in driving productivity growth (van Ark, 2003). Among the reasons, van Ark (2003) cites factors internal to the firm, such as lack of innovations in organisation, which prevents firms from exploiting the potential of ICT capital; or the existence of regulations and real rigidities in the product and

factor markets[20], which prevent the re-allocations of resources towards sectors that can benefit most from the use of ICT. If this scenario is correct, it is possible that the Netherlands (and the EU) will continue to be characterised by low productivity growth figures also in the next years.

The "electricity, gas and water supply sector"

3.37 The evidence for this sector is one piece of evidence to consider for deriving an estimate for productivity growth for electricity transmission. The figures for the Netherlands show that labour productivity consistently outperformed the economy as a whole, with acceleration in the 1995-01 period. In contrast, the performance of TFP has been consistently below the economy wide figures. However the wide coverage of this sectoral measure and the inclusion of non-network elements like electricity generation and energy supply suggest that those figures should not be taken at face value. The poor TFP performance in the electricity, gas and water supply sector as a whole could be due to a number of factors such as poor performance in one of the sub-sectors (including the non-network activities) or failure to take into account quality improvements. It is difficult, therefore, to take this sector level performance as indicative of potential for any one part of the sector.

3.38 What remains clear is the better performance displayed by the UK in the electricity, gas and water supply sector with respect to the same sector in other EU countries. In the UK the adoption of incentive based regulation has increased TFP growth considerably, even if in some utilities the increase has been realised only after the regulatory tightening following the first price reviews. This seems to suggest that the incentives provided by incentive based regulation using RPI-X can be a powerful spur to efficiency improvement for regulated networks.

[20] Van Ark (2003), using information contained in the OECD International Regulation database, shows that the tighter product and labour market regulations are associated with low shares of ICT investment in total GDP. The Netherlands is a country with an intermediate level of product and labour market regulation and, therefore, an intermediate level of ICT investment over total GDP. However, the regulation in the labour and (especially) product market is substantially higher in the Netherlands than in the US or in the UK.

4 THE EMPIRICAL EVIDENCE: SOME CONCLUSIONS

Comparisons between studies

4.1 In order to help in making comparisons between the studies reviewed here the main findings on productivity growth in electricity, gas and water are summarised in Tables 4.1, 4.2 and 4.3. For the most part these studies indicate TFP growth for network utilities in the range 1 to 2 per cent. Electricity and gas distribution in the US has shown rather lower growth on most estimates while the electricity and gas sectors in the UK have shown significantly higher growth. The New Zealand energy networks have also shown higher than average growth except for the gas transmission network.

Table 4.1: Electricity sector productivity studies

Electricity Sector			
	% pa	**TFP**	**PFP opex/RUOE**
CEPA (2003)			
GB Distribution		4.2	7.7
E&W Transmission		2.4	4.9
DNO composite index		2.0	
UK Economy		1.3	
UK Utilities		3.4	9.0
French Utilities		1.8	2.9
German Utilities		1.2	4.7
US Electric Utilities		1.9	2.0
Ofgem (2000)			
NGC			6.8
PES distribution (all)			6.0
PES distribution (top 6)			7.7
Water			3.7
Sewerage			4.1
British Gas/Transco			7.5
London Economics (1999)			
NSW		- 6 to 4	
UK DNO		3.5	
US Distribution		0.7	
New Zealand Distribution		1.4	
Meyrick 2003			
New Zealand Distribution		3.2	
Transmission		2.3	
NZ Economy		0.6	

Source: Studies as cited.

4.2 There is greater variation in the estimates of labour productivity (and other partial productivity measures such as RUOE and RUOC) with a range from 2 to 9 per cent The British gas network (distribution and transmission) is at the top end of this range. There is some evidence of increasing labour productivity in the water and sewerage sector in England and Wales following privatization although TFP fell, possibly reflecting the substantial investment made in the post-privatisation period in improving water quality. Where both TFP and labour productivity estimates have been made as part of the same study the growth in labour productivity has broadly been in the range of 1.5 to 2 times that of TFP. However care should be taken in generalizing that ratio without allowing for differences in capital investment.

Table 4.2: Gas sector transmission and distribution productivity studies

Gas Sector				
	% pa	**TFP**	**RUOE**	**RUOC**
Europe Economics (2001)				
UK Privatised industries	Range		-1.6 to -8.8	-0.7 to -9.4
BG/Transco			-8.8	-9.4
Nature of Work Comparison[21]			**Labour**	
Transco		2.45	3.58	
UK Economy		1.73	2.22	
Meyrick (2004)				
NZ Gas Transmission		0.85		
NZ Gas Distribution		2.8		
Southern California Gas (2005) Range		0.84-1.27		
Pacific Economics (2004)				
US gas distribution		1.16		
Gas & electricity distribution	Range	0.4 – 1.5		
	Average	0.86		
Fraguell & Erbetta (2002)				
Italy gas distribution				
	Average	0.64		

Source: Studies as cited

[21] See paragraphs 2.29 – 2.32.

4.3 Most of the estimates reflect changes both in technical efficiency of the companies (catch-up with the efficiency frontier) and technical change (movement in the efficiency frontier). Where an approach has been adopted which allows these to be separated the evidence is mixed. Studies of Australian and New Zealand electricity distributors suggest that the change in TFP is almost totally attributable to increases in technical efficiency. In contrast studies for electricity distributors in the UK and US show 2.5 per cent to 3.5 per cent growth in TFP attributable to technical change which is partly offset by declines in technical efficiency. This suggests that while there have been significant improvements in the efficiency frontier not all firms have been able to keep up with that development. Water sector studies for the UK also show strong growth attributable to technical change with better performance in the period 1990 – 2000, after privatization.

4.4 The composite or nature of work estimates of TFP may provide an estimate that is less influenced by catch-up effects since they derive the performance measure from outcomes in other sectors of the economy which are more open to competition and should be at or closer to their efficiency frontier than the network monopoly. These show TFP estimates for UK utilities of a 2.5 per cent per annum shift in the frontier for Transco, 2.0 per cent for electricity distributors and 1.7 per cent for water and sewerage companies.

Table 4.3: Water & Sewerage Sector Productivity Studies

Water & Sewerage Sector England and Wales		% pa	TFP	Labour Productivity
Saal & Parker (2001)				
1985-90			2.3	4.5
1990-99			1.6	5.5
Saal et all (2005)				
1985-90	Total		1.75	
	Efficiency		0.47	
	Technical change		1.61	
1990-00	Total		1.64	
	Efficiency		-0.16	
	Technical change		2.19	
London Economics (2003)				
Water			1.2	
Sewerage			3.8	
Electricity (whole sector)			0.5	
Gas			1.4	
Europe Economics (2003)				
Whole economy			1.4	
Out-performance adjusted for privatisation				
Water			0.26	
Sewerage			0.25	
Electricity (transmission and distribution			1.10	
Out-performance unadjusted for privatisation				
Electricity, gas & water			2.43	

Source: Studies as cited

4.5 At the macroeconomic level the rate of growth in TFP (as described in section 3) has generally fallen in EU countries over the past 20 years and growth has been at very low levels over the past four years in France, Germany and the Netherlands. In contrast the US has seen rising growth in TFP and the UK performance has also been good. There is a similar contrast between the US and EU countries in measures of labour productivity. Estimates for the electricity, gas and water sector as a whole show EU countries generally performing better than the US. However the performance in the Netherlands is poor with TFP falling at nearly 1 per cent p.a. between 1995 and 2001.

Productivity estimates and regulatory decisions

4.6 In setting incentive based price regulation regulators evaluate a wide range of information in order to establish the existing cost base of the company or companies, to assess the

scope for immediate efficiency savings and to evaluate future trends. In order to reach robust conclusions which can withstand challenge it is usual for a number of different measurement techniques to be adopted allowing the regulator to crosscheck the consistency of different findings. Estimation of total and labour productivity is one such approach but is usually combined with other economic analysis, for example using regression techniques to identify an efficiency frontier and with engineering assessments of efficient operation. These will provide a range of estimates for efficiency improvement and frontier shift within which the regulator can make a final judgement.

4.7 The general experience of incentive regulation, particularly but not exclusively in the UK, is that there has initially been considerable scope for efficiency improvements with quite high X factors being set in the early years following its introduction. These continue to a lesser extent in later years but there is still scope for improvement as the efficiency frontier moves out at a faster rate than for the economy as a whole. Efficiency assumptions adopted by UK energy and water regulators since 1991 are summarised in Table 4.4.

4.8 It is notable that the main focus of the application of efficiency factors in regulatory decisions has been on operating expenditure. In a number of the regulatory studies which we have summarised here estimates of both TFP and PFP have been put forward. In our view there is a lack of clarity in subsequent regulatory decisions as to how those estimates have been applied. In particular it is not clear whether there is consistency between the treatment of opex and capex with either a single TFP or separate PFPs being applied to both.

4.9 As regulation matures it should be the case that TFP estimates, particularly those variants which can identify or are equivalent to measures of frontier shift, become the principal indicator of future productivity improvements for a sector. The move by some US PUCs to performance based regulation using TFP is an example of a move in this direction. TFP is taken as the indicator of frontier shift with a stretch factor added to cover catch-up efficiency gains. This approach has also been explored in New Zealand. This should help to avoid giving perverse incentives to companies to substitute between capital and labour in order to meet targets. However care needs to be taken to avoid double counting where TFP estimates include elements of catch-up efficiency gains as well as frontier shift.

Table 4.4: Summary of Efficiency Assumptions Adopted by UK Regulators

Company	Duration	Real Reduction	Cost Category
British Gas (1991)	1992-1997	2.5% per annum	Total non-gas costs
BG Transco (1996)	1997-2002	3.1% per annum	Operating expenditure
Transco (2001)	2002-2007	2.5% per annum	Controllable operating cost
NGC (1992)	1993-1997	5% per annum	Operating costs
NGC (1996)	1997-2001	2.5% per annum	Operating expenditure
NGC (2000)	2001-2006	3.5% per annum	Controllable operating costs
REC distribution (1995)	1995-2000	2% per annum	Unit operating costs
REC distribution (1999)	2000-2005	2.3% per annum	Operating costs
DNO (2004)	2005-2010	1.5% per annum	Operating expenditure
Scottish transmission (1993)	1994-2000	2% per annum	Controllable operating costs
NIE distribution (1997)	1997-2002	1.7% per annum	Operating costs
Water/Sewerage (1994)	1995-2000	2% per annum	Operating expenditure
Water/Sewerage (1999)	2000-2005	2.7% per annum	Operating expenditure
Water/Sewerage (2004)	2005-2010	1.4% per annum	Operating expenditure

Source: Europe Economics (2001) and update

5 APPLICATION IN THE NETHERLANDS

5.1 We have reviewed studies of productivity measured in a variety of ways across a range of utilities in different countries. We have also looked at economy wide productivity trends in EU countries and the US. In assessing the relevance of these studies to setting a price control for TenneT, the electricity transmission operator in the Netherlands, we need to draw conclusions on the following issues:

(a) The relevance of studies of other countries and different utilities to decisions about TenneT;

(b) The validity of applying TFP estimates at utility and national level to TenneT;

(c) The ability to distinguish in TFP estimates between catch-up and frontier shift; and

(d) Alternative application of PFP estimates to TenneT.

5.2 Electricity transmission in the Netherlands is a network utility which shares common characteristics with electricity transmission businesses in other developed economies and with electricity distribution. Electricity transmission also forms part of a larger grouping of network utilities which have many similarities and which, in recent years, have increasingly been subject to incentive based price regulation designed to encourage increasing efficiency in operations.

5.3 Comparison of performance within this wider group of utilities has been the subject of a number of studies reviewed in this report. In making these comparisons the studies generally take into account significant differences between sectors such as economies of scale or investment in quality improvement. The read across from one sector or country study to another cannot be exact but in our view there is an adequate range of estimates available to allow a judgement to be made about the likely potential for efficiency improvements in the Netherlands electricity transmission network.

5.4 TFP represents a measure of the increase in output attributable to factors other than an increase in labour and capital inputs. It represents a shift in the efficiency frontier for an economy or group of firms and by covering all factors of production it avoids the possible distortion that can occur in PFP estimates from capital/labour substitution. As such it is in principle a useful tool for assessing the future performance of a utility such as TenneT. TFP estimates have been used by a number of national regulators in reviewing price controls.

5.5 However conventional index number based estimates of TFP cannot distinguish between efficiency improvements which represent pure shift in the efficiency frontier and other effects. This is particularly an issue with company level estimates of TFP where other factors may be significant. The development of incentive based regulation of utilities in recent years has been designed to encourage business which do not face competition and may not be operating at the efficiency frontier to improve their performance and, at the same time, to encourage further efficiency gains through moving the frontier. TFP

estimates based on historical data for such utilities are likely to include both catch-up and frontier shift effects. These need to be separated out in using TFP to set future price controls.

5.6 A number of studies have broken down TFP estimates into separate components or used other techniques to provide forward-looking estimates. These studies should provide better comparators for TenneT than undifferentiated TFP indices based on historic data.

5.7 The technical difficulties involved in TFP estimation and interpretation have generally led regulators to use TFP as one element in reaching a judgment about the scope for future efficiency gains. Improvement in unit operating expenditure has been the other main focus. This covers use of labour and bought in goods and services other than capital projects. Partial factor productivity measured in this way can be combined with a bottom-up cost based assessment of efficiency.

5.8 Where both TFP and PFP measures are employed it is important to maintain consistency of treatment with separate estimates for labour and capital productivity being applied in the use of PFP.

Frontier shift

5.9 From the studies we have reviewed, estimates of TFP growth representing movements in the efficiency frontier for network utilities mostly fall in the range of 1 to 2 per cent per annum. However there is evidence that in circumstances where strong incentive based regulation has been applied higher rates of growth have been achieved. It is in the nature of some of these estimates that they will include an element of catch-up efficiency, as well as a scale economies effect, but other estimates which are better focused on identifying shifts in the efficiency frontier show frontier growth rates in the range 1.5 to 2.5 per cent, with other estimates as high as 3.5 per cent and 4.4 per cent (although this appears to be an outlying result which is not typical).

5.10 Estimates of TFP growth derived using the “nature of work” comparison methodology can be regarded as indicative of frontier shifts. This approach aims to ascertain the rate of productivity improvement that a particular company could achieve on account of the type of work in which it is involved, on the assumption that it should be capable of operating at the same level of efficiency as its comparator sectors, which are mainly sectors open to competition. “Nature of work” TFP growth figures can thus be interpreted as the TFP growth attainable by a company operating in a competitive environment. Furthermore, as the comparators are mainly sectors where the assumption of constant returns to scale is likely to be valid, the “nature of work” TFP growth figures should not include any economies of scale effect.

5.11 Among the studies reviewed that provide evidence on TFP growth using the “nature of work” components approach, the Europe Economics (2001) study provided a central estimate of TFP growth for Transco as high as 2.45 per cent p.a. (with a lower and upper

bound of 1.9 per cent and 3.0 per cent, respectively). The CEPA study estimated a 2.0 per cent frontier growth for the UK electricity distribution companies.

5.12 Other studies estimated frontier shifts using econometric or DEA methods: Saal et al. (2004) estimated frontier shift of 1.7 per cent for the water industry in England and Wales, London Economics 1999 estimated TFP growth of 3.5 per cent for electricity distribution in England and Wales over the period immediately after privatisation.

Economy wide productivity growth and TFP out-performance

5.13 In making use of productivity estimates in RPI – x type price control formulae it is also necessary to consider the effect of productivity improvements in the economy as a whole. The price level in the economy will reflect productivity improvements and it is any out-performance against the economy wide benchmark which should be reflected in the price control formula.

5.14 For the UK the underlying growth in TFP for the economy as a whole was in the region of 1.5 to 1.6 per cent for the 1990-95 and 2000-04 period, but slightly lower at 1.1 per cent for the 1995-00 period. This suggests a level of productivity out-performance by the UK utilities studied in the range 0.5 to 2.0 per cent. A further study, Europe Economics 2003, estimated out-performance for the electricity sector of 1.1 per cent and 1.4 per cent for the electricity, gas and water sectors taken together. The trend TFP growth of 2.4 per cent for NGC estimated by CEPA suggests out-performance for electricity transmission of around 1 per cent.

5.15 In the Netherlands, TFP growth in the economy as a whole has been low in recent years at 0.2 per cent (it was 0.6 per cent in the 1990-95 and 1995-00 periods). TFP in the gas, electricity and water sectors fell by 0.8 per cent per annum in the five years to 2000 and in the whole 1990s it was consistently out-performed by the economy as a whole. This may suggest that the efficiency of these utilities has fallen behind the best practice level[22] but that has not been analysed in this study.

5.16 A number of explanations have been put forward for differences in productivity performance between countries. The scale of investment in ICT is one possible factor although this does not appear to explain the low level of TFP in the Netherlands.

5.17 Labour market rigidity (in terms of different hiring and firing costs, working time restrictions, union power, etc.) is another possible factor. The evidence briefly discussed

[22] See also section 3.

in section 3 above shows that both labour and product market rigidities are more significant in the Netherlands than in the UK and the US (even if the Netherlands has much more flexible labour and product markets than many other EU countries and a high level of GDP per capita). This may continue to restrict the scope for productivity growth in the Netherlands.

5.18 A further uncertainty is whether labour market rigidities might also restrict the extent to which TenneT's TFP might out-perform the economy wide growth in productivity. Out-performance will be driven by other factors, including incentive regulation. TenneT's overall level of TFP may be reduced by the same factors that lead to a low level for the Netherlands economy but the efficiency gains demonstrated by other utilities suggest that TenneT should still be able to achieve improvements on top of that base level.

5.19 The frontier shift TFP out-performance range of 0.5 to 2.0 per cent identified for UK utilities provides lower and upper bounds for TenneT's likely performance. Achievement at the upper end may be constrained by factors such as labour market rigidities while an outcome at the lower end of the range should be unlikely in the early years of operation of incentive based regulation.

5.20 The UK utility estimates quoted here already take the effects of economies of scale on TFP into account using a scale elasticity factor of 0.85 for electricity and 0.77 for water. We have assumed that this level of adjustment is appropriate for making comparisons with similar network businesses

5.21 Overall it is our view that on the basis of comparison with other network businesses Tennet should be expected to achieve TFP growth in the range 0.75 – 1.75 per cent over and above the underlying productivity growth in the economy as a whole. Assuming underlying productivity growth in the Netherlands of approximately 0.5% per annum (slightly lower than the 1990s figure but slightly above the level for 2000 – 04), the total expected productivity growth for TenneT would be 1,25-2,25%. This is within the ranges identified in the studies. This range is put forward as indicating the change associated with a shift in the efficiency frontier. If a firm is operating below the efficiency frontier then there may be potential for additional productivity growth as it catches up with the efficient level of operation. This study does not include estimates of the potential for 'catch up' increases in productivity in the Netherlands.

Partial factor productivity

5.22 We have also reviewed labour and opex productivity measures. These are only a partial measure of productivity and as such second best to TFP. However they are of interest because many price controls focus on assessing the efficiency of operating expenditure with separate allowance for capital costs. There is greater variation in labour productivity between the studies reviewed but it appears that there is a broad consistency between measures with labour productivity being in the range 1.5 to 2 times TFP. This would suggest that appropriate values for future growth in labour productivity in electricity transmission in the Netherlands should be in the range of 1.9 to 4.5 per cent per annum.

5.23 Labour productivity growth is often associated with real wage growth. If the association were one to one (and with no lags), one might think that labour productivity growth would result in an equal increase in real wage growth leaving unit labour costs unaffected. However, the behaviour of real wages is not only affected by labour productivity growth, but also by labour market conditions such as labour supply and unemployment so that a one-to one relation might well not occur.

5.24 Real wage growth in any particular sector will generally follow the wage levels in the economy as a whole unless there are particular skill shortages or other factors which need to be addressed. Productivity out-performance in the sector relative to the economy as a whole remains a key issue in setting the X factor in price control.[23] However, to the extent that real wages rise faster than prices in the economy as a whole and labour costs represent a higher proportion of sector operating cost than they do in the economy as a whole then a further adjustment may be necessary before finalising the X factor. An input price adjustment would be based on the difference between the whole economy input price inflation and the sector opex-related input price inflation. Other things being equal this would result in a downward adjustment to the X factor.

[23] See paragraph 3.20

APPENDIX 1: BIBLIOGRAPHY

Abramovitz, M., "Resource and Output trends in the United States since 1870", American Economic Review, 46, 2, 1956.

Bernstein, J.Y., and Sappington, D.E.M, "Setting the X factor in Price Cap Regulation", Journal of Regulatory Economics, 16, 1, 1999.

Cambridge Economic Policy Associates, Background to work on assessing efficiency for the 2005 distribution price control review. Report to Ofgem, 2003

Cambridge Economic Policy Associates, Productivity improvement in distribution network operators. Report to Ofgem, 2003.

Ellig, J. and Giberson, M., "Scale, Scope and Regulation in the Texas Gas Transmission Industry", Journal of Regulatory Economics, 5, 1, 1993.

Erbetta, F. and Rappuoli, L., "Estimating Optimal Scale and Technical Efficiency in the Italian Gas Distribution Industry". Paper presented at the EARIE conference, Berlin, 2004.

Europe Economics, Scope for Efficiency Improvement in the Water and Sewerage Industries. Uncertainty and Measurement Issues", Report to Ofwat, Birmingham, 2003

Europe Economics, Transco price control review. Top down study. Report to Ofgem, 2001.

Fabbri, P., Fraquelli G. And Giandrone, R., "Costs, Technology and Ownership of Gas Distribution in Italy", Managerial and Decision Economics, 21, 2000.

Fraquelli, G. and Erbetta, F., "Aspetti Gestionali e Analisi dell'Efficienza nel Settore della Distribuzione del Gas", Ceris-Cnr working paper, 3, 2002.

Granderson, G. And Linvill, C., "The Impact of Regulation on Productivity Growth: An Application to the Transmission Sector of the Interstate Natural Gas Industry", Journal of Regulatory Economics, 10, 1996.

Griffith, R., Redding, S. and Van Reenen, J., "Mapping the two faces of R&D: productivity growth in a panel of OECD industries", IFS, working paper 02/00, 2000.

Hattori, T. Jamasb, T. Pollitt, M. A comparison of UK and Japanese electricity distribution performance 1985 – 1998: lessons for incentive regulation. DAE Working Paper WP 0212, Cambridge 2003

Kumbhakar, S. and Lovell C.A.K., Stochastic Frontier Analysis, Cambridge University Press, 2000.

Kumbhakar, S. and Vivas, A.L., "Deregulation and Productivity: The Case of Spanish Banks", Journal of Regulatory Economics, 27, 3, 2005.

London Economics et al., PR04 Scope for Efficiency Studies. Final Report to Ofwat, Birmingham, 2003.

London Economics, Efficiency and benchmarking study of the NSW distribution businesses. Report to IPART, 1999.

Meyrick and Associates, Regulation of electric lines businesses. Resetting the price path threshold – comparative option. Report to Commerce Commission, 2003.

Meyrick and Associates, Comparative benchmarking of gas networks in Australia and New Zealand. Report to Commerce Commission, 2004.

Meyrick and Associates, Measuring output and productivity in electricity networks. SSHRC Conference, Vancouver, 2004

Meyrick and Associates, Productivity growth in New Zealand gas distribution networks. Report to Commerce Commission, 2004

O'Mahoney, M., Productivity in the EU, 1979-99, H M Treasury, 2002.

O'Mahoney, M., van Ark, B., Klaar, R., Mason G., Rincon A., Robinson, C., Stuivenwold, E., Stokes, L., Timmer, M.P and Vecchi, M., Performance Analysis of the EU economy From the Point of View of its Industrial Sectors", Report for DG Enterprise, European Commission, Brussels, 2003.

Pacific Economics Group LLC, Submission to the Productivity Commission. Review of gas access regime, 2004.

Romer, P., Advanced Macroeconomics, 2nd edition, McGraw Hill, 2001.

Saal, D., Parker, D., "Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales", *Journal of Regulatory Economics*, 20, 1, 2001.

Saal, D., D. Parker and T. Weyman-Jones, "Determining the Contribution of Technical, Efficiency and Scale Change to Productivity Growth in the Privatized English and Welsh Water and Sewerage Industry: 1985-2000", *Aston Business School,* RP0433, 2004.

Scarpetta, S., Bassanini, A., Pilat, D. and Schreyer, P., "Economic Growth in the OECD Area: Recent Trends and Sectoral Level", Economics Department Working Papers, 248, 2000.

Sickles, R., "Technical Inefficiency and Productive in the US Interstate Natural Gas Pipeline Industry under the Natural Gas Policy Act", CES working paper, 91-6, 1991.

Southern California Gas Company, Opening brief to the Public Utilities Commission of the State of California, U904-G, 2004.

Swinand, G. An empirical examination of the theory and practice of how to set X. London Economics, 2003.

Timmer, M., Ypma, G. and van Ark, B., "IT in the European Union: Driving Productivity Divergence?" Research Memorandum GD-67, Groningen Growth and Development Centre, 2003.

van Ark, B., "The Productivity Problem of the Dutch Economy: Implications for Economic and Social Policies and Business Strategy", Research Memorandum GD-66, Groningen Growth and Development Centre, 2003.