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Calculation of the X-Factor in the 2nd Reference Report of the Bundesnetzagentur

For Energie Baden-Württemberg

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Executive Summary

The Bundesnetzagentur (BNA) has set out a calculation using the "Tornquist index" of the parameter known as the X-factor – the expected rate of productivity growth to be included in price cap formulae for electricity and gas networks in Germany.

In the opening chapters to this report, we set out the economic principles of regulation that should guide the calculation of X-factors for regulated businesses. Starting from appropriate prices, the X-factor should be based on average rates of productivity growth for the industry as a whole. The BNA has applied these principles in using the Tornquist index to calculate its estimate of the X-factor.

However, we also set out an overriding principle, the need for objectivity in regulatory methods, which allows investors to be confident that the regulator is offering a reasonable prospect of cost recovery. The BNA has *not* derived its own estimate objectively, since for no good reason it gives a (more than) three-fold weighting to data for the short period 1993-97, which distorts the overall estimate. At the very least, the BNA should adopt a longer term estimate based on equal weighting. This would reduce the X-factor from 2.54% to 1.63%, using the BNA's own method. The BNA should also consider excluding data for 1993-97 on the grounds that it is an atypical period, which would reduce the X-factor to 0.91%.

The need for objectivity affects the choice of regulatory method and the type of data used for estimating parameters. In the current context, objectivity requires regulators to use long-term data series to estimate productivity growth, so that their estimates are not biased by results in short periods affected by one-off events. The BNA refers to many international estimates of productivity growth. However, these estimates mostly cover short atypical periods. Others suffer from data problems. Overall, they provide no guide to the productivity growth that should be expected of German electricity and gas networks in future.

The BNA used the Tornquist index to calculate productivity growth, but has indicated a preference to switch to a Malmquist index in future. Since both indices give similar estimates of productivity growth, the BNA's intention must be motivated by a desire to use a special feature of the Malmquist index, namely its ability to break down productivity growth into technological change ("frontier shift") and changes in efficiency ("catch-up").

Other European regulators have used "Data Envelopment Analysis" (DEA) based on the Malmquist index to estimate the current *level* of productivity of specific firms (rather than their long-term rate of productivity *growth*). The BNA Report reviews some of these attempts. However, regulators in Norway, the Netherlands and Britain have not used estimates of productivity levels in the way that the BNA suggests. Experience in these and other European regulatory regimes shows that the DEA/Malmquist procedure is not objective. It relies on the subjective or arbitrary choice of method and interpretation of results. Therefore, experience contradicts the impression given by the BNA Report; the DEA/Malmquist procedure is not a conventional, necessary or even a proven method of regulation.

We therefore strongly advise the BNA not to experiment with this approach, but to continue to improve the Tornquist index methods it has adopted in its 2nd Reference Report.

1. Introduction

Energie Baden-Württemberg (EnBW) has asked NERA Economic Consulting to review the 2nd Reference BNA Report on Incentive Regulation[1] issued on 26 January 2006 by the Federal network regulation agency, the Bundesnetzagentur or BNA. This report discusses the method of calculating an "X-factor" for future price controls applying to networks in Germany. This review comments on both the BNA's explanation of this concept and its proposed method of calculating it.

1.1. Definition of an X-Factor

Under the latest German Energy Law (Energiewirtschaftsgestez or EnWG), the BNA is required to impose a system of "incentive regulation" on electricity and gas networks.[2] The agency interprets incentive regulation to include caps on the prices (or total revenues) of each network, where the cap is automatically adjusted from year to year by a formula (instead of being reviewed in detail at the start of each year). The 2nd Reference Report does not lay out the proposed adjustment formula in any detail, but anticipates that it would include automatic adjustment for (at least) two factors:

- the general rise in prices, which increases the costs of a network business; and
- the expected increase in productivity, which decreases the costs of a network business.

Because the original papers on the design of regulatory price caps[3] recognised these two factors, this type of formula is sometimes called "RPI-X" or "CPI-X", where

- "RPI" and "CPI" stand for the rate of change in, respectively, the Retail Price Index or the Consumer Price Index (both measures of general inflation); and
- X stands for the expected rate of growth in productivity.

The choice of the price index is relatively straightforward, compared with the calculation of the X-factor. The BNA's 2nd Reference Report (which we refer to henceforth as "the BNA Report") sets out the BNA's proposed method of calculating an X-factor, i.e. the expected rate of productivity growth to be included in the price cap formula for German gas and electricity networks.

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1 BNA (2006), *2. Referenzbericht Anreizregulierung: Generelle sektorale Produktivitätsentwicklung im Rahmen der Anreizregulierung („2nd Reference BNA Report on Incentive Regulation: General sectoral productivity movements in the context of incentive regulation"),* Bundesnetzagentur, Bonn, 26 January 2006.

2 NERA Economic Consulting is not a law firm and we do not provide any legal advice on the laws and regulations covering network regulation in Germany. All our statements represent the views of economists familiar with the economic principles of network regulation. Legal interpretations may be different and affected parties are advised to seek legal advice.

3 See for example M.E. Beesley and S.C. Littlechild (1989), *The Regulation of Privatized Monopolies in the UK,* RAND Journal of Economics 20, pp 454–72, 1989.

1.2. Outline of the BNA Report and of Our Review

The structure of the BNA Report is as follows:

- The main text of the BNA Report begins with a discussion of the theoretical basis for an X-factor and its role in regulation, in chapter 2;
- The BNA Report then discusses in chapter 3 different methods of calculating the rate of change in productivity and hence the appropriate X-factor, focusing ultimately on the choice between the Tornquist[4] index and the Malmquist index.
- Chapter 4 of the BNA Report sets out the BNA's views of three cases from other countries, Norway, the Netherlands and Britain;[5]
- Finally, in chapter 5, the BNA Report describes the BNA's calculation of the proposed X-factor.

Our review broadly follows this structure, for ease of reference. However, certain parts of the BNA Report appear to indicate how the BNA intends to use indices of productivity (or productivity growth) for regulatory purposes. Although the BNA does not set out its intentions in detail, it states a preference for the Malmquist index, which can only mean that it wishes to collect and to use certain information derived from the Malmquist index to set company-specific (”individual”) X-factors. Although we can only infer this intention from the BNA Report, we have commented occasionally on this type of regulatory method.

To put our comments into context, we begin our review (chapter 2) by describing the purpose of X-factors and the economic principles that apply to every type of network regulation. We then turn our attention to the BNA report and comment on:

- The BNA's general approach to defining X-factors (chapter 3);
- The BNA's interpretation of international comparisons of productivity growth (chapter 4); and
- The BNA's calculation of the X-factor for German network companies (chapter 5).

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4 The name of this index is spelled in different ways by different writers, as Tornquist, Törnquist, Tørnquist, or in variants ending in -qvist. Similarly, both Malmquist and Malmqvist are found in the literature. For this report, we have adopted the Anglophone version of each name, except when quoting from other authors using different versions. The Tornquist index is also known as “the Tornquist-Theil index”.

5 The example in the BNA Report covers electricity distribution networks in England, Wales and Scotland, so this example actually describes a case from *Britain*. At the time, the electricity market for Scotland was separate from that in England/Wales, but the markets have since been combined into one British market.

2. Economic Principles & Methods of Regulation

2.1. Background

The BNA claims that the Malmquist index is theoretically preferable to the Tornquist index as the basis for calculating productivity growth, but it is forced to use the Tornquist index for the moment because it lacks the required data (paragraph 69). The BNA states its intention to switch to the Malmquist index at some time in the future.

The Malmquist and Tornquist indices provide different ways to calculate an index of productivity. For regulatory purposes, Tornquist index number methods have become relatively standard for the various components of outputs and inputs among productivity analysts, so the BNA's stated preference for the Malmquist index is a departure from normal practice.

The Tornquist index calculates an estimate of productivity growth from two separate components: (1) estimated growth in inputs; and (2) estimated growth in outputs. In contrast, the Malmquist index breaks down estimated productivity growth into two different components: (1) the estimated rate of change in a "best practice frontier" and (2) the estimated rate of change in a firm's efficiency relative to that frontier.

The BNA Report refers to the latter breakdown (paras 61-63) and also points out that the Tornquist index does not provide equivalent information (paragraph 65). The BNA Report even claims (paragraph 61) that the Malmquist index provides an "exact" ("exakt", "genaue") breakdown. Such a claim is incorrect, as we explain below, but the BNA's stated preference for the Malmquist index is based on its ability to divide productivity growth between a "frontier shift" (movements in the best practice frontier) and "catch-up" (other changes in efficiency relative to the frontier). This characteristic of the Malmquist index would only be relevant to the choice of method if the BNA expected to use the breakdown for regulatory purposes.

Although the BNA has not said how it would propose to use the different components of the Malmquist index, we note its intention to develop a "general" x-factor for the sector as a whole and also an "individual" x-factor for each company. The BNA seems to imagine therefore that breaking down the Malmquist index would provide a basis for estimating these two x-factors separately. Indeed, we are aware of attempts to carry out precisely this exercise in other countries. However, in practice it is impossible to calculate "general" and "individual" X-factors objectively using the Malmquist index. Attempts to carry out such a calculation will require subjective decisions and assumptions. This approach is therefore inconsistent with the need for transparent and objective regulatory methods to provide incentives for efficient behaviour, as we explain below.

2.2. Objectivity: The Overriding Consideration

Energy networks are characterised by irreversible investment in long-lived assets. To serve the needs of customers, the regulatory regime as a whole must offer investors an incentive to make such investments, knowing that they have a ***reasonable prospect of cost recovery*** over the long term. In this context, "costs" means that the firm's operating expenses, depreciation and a reasonable return on capital (also defined as the cost of capital). The regulatory regime does not have to ***guarantee*** cost recovery, but it must offer the prospect that a reasonably efficient company can recover its costs (i.e. that the regulatory regime will not systematically or arbitrarily prevent cost recovery). To meet this standard, the basis for setting future revenues must be reasonable, meaning that it should use objective, replicable methods and verifiable input data, to minimize the scope for disputes and subjective regulatory decisions.[6]

If these conditions for capital attraction are not met, then regulated firms will still have the short- to medium-term incentive to cut costs offered by the price cap formula, but they will have little or no incentive to make new investments. The firms may be obliged by licence conditions or regulations to meet certain minimum capacity and security of supply standards. However, if investors do not have a reasonable prospect of cost recovery, then either the regulated firms will not invest, or they will run into financial difficulties if they do invest. Neither outcome is efficient or in consumers' interests.

Our discussion of regulatory methods therefore places a high value on objectivity. A method of calculation is objective if the results do not depend upon subjective choices about the choice of input data, the method of calculation or interpretation of results. We note incidentally that section 21a of the German Energy Sector Law (EnWG)[7] obliges the regulator to estimate efficiency targets using methods that are not affected excessively by a small change in a single parameter.[8] Although we cannot offer a legal interpretation of this standard, it seems to be consistent with an economic interpretation of the need for objective regulatory methods.

2.3. Theoretical Basis for the X-Factor

As mentioned above, the typical form of incentive regulation is a combination of price indices, an X-factor and other factors (e.g. adjustments for the volume of demand, new costs imposed on the company, unpredictable costs that are outside the control of the company, and so on). The typical formula for adjusting prices from year to year is as follows:

(1) Price Cap in year t = $P_t = P_{t-1}.(1 + \Delta RPI_t - X + Z_t)$

where: ΔRPI_t is the rate of (retail) price inflation in year t;

X is a fixed factor which represents a target rate of growth in Total Factor Productivity (TFP[9]) defined as the <u>differential</u> between the

[6] These principles are found in a number of eminent sources, including: (1) Bonbright, James C; Danielsen, Albert L; Kamerschen, David R. (1988), *Principles of Public Utility Rates*, 2nd ed. Arlington, Va, Public Utilities Reports; and (2) Phillips, Charles F. (1993), *The Regulation of Public Utilities: Theory and Practice*, 3rd ed. Arlington, Va, Public Utilities Reports

[7] Energiewirtschaftsgesetz 2005.

[8] EnWG 2005, section 21a paragraph (5): „Die Methode zur Ermittlung von Effizienzvorgaben muss so gestaltet sein, dass eine geringfügige Änderung einzelner Parameter der zugrunde gelegten Methode nicht zu einer, insbesonderere im Vergleich zur Bedeutung, überproportionalen Änderung der Vorgaben führt."

[9] Total Factor Productivity (TFP) refers to measures of productivity that take into account all "input factors" (labour, capital, materials, land, etc), as opposed to partial measures such as "labour productivity", which relate outputs to only some inputs.

annual productivity growth in the regulated industry and annual productivity growth in the whole economy;[10] and

Z_t is an adjustment for exogenous unit cost changes, defined as the difference between the effects of the exogenous event on the industry and on economy-wide unit costs.

Between regulatory reviews, this formula updates a price cap from year to year, raising it in line with inflation (RPI), reducing it in line with expected growth in productivity (X) and adding an element for any special increase in costs faced by the industry. The regulated business must then ensure that its actual revenue is less that the amount calculated by applying this price cap to a quantity for that year (Q_t):

(2) Actual Revenue in year t = $R_t \leq P_t.Q_t$ = Allowed Revenue in year t

Internationally, the definition of the quantity for year t used to calculate actual and allowed revenues varies between different formulae (e.g. actual sales in that year, or a fixed quantity for a baseline year, or a mixture of both). However, the calculation of an x-factor is a key element in all such formulae.

Appendix A provides a technical derivation of the formula in equation (1), based on the following propositions:

1. **Appropriate prices:** the price cap regime begins in year 0 with a level of prices (P0) that is appropriate so that the value of total inputs (including a normal return on capital) equals the value of total output for the company, as well as the industry;
2. **Productivity growth, not levels:** the only relevant productivity measure is productivity *growth*, not the *level* of productivity (about which this exposition says nothing); and
3. **Industry average:** it is only the *industry average* productivity growth that mimics the constraints faced by firms in a competitive market.

In discussions on setting the appropriate X-factor, economists generally agree with the theory set out above and with these propositions about the calculation of relevant productivity measures. However, each of these three propositions requires closer examination in a European regulatory context, since previous discussions of the X-factor have often been confused by attempts to ignore them, and we consider each principle further below.

2.3.1. Appropriate Prices

In recent years, various European regulators have introduced new forms of regulation – which may loosely be termed “incentive regulation” – in place of existing methods. For example, Britain privatized its gas industry (in 1986) and its electricity industry (in 1990/91), at the same time replacing government control with profit incentives. The Netherlands replaced a variety of regulatory systems with a new common regime of “CPI-X” regulation,

[10] This differential is equal to the difference between the electricity industry and economy-wide TFP growth rates only if the rates of input price growth are the same for the industry and the nation: i.e., if $dw = dw^N$.

starting in 2000 for electricity networks and 2001 for gas networks. Germany is undergoing a similar transition.

This transition between methods has frequently resulted in a mis-match between existing prices and the prices that would be allowed by the new regime. Different regimes have adopted different ways to deal with this mis-match.

- The British regulatory regimes took 10-15 years to reach a stable agreement on the definition of allowable costs in its gas and electricity networks (although some ambiguity remains); changes in costs have led to large changes in the value of P0 adopted at each regulatory review.
- In the Netherlands, on the other hand, the relevant gas and electricity laws dictate that the regulator must set x-factors for a period of three to five years, thereby ruling out a one-year adjustment (i.e. a change in P0); instead the Dutch regulator had to include the adjustment towards appropriate prices within the X-factor.

In some cases, therefore, discussion of the X-factor has expanded beyond the consideration of productivity growth and has encompassed other adjustments such as (1) the elimination of "excess" rates of return on capital, or (2) a step-change in the costs that the company is allowed to recover. Such adjustments have nothing to do with productivity growth, and do not constitute a relevant consideration in the calculation of an X-factor. However, such discussions have affected the values of X-factors in other regimes, so that the figures seen in those regimes should not be taken as indicative of either expected or achieved growth in productivity. [11]

2.3.2. Productivity *Growth* versus Productivity *Levels*

In practice utility regulators have determined the X-factor by a variety of approaches which fall into two main categories: "level-based" and "growth-based". The first computes the ***X-factor*** as the *indirect* residual result of a comparison between forecasts of needed revenues during a multi year price cap period. The second calculates an X-factor ***directly*** on the basis of a procedure for comparing the rate of change in various firms' productivity.

In the method based on productivity levels, the regulator reviews information from the company to define a yearly revenue requirement (i.e. allowed costs, including a return on capital) for each year of the next price cap period, or just for the end-year of the next price cap period. This forecast may allow for predicted changes in regular expenditures and planned investment, but also incorporates assumed efficiency gains that the company is expected to achieve, based on a comparison of its costs with some "benchmark" level of costs. The resulting ***X-factor*** (which we italicise, to distinguish it from the normal meaning of productivity growth) includes all the factors necessary to make a transition between (1) the *level* of prices in the present year and (2) *level* of prices needed to cover the forecast revenue requirements at the end of the price cap period.

[11] For further discussions on the importance of the correct price level when setting X see Bernstein and Sappington (1999) pages 9, 11, Vogelsang (1999) page 31, Navarro (1996) page 128, Loube, R. (1995), Price cap regulation: problems and solutions, *Land Economics* 71(3):286, 1995, page 288.

As a result, this *X-factor* may indirectly measure the expected rate of productivity growth, being derived from a comparison of two different levels of productivity – the current level and a regulator's assessment of "efficient" operations – but it may contain a number of other adjustments as well.[12]

In practice, outside observers cannot estimate the *level* of productivity at any individual firm, using index number theory (the Malmquist index and the related procedure, Data Envelopment Analysis or DEA), for the following reasons:

§ Index numbers and DEA do not define each company's *level* of efficiency, because they cannot possibly control for all the environmental factors that determine a company's performance;

§ random shocks ("noise") in these unexplained factors can lead to further downwards bias in the "frontier" and hence to a further underestimate of a company's performance;

§ in any case, there is no objective way to convert one observation of the level of productivity into an x-factor; when choosing the period allowed for the required catch-up, it is necessary to have in mind a reasonable target for productivity growth;

The Malmquist index decomposes productivity growth into (1) "technological change" and (2) efficiency "catch up", i.e. the extent to which a firm is moving towards or away from a "frontier" defined by "industry best practice". The BNA Report states a preference for switching from the Tornquist index to the Malmquist index, which must be due to its ability to separate out an estimate of productivity into "technological change" and "catch-up". However, in practice, both the level and the time trend in the "frontier" will be of relatively little significance, because the frontier is defined partly by the extremely values affected by "noise".

In contrast, both Tornquist and Malmquist index numbers can be used to estimate the long-run trend in an industry's productivity *growth*. Over a long period, if the effects of biases due to omitted environmental factors remain constant, the effects of "noise" will average out, so it is possible to estimate the time trend in the index, i.e. the average rate of productivity growth.

2.3.3. Average Industry Productivity Growth

The final proposition underlying price cap regulation is the use of average industry productivity growth as the basis for setting the X-factor for regulated utilities. A number of writers confirm that the purpose of the price cap adjustment formula is to ensure that the constraint of regulated prices mimic the pressures that competition would place on a firm. Bernstein and Sappington state:

> *Price cap regulation is intended to replicate the discipline of competitive market forces. Competitive forces compel firms to realize productivity gains*

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12 This has been a popular method in the UK, the Netherlands and Australia. In Australia, however, a panel of experts is working on a revision of nationwide regulatory practices, noting the unsatisfactory results associated with using forecasts of costs as the basis for a *derived* X-factor.

> *and to pass these gains on to their customers in the form of lower prices, after accounting for unavoidable increases in input prices. Therefore, if all industries in an economy were competitive, output prices in the economy would grow at a rate equal to the difference between the growth rate of input prices and the rate of productivity growth.*
>
> *More generally, the X-factor should reflect the extent to which (1) the regulated industry is capable of increasing its productivity more rapidly than are other sectors of the economy and (2) the prices of inputs employed in the regulated industry grow less rapidly than do the input prices faced by other sectors of the economy.*[13]

General agreement also exists among economists that the relevant measure of productivity should be based on industry rather than firm-specific productivity measures. For example Loube notes the following:

> *Industry productivity growth rates have been estimated using total factor productivity methods. In some cases, price cap proposals have included productivity growth rates for the individual firm instead of the industry rate. However, these proposals are inconsistent with the logic of price cap regulation, where the firm is tested against an industry-wide standard…In theory, the productivity offset measures the difference between the productivity of the telephone industry and the productivity of all industries in the United States.*[14]

These extracts state clearly the need to use an industry-wide standard for setting the X-factor. However, we are aware that discussions with European utility regulators have not always proceeded on this basis and the following sections try to remove some misunderstandings.

2.4. Implications for Regulation

2.4.1. The Competitive Market Standard and "Efficient Costs"

Several commentators have suggested that regulators must strive to set revenues for regulated companies equal to a measure of "efficient costs" (as defined by an "efficiency frontier") because that is the standard imposed by a competitive market. This assertion is not supported by any economic theory of competitive markets.

It is true that competitive markets will eventually drive inefficient firms out of the market. However, at any one time, a market will contain a number of firms operating at different levels of efficiency and earning different rates of return. Economic theory says that prices in a competitive market will reflect "marginal costs", i.e. the cost of the most expensive unit

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[13] Bernstein and Sappington (2000) page 64. For additional discussions on the intention to track efficient costs by X tracking the differences in input price and productivity growth rates between the relevant industry and the economy, see Vogelsang (1999) page 10, Bernstein and Sappington (2000) page 64, Vickers and Yarrow (1989) page 296, Loube (1995) pages 289-290

[14] See: Loube (1995) page 289

produced to satisfy demand. This unit may come from an efficient firm operating in a "difficult" (i.e. expensive) environment, or it may come from an inefficient firm that is operating more expensively than necessary.

Given what we have said above, there is no way to tell how efficient each firm is in practice. All that economists can say is that more efficient firms will earn higher than average rates of return, whilst less efficient firms will earn lower than average rates of return, after allowing for other factors. The rate of return offered to regulated companies is set by reference to the rate offered by the stock market or other sectors, which represents an average rate of return, consistent with average levels of and growth in efficiency. Appendix A showed how the calculation of the X-factor was derived from analysis of overall, or average, conditions in the economy and the industry concerned.

Incidentally, we note that section 21a paragraph (5) of the EnWG 2005 obliges requires the regulator to set efficiency targets for a network operator, or group of network operators, which they can "reach and surpass" using feasible measures which can reasonably be expected of them.[15] We are not lawyers and cannot offer a legal interpretation of these phrases, but the economic interpretation of the ability to "surpass" a target must be that the target is not defined as an efficiency frontier (beyond which no-one can pass). Moreover, an economic interpretation of the phrase "reasonably expected" ("zumutbar") would imply some average or reasonable rate of productivity growth, judged by past experience, rather than an exceptional rate of productivity growth completely divorced from any past experience or objective analysis of what is feasible.

2.4.2. Disallowing "inefficient costs" and encouraging efficiency

In many jurisdictions (particularly in the US), regulators have decided that appropriate prices should not include some costs incurred by a regulated company, because the company incurred them "inefficiently" or "imprudently". The procedure for disallowing such costs provides an incentive for more efficient behaviour in the future, if it is conducted in an objective and transparent manner. That means that the regulator must provide *objective evidence* that the regulated company incurred the costs inefficiently or imprudently, *taking into account the information available to the company at the time when it incurred the cost.*

Such procedures require detailed investigation of the costs involved and their appraisal by stated criteria, so that the regulated company understands clearly what kind of costs to avoid in the future. Otherwise the process will appear opportunistic or arbitrary and will undermine incentives for efficient behaviour. These requirements rule out, for example, disallowing costs on the basis of statistical comparisons of costs in one year (such as the DEA/Malmquist procedure discussed below), because:

- These methods do not control for all the differences between companies, but instead rely on a subjective selection of explanatory factors;

[15] EnWG 2005, section 21a paragraph 5: „Die Effizienzvorgaben müssen sogestaltet und über die Regulierungsperiode verteilt sein, dass der betroffene Netzbetreiber oder die betroffene Gruppe von Netzbetreibern die Vorgaben unter Nutzung der ihm oder ihnen möglichen und zumutbaren Maßnahmen erreichen und übertreffen kann."

- Assessments of costs in any year will not consider the information available at the time when the cost was incurred; and
- Statistical comparisons vary from one application to the next, so the regulator's assessment criteria will not be clear and will not provide incentives for efficient behaviour.

Thus, the process of calculating productivity indices can contribute nothing to a procedure for reviewing costs and disallowing those incurred "inefficiently" or "imprudently".

2.4.3. Additional Performance and "Stretch Factors"

The long-term historical trend rate of growth in productivity represents in most cases an unbiased estimate of expected future productivity growth, the basis for the X-factor. However, regulators often set X-factors that include some allowance for productivity to grow faster in the future than in the past. Such additional factors need to be justified objectively. That means that the future must be different from the past in some objective sense.

For example, if the regulated company is moving from a regime of cost pass-through to a regime of incentive regulation, it might be legitimate to expect an acceleration in productivity growth, due to the stronger incentive to cut costs. Similarly, the effect of privatising a company is often a rapid fall in costs, as the profit motive gives the company a much greater incentive to seek out efficiency savings that the previous system of government controls and targets. In Britain, the effect of privatisation on future productivity growth was no longer a factor in regulatory reviews 10-15 years after privatisation and the effect may have been even more short-lived.[16] These observations also mean that productivity growth observed just after a change in the regulatory regime or just after a privatisation does not provide an unbiased estimate of future expected productivity growth.

Consequently, regulators can objectively justify adding a "stretch factor", over and above the long-term historical trend rate of growth, *only* if the regulated company is demonstrably facing stronger incentives for efficiency than in previous years. In the United States, such "stretch factors" are only ever about 1 percentage point per annum.

In Germany, privatisation is not a relevant factor in the coming regulatory period. Indeed, the privatisations that took place after re-unification of the country may have caused a short-term acceleration of productivity growth, lasting for five to ten years, which biases historical information over that period. The expected rate of productivity growth for the immediate future might therefore have to be estimated without taking into account the period of temporary acceleration in productivity growth after re-unification.

A strengthening of incentives might provide a good reason for adding a stretch factor. However, it is not clear whether the new regulatory regime will create much stronger incentives for efficiency than the regime that went before.

Thus, the case for a stretch factor has yet to be made in Germany.

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16 For the first five years of their existence, the electricity distribution companies of England and Wales were protected from takeover by a Golden Share held by the British government. The full effect of privatisation may have only begun after that Golden Share had expired.

2.5. Conclusions

The derivation of the price cap formula and the definition of the X-factor set out in Appendix A suggests that the appropriate value of X is the difference between productivity growth in the industry to which the regulated company belongs and productivity growth in the economy as a whole. The discussion above has confirmed this finding.

It is important, however, that the normal definition of X-factors, as the expected rate of growth in productivity, should not be confused with other definitions of ***X-factors*** which include other effects. For instance, in the Netherlands, the current values of X used in the CPI-X formulae for electricity and gas distribution networks include not only the expected rate of productivity growth but also an annual price reduction intended to close a gap between revenues and allowable costs. Such values give no guidance as to what rate of productivity growth should be expected in Germany.

It should also be noted that index numbers do not measure the level of productivity, because of a number of data errors and other "noise", so it is not possible to identify "efficient costs". In any case, "efficient costs" are not a relevant standard for regulation of utilities. (Contrary to some statements, prices in competitive markets do not equal "efficient costs".)

Instead, the standard used to define an X-factor is industry average productivity growth. The basis for this standard can be traced back to the theoretical underpinnings for "RPI-X" price caps.

Regulatory decisions frequently include some kind of additional "stretch factor" that increases the rate of reduction in prices above the long-run value of expected productivity growth. Some of these higher values represent informal or subjective methods of regulation, that are not supportive to long-term incentives. However, some "stretch factors" reflect a recognised change in the incentives facing the company, so that it is reasonable to expect the future to differ from the past. In these cases, when an additional "stretch factor" can be justified by a change in the regime, it has usually taken a value around 1 percentage point per annum.

3. Comments on the BNA's Approach

Having set out the principles of economic regulation in the preceding chapters, we can comment on particular phrases which describe the BNA's thinking and which either imply a misunderstanding on the part of the BNA, or which will require careful interpretation in the coming months. These comments are broadly in the order that the phrases are found in the BNA report, although some refer to several such comments or compare comments in different parts of the report.

3.1. Incentive Properties of the X-Factor

The introduction (paragraph (4)) contains a phrase which requires careful interpretation. It says that consideration of productivity growth stems from the intention of encouraging a regulated sector to achieve efficiency gains and to pass them on to customers.[17] A casual reader of this phrase might conclude that the inclusion of the X-factor creates the incentive to achieve efficiency gains, or even that setting a higher X-factor will strengthen the incentive for efficiency gains. Both interpretations of this phrase would be incorrect.

The incentive properties of price caps stem from the fact that they are fixed for some time independently of costs, so that the regulated company can increase its profit by reducing its costs. Price caps therefore harness the profit motive. This incentive to *increase* profits applies regardless of the starting level of the price cap – although as discussed in chapter 2 the level of the price cap must offer a reasonable prospect of cost recovery in the long-run. The inclusion of an X-factor merely ensures that the price cap stays reasonably close to costs during the course of the price cap period.

The inclusion of the X-factor does not in itself increase the incentive for the incentive for the company to reduce its costs, nor does setting a higher X-factor mean that the company has a incentive to (or will actually) achieve lower costs than under a lower X-factor. Such ideas might applicable in the public sector, where officials may have an incentive to spend up to a budget limit, so that setting lower budgets leads to lower spending.[18] However, profit oriented companies have no incentive to spend money, unless the regulatory system rewards them for doing so, and will not regard annual revenues as a budget that must be spent.

Paragraph (15) of the BNA Report suggests that the BNA may have been influenced by this type of public sector thinking. It says that the efficiency target "must give the greatest possible incentive to raise productivity", whilst not setting an excessive challenge.[19] In fact, the efficiency target itself does not give an incentive – rather it is the fixed nature of the price cap that allows the company to increase profits by cutting costs.

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[17] „Die Berücksichtigung der Produktivitätsentwicklung in einem Anreizregulierungssystem ist von dem Willen getragen, die regulierte Branche zur Realisierung von Produktivitätsfortschritten anzuspornen und die sich aus diesen Fortschritten ergebenden Vorteile mit den Konsumenten zu teilen." BNA Report, paragraph (4).

[18] This idea survives in, for instance, the Dutch Electricity Law 1998 and the Gas Law 2000, which both define the X-factor in a price cap as "the discount to promote efficient operations" ("korting ter bevordering van de doelmatige bedrijfsvoering"). However, the x-factor is a not a one-off "discount" (but rather an annual rate of change), and it does not promote efficiency (but rather, allows the price cap to follow the path of costs after allowing for efficiency gains).

[19] „Die Vorgaben müssen so gesetzt warden, dass der Netzbetreiber einen möglichst großen Anreiz hat, Produktivität zu steigern. Gleichzeitig muss der Netzbetreiber nicht überfordert sein." BNA Report, paragraph (15).

These possible misunderstandings about how incentive regulation works are important, since they may lead the BNA to false conclusions about the required methods of setting X-factors and the appropriate values.

3.2. Efficiency Targets

At various points, the BNA seems to have fallen into the trap of believing that the applicable standard for the X-factor is some definition of "efficient costs", or a maximum possible rate of productivity growth, rather than the average industry rate of productivity growth, as discussed in section 2.3.3. Paragraphs (6) and (14) both refer to a desire to set X-factors that ensure that "every possible potential efficiency gain is exhausted".[20] This desire conflicts not only with the principles of price cap regulation, but also with the requirement to set targets which the network operators can "reach and surpass" using "measures that are possible and can reasonably be expected of them", as the BNA recognises in paragraph (15).

The internally consistent method of regulation imposes on regulated companies a target for productivity growth which equals the norm for the industry and in return offers a rate of return comparable with the average returns earned in other sectors. Offering this combination will allow regulated firms attract the capital they need for their investments. Imposing higher-than-average targets for productivity growth, alongside an average rate of return, will make the regulated firms appear unattractive to investors. After all, firms in other sectors that achieve higher-than-average productivity also offer higher-than-average rates of return. The BNA has not suggested (as far as we know) that it will calculate the appropriate prices using a rate of return higher than the industry norm, to compensate for setting an efficiency target that is also higher than the industry norm.

3.3. Misunderstanding of the Malmquist Index

In paragraph (7), the BNA claims that the Malmquist index allows an "exact" (genaue) calculation of the separate contributions of technical progress (Productivitätsfortschritt) and the individual increase in efficiency of each firm. Based on the preceding sections, paragraph (61) rephrases this claim as the statement that an advantage of the Malmquist index lies in its ability to separate "exactly" (exakt) the "Frontier Shift" from the "Catch-Up".

These statements appear to relate to productivity *growth* and do not therefore commit the error of assuming that the Malmquist index can identify the *level* of productivity at any firm. However, the references to the "exact" calculation of the two elements are mistaken.

As we discussed in section 2.3.2, these index numbers are subject to a number of estimation errors, particularly in the calculation of the "efficiency frontier" and its contribution to productivity growth, because of the effects of omitted factors and of random "noise". If it is possible to assume that both effects remain constant over a long period, the breakdown of the trend rate of growth would be unaffected, but such assumptions are difficult to test.

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[20] „...damit sämtliche Produktivitäts- und Effizienzsteigerungspotentiale umfassend ausgeschöpft werden"., paragraph (6) and „...um die vorhandenen Produktivitätssteigerungspotentiale möglichst weitgehend auszuschöpfen....", paragraph (14)..

The reference to the "exact" nature of the index may be drawn from a misunderstanding of the literature on index numbers. Some index numbers are described as "exact" because they have a specific relationship with production functions (i.e. a mathematical model of production methods). However, this term does not mean that the calculations are immune to estimation errors.

3.4. General and Individual X-Factors

In paragraphs (16) and (17), the BNA claims that "in practice" the X-factor is often divided into the general rate of productivity growth for the industry and the specific rate of productivity growth for each company, and that it *must* take both into account when setting the X-factor.

As discussed above and in chapter 2.3.3, the theory of price caps implies that the X-factor, properly defined, should reflect industry average productivity growth, so that companies which raise their productivity faster than average can achieve higher-than-average rates of return. The only theoretical rationale for adding a "stretch factor" is an objectively justified reason to expect a company will increase its productivity faster in the future than the industry achieved on average in the past – because incentives are stronger than in the past.

It is *not* possible to justify a higher X-factor because the company is deemed to be "inefficient" relative to the frontier, because index numbers and the DEA/Malmquist procedure do not provide reliable information on *levels* of productivity. In any case, if it were possible to identify a company as inefficient, there is no objective basis for converting an excess *level* of costs into an annual rate of *change*, without referring to a reasonably expected rate of productivity growth. Regulatory decisions in Europe which seem to have adopted this approach do not, on closer inspection, reveal any objective basis for the final outcome. (See section 4.3.)

3.5. Correction of X-Factors

Paragraphs (32) and (33) refer to the proposal of the Dutch energy regulator, DTe,[21] to recalculate the industry average rate of productivity growth in arrears and to adjust the X-factor retrospectively, or rather to adjust the future revenues of energy networks to allow for the "error" in estimating the actual rate of change in average costs. DTe set out this proposal in Decision 100947-82 of 11 September 2003. In it, DTe proposes to review the performance of the electricity networks in 2006 based on their performance in the period 2003-05, but has yet to carry out this calculation.

In practice, the calculation is likely to involve a number of subjective judgements. DTe has declared its intention to limit the analysis to companies deemed to have been "efficient" at the start of the period, in order to avoid mixing up the rate of "frontier shift" with the rate of "catch-up" by companies that are "inefficient". In fact, as explained earlier, the Malmquist/DEA procedure used by DTe does not identify levels of productivity or divide companies into "efficient" ones and "inefficient" ones.

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[21] DTe is the "Dienst Toezicht Energie", which is now a division of the Dutch Competition Authority (the NMa) which now exercises regulatory powers under the Electricity and Gas Laws. Before July 2005, DTe was the "Dienst uitvoering en Toezicht Energiebeheer" and regulatory powers were vested in the DTe's director-general.

Moreover, there is no basis in theory for resetting the X-factor ex post. In practice, DTe will calculate the observed rate of change in *average costs*, which incorporates not only productivity gains but also cyclical changes in capital costs due to variation in the rate of investment. We cannot say whether the German law would permit an ex post adjustment to the X-factor calculated on this basis, i.e. by reference to factors other than productivity growth.

3.6. Economies of Scale

In paragraph (63) and in "Exkurs 2", the BNA claims that it is necessary or usual to assume constant returns to scale ("konstante Skalenerträge"), when applying the DEA/Malmquist procedure, in order to estimate the division between technological change ("frontier shift") and growth in efficiency ("catch-up") as exactly as possible ("möglichst genau"). Here, the BNA is confusing accuracy with administrative convenience.

Most industries experience either increasing or decreasing economies of scale, meaning that average costs either fall or rise as a firm gets bigger. The BNA actually represents *decreasing* returns to scale (larger firms achieve less output per unit of input) in the diagram in "Exkurs 2", which shows a curved relationship between inputs and outputs. A diagram with *constant* returns to scale would show straight lines, indicating that the ratio of outputs to inputs is the same for small and large companies. In practice, electricity and gas distribution networks are regulated in many countries because they are "natural monopolies", one of whose characteristics is a tendency for *increasing* returns to scale.

If an industry faces increasing or decreasing returns to scale, then assuming constant returns to scale will not produce a more accurate estimate of productivity, but in fact just the reverse. Assuming constant returns to scale in a DEA/Malmquist procedure would be equivalent to assuming that all firms can achieve the same input/output ratio as the firm(s) with the lowest ratio. When there are increasing/decreasing returns to scale, that assumption sets up an unrealistically low target for small/large firms.

Estimating the degree of economies of scale is very difficult and in practice it is impossible to break down productivity growth or the level of productivity into their constituent parts. For this reason, most analyses of productivity do not attempt to estimate economies of scale, but merely measure the observed rate of productivity growth, whatever its source. Regulatory methods based on observed rates of growth in productivity avoid any need to decide whether economies of scale are increasing, decreasing or constant.

The BNA would only need to make such an assumption in order to break down the level or growth rate of productivity into their constituent parts, using a DEA/Malmquist procedure. In that case, the results will be uninformative (for the reasons set out in this paper), and the assumption of constant returns to scale will guarantee that they are inaccurate. The BNA may feel that it is unable to estimate the correct degree of economies of scale and must therefore assume constant returns to scale to avoid disputes over this element of the calculation. However, such a choice is merely a matter of convenience and does not reflect either the theory of index numbers or an accurate estimation method in practice.

3.7. Conclusion

The BNA has not said specifically how it intends to use the different indices to set X-factors. The actual estimation of the rate of growth in a Tornquist index is consistent with the economic theory of price cap (incentive) regulation and with best international practice.

Several phrases in the BNA Report indicate a desire to adopt the DEA/Malmquist procedure used in other regimes in Europe, where regulators use the distinction between technological change ("frontier shift") and growth in efficiency ("catch-up") to set a higher X-factor than average historical trends would indicate. However, such ideas indicate on a misunderstanding of the information provided by the DEA/Malmquist procedure. The application of such methods departs from the principles of price cap regulation, or incentive regulation in general. It will only be possible to apply such methods by making heroic, but highly subjective, assumptions about the estimates of productivity.

4. International Comparisons

In Tabelle 1 in chapter 4 of the BNA Report, the BNA refers to a number of studies of the rate of growth in TFP (Total Factor Productivity, i.e. productivity taking account of all input factors). In paragraph (9), the BNA singles out a study that produced one of the highest estimates of TFP growth – 6.3% – i.e. a 1999 study of electricity distribution networks in England and Wales, by Tilley and Weyman-Jones.[22] Below, we comment on this study in detail, before considering the other studies in Tabelle 1.

Chapter 4 of the BNA Report also discusses some European examples of the use of productivity estimates in regulation. We comment on this discussion below.

4.1. Tilley and Weyman-Jones (1999)

The results emerging from this study are of limited use in setting a target for German network companies, primarily because the eight year (1990-1998) period covered by this study is too short to provide robust estimates of productivity growth, and hence the results are biased by a number of one-off or cyclical effects specific to Britain.

First, this study only covers the immediate period after privatisation of the British network companies, which led to major increase in incentives for efficient operation and a large – but one-off – reduction in costs. German companies will not be subject to such a major change in their incentives in the next few years, so the estimates derived from British companies during this period are not directly applicable.

Second, the study ends in 1998 (or rather in financial year 1997/98), which falls three years into the second price cap period, the first price cap period having lasted from 1990/91 until 1994/95 inclusive. The British regulatory system gave regulated companies a strong incentive to cut costs during the first years of a regulatory period, so that they could capture the benefits for as long as possible. (The Hattori/Jamasb/Pollitt study estimates productivity growth for 1995-1997 to be 10.8% per annum.) However, the rates of cost cutting seen over these short periods were not sustainable over the whole regulatory period. Any estimated productivity growth estimated from the start of one regulatory period (e.g. 1990) to the middle of another regulatory period (e.g. 1998) will overstate the long-term trend, because it includes this cyclical factor.

Third, by inspecting the model that Tilley and Weyman-Jones used to produce this estimate, we found that the authors had defined inputs for the purpose of measuring productivity as follows:

  Operating costs (= turnover – operating profit – depreciation)
+ total network length
+ total transformer capacity

[22] Tilley B and Weyman-Jones TG (1999), *Productivity Growth and Efficiency Change in Electricity Distribution*, presented to a conference of the British Institute of Energy Economics, St John's College Oxford, 20-21 September 1999.

In this model, network length and transformer capacity substitute for a monetary measure of the capital stock. However, this measure of inputs is subject to severe bias over the period of the study (1990-1998), because of two factors:

- None of these measures capture inputs in the form of non-network investments; and
- The trend in operating costs is biased by increasing capitalisation of maintenance and other costs.

During the 1990s, the network companies in England and Wales were investing substantial amounts in "non-operational capital expenditure", which included a number of IT systems designed to increase efficiency and to reduce operating costs. The authors' proposed measure of inputs captures the reduction in operating costs, but not the associated rise in investment, thereby omitting a growing volume of inputs and over-estimating growth in productivity.

The trend in operating costs over this period is also biased by the tendency for the distribution companies to capitalise more types of expenditure as time went on. The companies were able to switch expenditure from operating costs to capital expenditure, because the accounting guidelines in Britain did not tightly define how expenses should be recorded. The companies had an incentive to capitalise certain expenses, because they might then enter the "regulatory asset base" and earn a rate of return (which they did not, if recorded as operating expenditures).

The effect of these changes cannot be measured precisely, but the scale of the effects is shown by later adjustments to the definition of costs needed to put the accounts on a standard or "normalised" basis. In the regulatory review of 1999, at the end of the period covered by the authors, the energy regulator transferred £79.7 million of annual capital expenditure to annual operating costs, out of total "controllable costs" of £1451.9 million for all fourteen distribution companies (including the two in Scotland); the regulator imposed an even bigger adjustment (minus £263.7 million) in relation to the allocation of costs between distribution networks and other businesses.[23] The regulator imposed similar, indeed larger, adjustments in the 2004 review of distribution business costs.

Given these major adjustments to operating costs, it is likely that the estimated trends in efficiency observed by Tilley and Weyman-Jones are biased by ever greater understatement of operating costs, given a false impression that inputs were falling faster (or rising more slowly) than the reality. This would have led to an apparent increase in productivity, because the authors' definition of inputs does not capture the corresponding rise in capital expenditure.

Together, the "post-privatisation" effect and the accounting problems inherent in their cost data mean that the estimate by Tilley and Weyman-Jones is severely biased upwards by data errors and by factors that are not applicable in Germany. Their estimate therefore provides no guidance as to expected future rates of productivity growth among German energy networks.

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[23] Ofgem (1999), *Review of Public Electricity Suppliers 1998-2000, Distribution Price Control Review, Final Proposals,* December 1999, Table 2.4.

4.2. Overview of International Studies

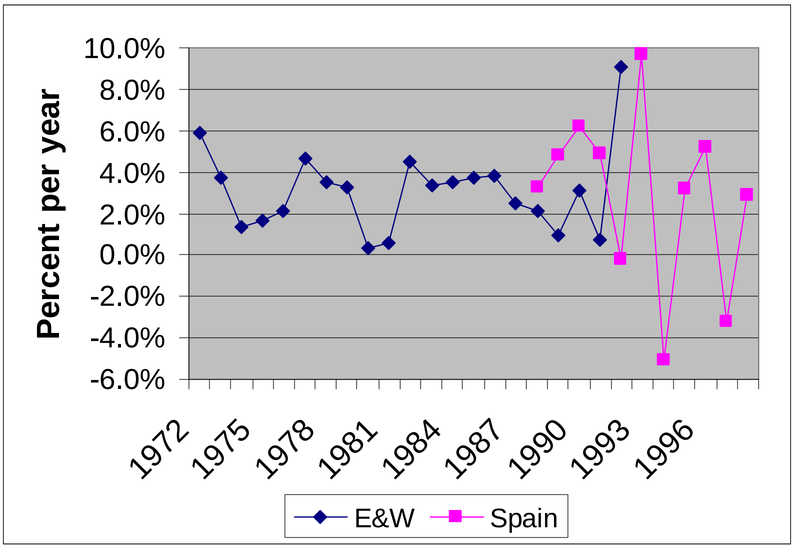
Tabelle 1 on page 21 of the BNA Report (Chapter 4) sets out a number of past estimates of TFP growth in the electricity and gas sectors in various countries around the world. The range of estimates varies between minus 3.7% and 10.8%. We have tracked down the papers to which the BNA was referring, where possible, and we have reviewed their content. We conclude that few of the figures quoted in "Tabelle 1" provide any useful guide to future productivity growth for the companies regulated by the BNA, because of flaws in the analysis, limited data sets, or confusion between productivity growth and other price changes.

Below, we set out the reasons why certain figures quoted in the BNA Report must be discarded.

4.2.1. Short periods

Estimates of productivity growth vary considerably from year to year, because of temporary variations in input/output data and prices. Figure 4.1 shows estimates of annual TFP growth taken from other papers listed in Tabelle 1.[24] It shows how annual figures fluctuate, so that short-term estimates provide no guidance as to future trends.

Figure 4.1
Short-Term Volatility in the Growth of Total Factor Productivity (TFP)



Since shorter term estimates are biased by various forms of "noise", only long-term trends provide any guidance as to what rate to expect in the future. It is therefore necessary to discard estimates taken from short periods, which in practice means any periods less than 10 years. Therefore, the following examples in Tabelle 1 (including the Tilley/Weyman-Jones paper) provide no guidance as to future productivity growth in the German network businesses.

24 Weyman-Jones/Burns (1994) and Arocena et al (2002).

Table 4.1
Results to be Discarded: Short Periods

Author(s)	Publication Date	Study Country	Period	Sector	"TFP per Year"
Tilley, Weyman-Jones	1999	England/Wales	1990-1998	Electricity	6.30%
London Economics	1999	England/Wales	1990-1997	Electricity	3.50%
Hattori, Jamasb, Pollitt	2003	England/Wales	1985-1989	Electricity	2.5%
Hattori, Jamasb, Pollitt	2003	England/Wales	1985-1989	Electricity	-3.7%
Hattori, Jamasb, Pollitt	2003	England/Wales	1990-1994	Electricity	0.9%
Hattori, Jamasb, Pollitt	2003	England/Wales	1995-1997	Electricity	10.8%
Forsund/Kittelsen	1998	Norway	1983-1989	Electricity	1.9%
Bowitz et al. (quoted by E-Control)	2000	Norway	1994-1998	Electricity	2.8%
NVE	2001	Norway	1995-1998	Electricity	2.5%
Ontario Energy Board	1999	Ontario	1993-1997	Electricity	2.1%
London Economics	1999	New Zealand	1994/5-1996/7	Electricity	1.4%
London Economics	1999	USA	1994-1996	Electricity	0.7%

Note that this criterion excludes both the highest value of productivity growth in Tabelle 1 (10.8%) and the lowest value (-3.7%), as well as the lowest positive value (0.7%). This outcome is to be expected, as the shortest periods will include the most random “noise” and produce the widest range of results.

4.2.2. Wide definition of energy sector

A number of studies – like the BNA’s own estimate – estimate TFP growth for the sector as a whole, without trying to separate out the performance of the networks. Including production and trading activities within the study will bias the estimated TFP growth. In general, productivity improves within networks at a different rate from within other activities in the sector. In particular, the productivity of the generation sector experienced rapid technical change during the 1990s, as a result of the widespread introduction of combined cycle gas turbines.

This problem affects the 2002 study of (10-year) TFP growth in the Spanish energy sectors by Arocena, Contin and Huerta. It also affects the 1994 Burns/Weyman-Jones study of efficiency growth in electricity distribution networks for the period 1971-1993. For most of this period, the electricity companies did not separate their costs between network and other business, so the authors used a *share* (20-30%) of total costs as a proxy for network costs.[25] However, a share of total costs for the wider businesses will also be affected by productivity trends in the other businesses, making the final estimate unsound.

Table 4.2
Results to be Discarded: Wide Definition of Sector

Author(s)	Publication Date	Study Country	Period	Sector	"TFP per Year"
Burns, Weyman-Jones	1994	England/Wales	1971-1993	Electricity	2.80%
Arocena, Contin, Huerta	2002	Spain	1987-1997	Electricity	2.9%
Arocena, Contin, Huerta	2002	Spain	1987-1997	Gas	4.1%

[25] Burns P. and Weyman-Jones T.G. (1994a), *The Performance of Electricity Distribution Businesses – England and Wales, 1971-1993*, Centre for the Study of Regulated Industries, Discussion Paper 8, May 1994, p13-14. The same authors report the same data in Burns P. and Weyman-Jones T.G. (1994b), *Regulatory Incentives, Privatisation, and Productivity Growth in UK Electricity Distribution,* Centre for the Study of Regulated Industries, Technical Paper 1, April 1994

4.2.3. Non-productivity factors

The BNA refers in Tabelle 1 to a slide presentation by a Mr Haffner on TFP growth in the Netherlands. However, the figures quoted in the Tabelle are not rates of growth in TFP, but rather rates of change included in price caps for the respective periods.

Strictly speaking, the applicable periods for these price controls are 2001-03 and 2004-06 for electricity networks[26] and 2002-04 and 2005-07 for gas networks.[27] These periods are too short to provide long-term guidance, but in any case the figures in the Tabelle do not represent observations or estimates of productivity growth.

The figures for the earlier periods (2001-03 and 2002-04) represent a compromise agreed between DTe and the respective industries, after DTe had tried to impose higher X-factors but had provoked a large number of appeals against its decisions. The figures are encapsulated in an "Agreement" (overeenkomst) for each sector and were only later confirmed in a decision (besluit) of the DTe.

The figures for the later periods (2004-06 and 2005-07) are only estimates of the actual outturn, since the actual data for the periods is not yet available. The agreements with the respective industries incorporated different figures for different companies, but underlying them was a "generic" rate of productivity growth of 1.5% per annum for electricity networks and 1.0% per annum for gas networks. Rates for individual companies varied considerably in this later period – 1.3% to 6.3% for electricity networks and -2.0% to 7.0% for gas networks. However, these figures do not represent a forecast rate of productivity growth.

When DT e calculated X-factors for the networks, it was arranging a transition from tariffs calculated on a company-specific basis at the start of the period (2000 or 2001) to tariffs calculated on a common basis at the end of the period (2006 or 2007). In some cases, the transition involved the elimination of high/low rates of return (above/below the estimated cost of capital). The overall rate of change in the Netherlands therefore reflects a change in regulatory systems and accounting rules, as well as forecast or observed productivity growth. These Dutch figures therefore offer the BNA no useful information about the productivity growth that should be expected of German energy networks.

Table 4.3
Results to be Discarded: Non-Productivity Factors

Author(s)	Publication Date	Study Country	Period	Sector	"TFP per Year"
Haffner	2005	Netherlands	2001-2003	Electricity	3.2%
Haffner	2005	Netherlands	2001-2003	Gas	3.8%
Haffner	2005	Netherlands	2004-2006	Electricity	2.8%
Haffner	2005	Netherlands	2004-2006	Gas	3.7%

[26] DTe (2003a), "Overeenkomst regulering nettarieven electriciteit (2001-2006)", 26 May 2003.

[27] DTe (2003b), "Overeenkomst Regulering Transporttarieven Gas", 3 November 2003

4.2.4. Other reasons

The table on page 21 of the BNA report also refers to a Competition Commission study of 2002, concerning Northern Ireland, which gives a figure of 3.1% per annum productivity growth over the period 1971-1994. We were unable to identify any such study, but did find a reference to that rate of growth over that period for electricity companies in England and Wales in a 1997 report on Northern Ireland Electricity issued by the Monopolies and Mergers Commission (MMC, the predecessor of the Competition Commission).[28]

The MMC says that productivity growth accelerated in years after privatisation (1990-1994) to 5.2%, which implies an average rate in the period 1971-1990 – years unaffected by the stronger incentives created by privatisation – of only 2.7%. Even this figure seems to include not just network businesses but also the employees of the supply (retail) businesses of these companies. The list of inputs is also incomplete: although it includes the number of employees, total circuit length and transformer capacity, it omits inputs such as materials and investments in the quality of supply. This number is therefore unreliable as an estimate of long-run productivity growth.

We were also unable to identify the study listed in Tabelle 1 as "London Economics 1994" and covering "Australia" for the period 1981/82-1993/94. The closest we could find was a 1999 study by London Economics of electricity distribution networks in New South Wales.[29] We were therefore unable to check the study mentioned, but we note the following extract from the 1999 study:

> *"To form a consistent monetary capital stock measure across the sample was outside the scope of this study. At a minimum would have required the following information from the NSW distributors and all other distributors in the sample:*
>
> - *historic cost asset values from at least 20 years ago;*
> - *any asset retirements for each year until the present; and*
> - *capital expenditures for each year until the present.*
>
> *We were advised early on that this information was not readily available and that such an exercise, while in theory being possible, was not within the scope of the current study."*[30]

London Economics was therefore forced to use other data to estimate the inputs of capital stock for the companies. However, ease of collection is not a reason for choosing inappropriate data to measure inputs (or outputs). This admission merely means that the rate of productivity growth was not properly estimated in the 1999 study.

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28 Monopolies and Mergers Commission (1997), Northern Ireland Electricity, March 1997, p322.

29 London Economics (1999), *Efficiency and Benchmarking Study of the NSW Distribution Businesses*, Research Paper No. 13, Sydney, prepared by London Economics for the Independent Pricing and Regulatory Tribunal (IPART), New South Wales, February 1999. Even this study does not refer to any earlier one by the same company.

30 London Economics (1999), page 36.

If the authors of this 1999 study were unable to access suitable data, it seems to us very unlikely that a 1994 study by the same organisation could have obtained suitable data for the earlier period. The results from this study (assuming it can be identified) are therefore unlikely to be sound.

Table 4.4
Results to be Discarded: Other Reasons

Author(s)	Publication Date	Study Country	Period	Sector	"TFP per Year"
Competition Commission	2002	Northern Ireland	1971-1994	Electricity	3.1%
London Economics	1994	Australia	1982-1994	Electricity	3.6%

4.2.5. Summary of Review of International Studies

Few if any of the studies listed in Tabelle 1 offer any guidance as to the rates of productivity growth that are "possible and reasonable" (möglich und zumutbar) for German network companies.

Nearly all the studies cover a period that is too short to provide any indication of expected future productivity growth, because the results are biased by one-off effects like privatisation, cyclical effects like regulatory periods, or random effects like the "noise" shown in Appendix B. Moreover, many of the studies suffer from severe data problems, including mis-specification in input data (particularly the capital stock), omission of key inputs and inclusion of non-network activities. The Dutch figures quoted in Tabelle 1 do not even refer to actual rates of productivity growth, but rather to a combination of forecast productivity growth and price adjustments intended to eliminate excess profits.

We note that the BNA refers to studies undertaken by one of the authors of this report, which give a long-term estimate of productivity growth in US electricity networks – before deducting any allowance for productivity growth in the economy as a whole – of 1.86% over 20 years. (The 10-year figure of 2.08% is used to check whether there is any significant break in the trend.) We stand by this estimate as having been conducted in accordance with the underlying theory and according to the most demanding standards for data collection and processing.

4.3. Selected Examples of International Applications

The BNA Report refers to recent regulatory decisions in Norway, the Netherlands and "England/Wales" (or more accurately, Britain). The BNA's review of this experience prompts the following comments.

4.3.1. Norway

The study of Norwegian electricity distribution covers a relatively short period, 1983-1989. According to the BNA, the authors of the study asserted that the period was "representative", because it was not affected by extra-ordinary events or the introduction of regulatory targets (i.e. stronger incentives for efficiency) in 1990. There is no way to be sure whether productivity growth in this short period was affected by temporary factors.

In any case, the result of the study was an estimate of annual productivity growth of 1.5%-2.0% (although Tabelle 1 reports a figure of 1.9% for a study of Norway covering the same period). The X-factor that NVE finally adopted was 1.5%.

The BNA does not report any "individual" X-factors for Norwegian distribution networks. In practice, NVE at first limited these "individual" factors to 0%-3% per annum, awarding each company a factor within this range and proportional to the results of the DEA/Malmquist procedure.[31] The result was a target that required network companies to eliminate 38% of their "estimated inefficiency" within five years – another arbitrary method of applying the DEA/Malmquist procedure.

NVE may have chosen deliberately to limit the impact of such procedures on individual companies, due to concern over the objectivity of the method. A paper published by NVE around this time sets out the following position:

> *"NVE's main task as the monopoly regulator is to make sure that transmission tariffs of electricity at all times reflect the cost of the efficient operation and maintenance of the networks and their investments. Efficiency is a key concept in this respect. Determining which network companies are efficient and which are not is a very complicated task. In theory, NVE could differentiate the permitted rate of return according to the individual company's efficiency, as measured by NVE.* ***The problem here is that there is no method of measuring efficiency that is generally accepted as fair, open and understandable.*** *Defining the term efficient is especially difficult in the Norwegian electricity sector. The network companies all differ in size, structure and geographical location and surroundings. The demographic catchment areas also vary greatly.* ***A mere comparison of the companies' cost levels and cost structures will therefore often produce a misleading picture of their individual efficiency****. From NVE's point of view, the problem is one of information deficiency: the network companies all have better insight into their own potential for efficiency improvements and cost reductions than NVE does."*[32] *(emphasis added)*

We agree with this analysis of the problem facing regulators.

NVE has used the DEA/Malmquist procedure to determine a cost target for each electricity network in two periods: 1998-2001 and 2002-06. However, it would be a mistake to regard this general rule as a fully specified regulatory system. NVE's decisions on the second set of X-factors prompted a lot of complaints (i.e. appeals) from network companies. During the period 2002-06, some companies received special revenue allowances to cover costs that the DEA/Malmquist analysis had failed to recognise as necessary. Even now, in the final year of the regulatory period, some complaints remain unresolved, despite continuing attempts to revise and update the analysis.

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[31] The following description of Norwegian regulatory methods derives from the experience of the authors and from personal communication with the officers responsible for network regulation at NVE.

[32] Gresto K. (undated), *Incentive-based regulation of electricity monopolies in Norway - background, principles and directives, implementation and control system*, Norwegian Water Resources and Energy Administration, Oslo, Norway.

In practice, therefore, NVE's DEA/Malmquist analysis has only defined X-factors for network companies that were prepared to accept the resulting revenues (presumably because they were sufficient to cover their costs and to allow a reasonable return), but has prompted long-lasting disputes with companies whose position is not adequately represented. NVE has not avoided the need to give special cost allowances to some networks and it has proven impossible so far for NVE to resolve some disputes over its methodology. These problems derive from the lack of objectivity in the DEA/Malmquist procedure and its inability to identify any individual company's level of productivity.

4.3.2. The Netherlands

The BNA Report describes in paragraphs (80) to (83) the attempt by the DTe to calculate X-factors using a DEA/Malmquist procedure, but does not accurately describe how this attempt at analysis resulted in a large number of appeals and had to be replaced with new X-factors that emerged from a ***negotiation*** with the industry.

In paragraph (82), the BNA Report states incorrectly that the maximum X-factor of 8% per annum applied to a six-year plan to reach the "efficient" level of costs. In fact, this cap applied to the DTe's original proposals, issued in 2000, that required companies to reach an estimated level of "efficient" costs within *three* years (i.e. from 2000 to 2003).[33] The DTe press release issued at that time of the draft decision in September 2000 says that the average reduction in tariffs for efficiency arising from that decision was 5.9% per annum, although the figure for some companies was as high as 9% per annum.

The companies concerned lodged a series of appeals against these X-factor decisions, and the related tariff decisions. In February 2002, i.e. over a year later, the court of appeal for business affairs, the *College van Beroep voor het bedrijfsleven* (CBb), issued its judgement on one of these appeals.[34] In that judgement, the CBb decided that the law did not permit DTe to set different X-factors for different networks, but only one X-factor for each type of activity.[35] Following the CBb decision, the Dutch Government amended the legal framework so that DTe had the power to set different X-factors. However, DTe recognised that its proposals were likely to face opposition on a number of technical and legal grounds, and so entered into negotiation with the industry over the definition of X-factors.

A settlement for the period 2001-06 – the six-year period mentioned by the BNA – emerged another year later, in the form of an "Agreement on Electricity Network Tariffs" that DTe negotiated with the industry in May 2003.[36] That agreement set X-factors of 3.2% for all networks in the period 2001-03 and of 1.3%-7.2%, depending on the network, in the period

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[33] The cap is mentioned in each of DTe's decisions on X-factors for individual networks, dated 22 September 2000, e.g. decision 00-053,para 89.

[34] CBb decision No AWB01/623 18050 of 6 February 2002.

[35] The decision related to an appeal on behalf of a retail supply business, but the same principles applied to network businesses.

[36] *Overeenkomst Regulering Nettarieven Elektriciteit (2001-2006)*, 26 May 2003, available from the DTe website.

2004-06. A similar agreement on gas network tariffs for the period 2002-07 followed in November 2003.[37]

This experience shows that converting DEA/Malmquist estimates of productivity levels into annual growth rates was not a simple process and involved a number of arbitrary decisions. At first, DTe tried to use the DEA/Malmquist to define the level of "efficient costs" that companies should achieve within *three* years. Later, the DTe-industry agreements used updated results from a similar DEA/Malmquist procedure to set the rate of tariff reduction over *six* years. The conversion of DEA/Malmquist into X-factors is always subject to this arbitrary choice of the "catch-up" period. The process followed in the Netherlands sheds no light on principles that might be used to define it. Moreover, the fact that the settlement emerged from a ***negotiation*** also means that DTe's DEA/Malmquist procedure was not a key determinant of the outcomes, contrary to the BNA's assertion in paragraph (85).

Paragraphs (84) and (85) report the average ***X-factors*** negotiated by DTe. However, as indicated by our italicisation of the term, these ***X-factors*** do **not** represent an estimate of productivity growth alone. Under Dutch law,[38] DTe was required to set electricity network tariffs for 2000 "on the same basis" as in 1996. The DTe-industry agreements show that DTe believed tariffs in 2000 were too high relative to the allowable costs of each company. Therefore, the condition of "appropriate prices" (see section 2.3.1) did not apply. Since the respective laws only allow DTe to set ***X-factors*** for periods of three to five years,[39] DTe was not able to impose immediate adjustments (changes in P0).

Hence, the Dutch network ***X-factors*** of 2000-06 incorporate a transition from one set of tariffs (based on a 1996 definition of costs) to another set of tariffs (based on DTe's own forecast of allowable costs in 2006). For many of the affected network companies, this transition required the elimination of returns above the allowed level. The ***X-factors*** adopted in the Netherlands therefore include a reduction in profits, as well as the rate of expected productivity growth, and offer no guidance as to the rate of productivity growth that should be expected of electricity and gas networks in Germany.

Paragraph (83) reports some estimates of productivity growth used in the Netherlands. However, each estimate covers a two year period, which is too short to provide useful evidence of trends or expected rates of productivity growth. Neither estimate therefore provides any guidance was to what rate is possible or should be expected of German network companies.[40]

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[37] *Overeenkomst Regulering Transporttarieven Gas*, 3 November 2003, available from the DTe website.

[38] Article IV of the 1999 law amending the Electricity Law 1998 ("Wet van 3 juni 1999 tot wijziging van de Elektriciteitswet 1998 ten behoeve van het stellen van nadere regels ten aanzien van het netbeheer en de levering van elektriciteit aan beschermde afnemers").

[39] Gas Law 2000, articles 81a and 81b; Electricity Law 1998, articles 41a and 41b.

[40] For companies that DTe believed to be already efficient in 2000, DTe applied X-factors of 2.0% per annum for 2001-03 and 1.5% per annum for 2004-06. These figures represent DTe's estimate of "frontier shift", in effect a rate of productivity growth that does not include any "catch-up". However, DTe's estimate is not directly comparable with a long-term industry average rate of productivity growth.

4.3.3. England/Wales

Paragraph (88) refers to a study by CEPA into the past and future productivity growth of electricity distribution networks in Britain (i.e. England/Wales/Scotland). It reports CEPA's estimate of annual growth in productivity between 1991 and 2001 as 4.2%, and CEPA's forecast of annual growth in productivity as 1.4%-3.4%.[41] We have commented previously on this study and its shortcomings.[42] The key points of relevance to German energy networks are:

§ The methods used by CEPA to estimate productivity growth did not follow the standard prescriptions derived from the theory of index numbers. The effect of these deviations from the standard method is hard to estimate.

§ CEPA noted that the definition of distribution business costs changed substantially in the year 2000/01, due to a change in accounting standards adopted by the regulator. CEPA had to make subjective adjustments for this effect. Although CEPA reported a figure of 4.2% for the period 1991/92-2001/02 (sic), the figure for the same period ***excluding 2000/01*** is only 2.9%.[43]

§ The period 1991/92-2001/02 includes the immediate post-privatisation era. Therefore, the observed rates of productivity growth include the "catch-up" associated with stronger incentives because of (1) the replacement of cost pass-through with price cap regulation ***and*** (2) privatisation and introduction of the profit motive. CEPA's range of forecast productivity growth (1.4%-3.4% per annum) is relatively wide, since there is no real basis for separating out the "privatisation effect" from underlying trends.

German networks will not experience the effect of privatisation in the coming years and some are not coming to incentive regulation from a regime of cost pass-through. Therefore, German network companies cannot be expected to experience the same strengthening of incentives, or to achieve the same degree of "catch-up" as electricity networks in Britain.

4.4. United States

The BNA Report does not contain any experience from outside Europe. The selection of results in Table 4.5 provides some indication of the level of X-factors actually used in price cap plans for gas distribution networks in the United States. These values are somewhat lower than the figures which the BNA quotes.

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41 CEPA (2003), ***Productivity Improvements In Distribution Network Operators***, Cambridge Economic Policy Associates Ltd, November 2003

42 Makholm J.D. and Shuttleworth G., (2003), *A Critique of CEPA's Report on "Productivity Improvements in Distribution Network Operators", A Report for EDF Energy,* NERA, London, 16 December 2003.

43 CEPA (2003), Figures 3 and 7. Estimates refer to the volume adjusted Compound Annual Growth Rate ("CAGR") in Total Factor Productivity (TFP).

Table 4.5
Gas Distribution X-Factors in the United States

Company	Jurisdiction	Timeframe	X Factor	Source
San Diego Gas & Electric	California	1994-1999	1.50%	California Public Utilities Commission (CPUC) D.94-08-023, August 3, 1994
San Diego Gas & Electric	California	2000-2002	1.08%, 1.23%, 1.38%	CPUC D.99-05-030, May 13, 1999
Boston Gas	Massachusetts	1996-2001	1.5%	Massachusetts Department of Public Utilities, D. 96-50-C, May 16, 1997
Southern California Gas	California	1998-2002	2.1%, 2.2%, 2.3%, 2.4%, 2.5%	CPUC D.97-07-054, July 16, 1997

4.5. Conclusion

The review of international studies and experience in Chapter 4 of the BNA Report is selective and partial. It contains errors of fact or presentation, which give a misleading impression of the role that the DEA/Malmquist index has played in recent regulatory decisions. It also reports short-term estimates of productivity growth, which are distorted by one-off events, or *X-factors* that incorporate adjustments to appropriate prices (elimination of excess profits) as well as productivity growth. The survey contains no examples of the procedures used in the United States, where regulatory procedures demand a high degree of rigour in analysis and objectivity in decision-making.

The experience described in Chapter 4 of the BNA Report therefore provides no guidance as to the rates of productivity growth that are possible for, or can be expected of, German energy networks.

5. BNA Calculation of Productivity Growth

Chapter 5 of the BNA Report describes a method of calculating productivity growth for the energy sector and for the Germany economy as a whole. The decision to calculate both rates of growth is consistent with the formula developed on the basis of economic theory and set out in Appendix A, equation (4). However, we have some concerns about the method of calculation adopted by the BNA.

5.1. Data and Method

EnBW sent us the data that the BNA used to calculate productivity growth and we found details of a previous study by WIK, including the method that WIK used. In the time available, we were unable to replicate the BNA's calculation using the WIK method, because of errors in the BNA data set (which the BNA later corrected) and also perhaps because the BNA used a slightly different method from WIK. (The BNA does not give full details of its method in the BNA Report.)

However, we were not asked to audit the BNA's method and did not fully review the reasons for our inability to replicate the calculation; we merely note that our difficulty in doing so should perhaps be a concern.

The BNA has used data for different definitions of the energy sector. The measure of output includes production, trade and corporate activities (Vertrieb), in addition to the networks for which the measure of productivity growth is required (paragraph (94)). Producer prices used for the energy sector cover electricity and gas, but also district heating and water (paragraph (96)), whereas the data series for the number of hours of labour excludes district heating (paragraph (98)).

These differences in definition may have been imposed by the availability of data, but have effects that are unquantifiable and should lead to the results being treated with care.

5.2. Definition of Outputs

The BNA defined the output of the energy sector and the German economy in terms of "Produktionswert", which we translate as total sales revenue. In paragraph (109), the BNA contrasts the use of this value with the use of "Bruttowertschöpfung", which we translate as gross value added. However, both measures of output are ultimately driven by the monetary value of sales.

Just as the measurement of "social welfare" depends on examining quantities (not prices, which are important for the secondary determination of surpluses and rents), productivity is defined as the comparison of physical output quantities to physical input quantities. Prices of either inputs or outputs are an irrelevant theoretical consideration.

There may be some industries where a suitably deflated monetary value measures outputs (because the output is homogenous and prices are known with certainty). However, in a capital intensive network business offering multiple services at complex tariffs, the measure of real output would be better defined by quantities of connections, capacity, line lengths and similar measures.

It is also possible that monetary values (calculated and deflated with due care) are the only available basis for estimating quantities, as in the case of perpetual inventory capital stock methods for measuring capital inputs (i.e. rather than measuring tonnes of steel embodied in capital equipment). However, the use of monetary values is only a last resort when looking for the information on quantities, on which productivity depends.

5.3. Interpretation of Results by Period

On pages 30 and 31, the BNA Report summarises the results of the BNA's calculations in two tables, one showing the rates of productivity growth for the German economy and the German energy sector, and one showing rates of increase in producer prices on the same basis. As per equation (4) in section A.1, the BNA defines the appropriate X-factor as:

$$X = [dTFP_{energy} - dTFP_{economy}] + [dw_{economy} - dw_{energy}]$$

Where $dTFP_i$ refers to the rate of growth in total factor productivity for sector i; and

dw_i refers to the rate of change in producer prices for sector i

The BNA reports the results of its calculations for different periods starting after or ending before the year 1992, when reunification affected the collection of statistics and led to a step change in reported numbers (paragraph (107)). The BNA then calculates its proposed value of X from data for two periods: 1977-91 and 1993-97. Table 5.1 shows the BNA's reported results and the calculation based on the final two columns.

Table 5.1
BNA Results and Calculation of TFP Growth

Start Year End Year		1977 1997	1992 1997	1977 1991	1993 1997	Weighted Average
Number of Years		21	6	15	5	
Productivity Growth	Economy	0.43%	-2.02%	1.40%	0.07%	
	Energy Sector	2.19%	3.26%	1.76%	4.16%	
	Differential	1.76%	5.28%	0.36%	4.09%	
	Weighting	0	0	**1**	**1**	
	Weighted Diff	0.00%	0.00%	0.36%	4.09%	2.23%
Input Price Inflation	Economy	2.09%	0.59%	2.69%	0.44%	
	Energy Sector	1.60%	0.26%	2.14%	0.36%	
	Differential	0.49%	0.33%	0.55%	0.08%	
	Weighting	0	0	**1**	**1**	
	Weighted Diff	0.00%	0.00%	0.55%	0.08%	0.32%
Total X-Factor		2.25%	5.61%	0.91%	4.17%	2.54%

The shaded rows show the weighting applied to each column in the final result, and the resulting weighted averages. The BNA ignored the data in the first two columns (1977-97 and 1992-97) and hence those columns have a zero weight. The BNA used only the data in the last two columns (1977-91 and 1993-97) and gave each column an equal weighting, here shown as a weight of one. The weighted average X-factor is 2.54% as reported in paragraph (124).

This approach is not, however, a robust way to estimate the trend rate of productivity growth that one might expect in the future. The BNA acknowledges in paragraph (118) that its approach awards a triple weighting to the data for 1993-97, because the data from this five year period has equal weighting with data from the 15 year period 1977-91. There is no reason to place so much greater emphasis on any short period like this and we do not know of any international precedent for giving some years a much greater weight than others.

The BNA claims that the more recent data are more representative of current conditions. In fact, if the evidence from Britain shows anything useful, it shows that the effect on productivity growth of privatisation and other major changes in incentives can persist for five or more years after the event. The figures for 1993-1997 are therefore likely to have been affected by the major changes caused by reunification and privatisation of utilities in the former East Germany – something that will not affect expected productivity growth in the coming years.

Table 5.2 shows other, less biased, estimates of total factor productivity growth, using a more representative approach, i.e. weighting by time. The figure for 1977-1997 is 2.25%, as before, but this period includes the break in data series in 1992. The final column therefore shows the effect of weighting the separate series for 1977-91 and 1993-97 (third and fourth columns) by the number of observations in each. The number of observations in each series is 14 and 4 annual growth rates, derived from 15 and 5 years, so the decision to weight each period equally gives the shorter period a more-than-three-fold weighting. Weighting in proportion to time reduces the estimate of X to 1.63%.

Table 5.2
Time-Weighted Calculation of TFP Growth

Start Year **End Year**		**1977** **1997**	**1992** **1997**	**1977** **1991**	**1993** **1997**	**Weighted** **Average**
Number of Years		21	6	15	5	
Productivity Growth	Economy	0.43%	-2.02%	1.40%	0.07%	
	Energy Sector	2.19%	3.26%	1.76%	4.16%	
	Differential	1.76%	5.28%	0.36%	4.09%	
	Weighting	0	0	**14**	**4**	
	Weighted Diff	0.00%	0.00%	5.04%	16.36%	1.19%
Input Price Inflation	Economy	2.09%	0.59%	2.69%	0.44%	
	Energy Sector	1.60%	0.26%	2.14%	0.36%	
	Differential	0.49%	0.33%	0.55%	0.08%	
	Weighting	0	0	**14**	**4**	
	Weighted Diff	0.00%	0.00%	7.70%	0.32%	0.45%
Total X-Factor		2.25%	5.61%	0.91%	4.17%	1.63%

It would be possible to argue that the period 1993-1997 is so atypical that it should be excluded altogether – not least because the period shows very different figures from previous years for productivity growth in *both* the energy sector *and* the economy. According to the BNA's own estimates in Table 5.2, re-unification had the effect of slowing productivity growth in the economy as a whole (from 1.40% to 0.07%) and accelerating productivity growth in the energy sector (from 1.76% to 4.16%). Neither of these effects can be expected to apply in the coming years.

After excluding both 1992 and the period 1993-1997, on the grounds that both were distorted by reunification, the remaining years (1977-91) produce an estimate of the X-factor of 0.91%.

The BNA might feel that the estimate would benefit from using data from more recent years than 1991, whilst noting the data problems with 1992. Data from the period 1993-2005 might provide a stable estimate of productivity growth but it would be necessary to check for evidence of a break in the trends within this period. Appendix B shows the short-term variation in efficiency indices for individual companies, even in a painstaking and well structured estimate of productivity growth. The "noise" caused by this variation does not show any particular differences between different periods. However, whenever it seems likely that different sub-periods exhibit different trend rates of productivity growth because of factors that are unlikely to recur, those periods should be excluded from an estimate of future productivity growth.

5.4. Conclusion

We have some concerns about the data used by the BNA and were not able to replicate the BNA's calculation. However, even if the calculations prove to be accurate, the BNA has distorted the results by subjectively deciding to give excessive weight to a short period which is, if anything, less representative of the future. The period 1993-97 will have been affected by the reunification of Germany, an event that will not recur or be mimicked by any event in the next few years. Giving this period a "(more-than-)three-fold" weighting relative to earlier, more stable periods, cannot be justified.

Even giving an equal weight to each of the years in the series (except 1992, where the data problems are insurmountable) reduces X to 1.63%; omitting all years since 1992 would reduce it further to 0.91%. Although our concerns about the data and method mean that we cannot endorse these estimates, the BNA's choice of weighting seems unjustifiable to us. We conclude that these lower figures, produced with a more equal weighting of years, give a better indication of the future productivity growth that is to be expected (zumutbar), on the basis of the BNA's data and method.

6. Conclusion

In the opening chapters to this report, we set out the economic principles of regulation that should guide the calculation of X-factors for regulated businesses. Starting from appropriate prices, the X-factor should be based on average rates of productivity growth for the industry as a whole. The BNA has applied these principles in using the Tornquist(-Theil) index to calculate its estimate of the X-factor.

However, we also set out an overriding principle, the need for objectivity in regulatory methods, which enables investors to be confident that the regulator is offering a reasonable prospect of cost recovery. This need affects the choice of regulatory method and the type of data used for estimating parameters. In particular, it implies that regulators should use long-term data series in order to estimate productivity growth, so that their estimates are not biased by the choice of short periods affected by one-off events. The BNA has not applied this principle effectively, since it gives a (more than) three-fold weighting to data for 1993-97, which distorts the overall estimate. At the very least, the BNA should adopt a longer term estimate based on equal weighting. This would reduce the X-factor from 2.54% to 1.63%, using the BNA's method. The BNA should also consider excluding data for 1993-97 on the grounds that it is an atypical period, which would reduce the X-factor to 0.91%.

The other aspect of objectivity requires the use of standard methods whose results do not depend largely on subjective judgements. Theory supports the use of the Tornquist index for estimating growth in productivity, as the basis for setting the X-factor. In the 2nd Reference Report, the BNA has adopted this standard approach, although the choice of data sources departs from good practice in several areas.

The BNA has indicated a preference for switching to the Malmquist index. Since the Tornquist and Malmquist indices produce similar estimates of productivity growth, a switch to the Malmquist index would only be useful, if the BNA planned to make use of the DEA/Malmquist procedure for distinguishing between technological change (shifts in the "frontier") and changes in efficiency ("catch-up"). European regulators have occasionally used the procedure to estimate the level of productivity of specific companies, although the procedure is by no means standard. Unfortunately, it does not provide any objective basis for estimating either the "efficient" level of costs or the "required" level of catch-up for a single firm.

Experience in other European regulatory regimes confirms the subjective or arbitrary nature of such analysis and contradicts the impression given by the BNA Report, that such an approach is conventional, necessary or a proven method of regulation. We have reviewed the experience cited by the BNA and have found that regulators have been unable to use the results of a DEA/Malmquist procedure without making a number of arbitrary choices and assumptions, over the form of the model, the source of data, the duration of the "catch-up" period required to reach the cost target, and the adjustments for special factors not included in the DEA/Malmquist procedure. In practice, therefore, although regulators have referred to the results of DEA/Malmquist procedures in their decisions, the actual results have played a small role in determining the final outcomes. Instead, the decisions on allowed revenues either emerged from a process of negotiation (Netherlands) or from more detailed consideration of each company's actual costs (Britain). In Norway, the regulator has tried to apply mechanistically some DEA/Malmquist results, but had to make individual adjustments for particular companies and has *still* not resolved some of the disputes arising over the X-factor for the 2002-06 regulatory period.

In this report, therefore, we have explained why adopting a regulatory policy based on assessing the *level* of productivity would lead to many subjective regulatory decisions, which undermine confidence in future cost recovery and eventually destroy the incentives for efficient behaviour that incentive regulation is intended to create. Hence, we strongly advise the BNA not to proceed down this path, but to continue to improve the Tornquist index methods it has adopted in its 2nd Reference Report.

Appendix A. Theoretical Justification for X-Factors

The X-factor lies that the heart of the discussion regarding the possible use of the Malmquist index to regulate utility prices as a component of price cap regulation. Early in the application of price cap regulation in the UK, there existed a general notion that the X-factor was simply the regulator's choice variable. For example, Beesley and Littlechild describe the X-factor as: "…a number specified by the government."[44] More recent consensus is that it the X-factor derives from a regulatory regime designed to limit monopoly utility prices, over a defined number of years, in a way that mimics the constraints that a competitive firm would face.

A.1. Theoretical Formulation for the X-Factor[45]

The X-factor lies that the heart of the discussion regarding the possible use of the Malmquist index to regulate utility prices as a component of price cap regulation. Early in the application of price cap regulation in the UK, there existed a general notion that the X-factor was simply the regulator's choice variable. For example, Beesley and Littlechild describe the X-factor as: "…a number specified by the government."[46] More recent consensus is that it the X-factor derives from a regulatory regime designed to limit monopoly utility prices, over a defined number of years, in a way that mimics the constraints that a competitive firm would face.

The annual price cap adjustment formula is designed to emulate competitive markets, so that if a company exceeds industry average productivity growth, its earnings will increase, and if it falls short of *industry average productivity growth*, its earnings will decline. Assume the price cap plan begins with appropriate prices so that the value of total inputs (including a normal return on capital) equals the value of total output for the company as well as the industry. For the industry, we can write this relationship as

$$\sum_{i=1}^{N} p_i Q_i = \sum_{j=1}^{M} w_j R_j \ ,$$

where the industry has N outputs ($Q_i, i = 1, \mathbf{K}, N$) and M inputs ($R_j, j = 1, \mathbf{K}, M$) and where p_i and w_j denote output and input prices, respectively. We want to calculate a productivity target for a company based on industry average productivity growth.

44 Beesley and Littlechild (1989) page 455, also see Armstrong, Cowan and Vickers (1994) page 174 for a discussion on the flexibility available to regulators when setting the *X-factor*.

45 This theoretical presentation is taken from Appendix A, from: Makholm, J.D., and Quinn, M. J., "Price Cap Plans for Electricity Distribution Companies Using TFP Analysis," NERA Working Paper, October 21, 1997, pages 36-39.

46 Beesley and Littlechild (1989) page 455, also see Armstrong, Cowan and Vickers (1994) page 174 for a discussion on the flexibility available to regulators when setting the *X-factor*.

Differentiating this identity with respect to time yields the following:

$$\sum_{i=1}^{N} \dot{p}_i Q_i + \sum_{i=1}^{N} p_i \dot{Q}_i = \sum_{j=1}^{M} \dot{w}_j R_j + \sum_{j=1}^{M} w_j \dot{R}_j \ ,$$

where a dot (·) indicates a derivative with respect to time. Dividing both sides of the equation by the value of output ($\mathrm{Re}v = \sum_i p_i Q_i$ or $C = \sum_j w_j R_j$), we obtain

$$\sum \dot{p}_i \left(\frac{Q_i}{REV} \right) + \sum \dot{Q}_i \left(\frac{p_i}{REV} \right) = \sum \dot{w}_j \left(\frac{R_j}{C} \right) + \sum \dot{R}_j \left(\frac{w_j}{C} \right),$$

where *REV* and *C* denote revenue and cost. If rev_i denotes the revenue share of output ***i*** and c_j denotes the cost share of input ***j***, then

(1) $$\sum_i rev_i dp_i = \sum_j c_j dw_j - \left[\sum_i rev_i dQ_i - \sum_j c_j dR_j \right] ,$$

where ***d*** denotes a percentage growth rate: $dp_i = \dot{p}_i / p_i$. The first term in equation (1) is the revenue-weighted average of the rates of growth of output prices, and the second is the cost-weighted average of the rates of growth of input prices. The term in brackets is the difference between weighted averages of the rates of growth of outputs and inputs. It thus is a measure of the change in TFP. Rewriting the equation for clarity, we see that

$$dp = dw - dTFP .$$

In words, the theory underlying the annual price cap adjustment formula implies that the rate of growth of a revenue-weighted output price index is equal to the rate of growth of an expenditure-weighted input price index plus the change in total factor productivity (TFP). This equation shows that TFP is the appropriate foundation for a productivity target in the price cap plan: if the price cap plan begins with revenues which just match costs for a company, and if it attains the same productivity growth as the industry (measured in terms of TFP), then that company's revenues will continue to match its costs.

Applying this rule more generally to admit the possibility of exogenous cost events outside of a regulated company's control, we may write

$$dp^* = dw - dTFP$$

where dp^* represents the annual percentage change in industry output prices inclusive of these exogenous costs, and dw represents the annual percentage change in input prices. To raise or lower industry output prices in order to track exogenous changes in cost, we write

(2) $$dp = dw - dTFP + Z^*$$

where dp represents the annual percentage change in industry output prices adjusted for exogenous cost changes, and Z^* represents the unit change in costs due to external circumstances.[47] Thus to keep the revenues of the industry equal to its costs despite changes in input prices, the price cap formula should (i) increase industry output prices at the same rate as its input prices less the target change in productivity growth, and (ii) directly pass through exogenous cost changes.

Equation (2) sets the allowed price change as input price changes less TFP growth adjusted for exogenous cost pass-throughs. If the economy-wide inflation rate were ***assumed*** to be the measure of the industry's input price growth and the X-factor was similarly ***assumed*** to be its TFP growth target, equation (2) would indeed be the basis for the ideal price adjustment formula. However, these two assumptions are incorrect:

(a) Broad inflation measures capture national ***output*** price growth, not the industry's input price growth. So even if the industry is a microcosm of the whole economy, a measure which captures national output price growth would not be an appropriate measure of its input price growth.[48]

(b) The X-factor is a target TFP growth rate relative to the economy as a whole (or relative to the TFP growth already embodied in national output price growth). The change in TFP in equation (2) is the absolute TFP growth for the industry. Again, unless economy-wide TFP growth is zero, the X-factor is not equal to $dTFP$.

To get from equation (2) to the price adjustment formula, we must compare the productivity growth of the industry with the productivity growth of the whole economy. It is difficult to measure input price growth objectively. No agency of which we are aware maintains an index of industry-specific input prices. Further, a productivity adjustment based on company-provided calculations of changes in their own input price index would be controversial and would not necessarily be based on information outside the company's control. However, by comparing productivity growth of the industry with that of the whole economy, we avoid the difficulty of measuring input price growth.

For the economy as a whole, the relationship among input prices, output prices, productivity, and exogenous cost changes can be derived in the same manner as it was derived in equation (2) above:

(3) $$dp^N = dw^N - dTFP^N + Z^{*N}$$

where dp^N is the annual percentage change in a national index of output prices; dw^N is the annual percentage change in a national index of input prices; $dTFP^N$ is the annual change in the economy-wide total factor productivity and Z^{*N} represents the change in national output prices caused by the exogenous factors included in equation (2). Subtracting equation (3) from equation (2) gives

47 Note that Z^* can be positive or negative.

48 Recall that input price growth differs from output price growth by the growth in TFP. Only if national productivity growth were zero could GDP_PI be a good measure of national input price growth.

$$dp - dp^N = \left[dw - dw^N\right] - \left[dTFP - dTFP^N\right] + \left[Z^* - Z^{*N}\right],$$

or

(4) $$dp = dp^N - \left[dTFP - dTFP^N + dw^N - dw\right] + \left[Z^* - Z^{*N}\right],$$

which simplifies to

(5) $$dp = dp^N - X + Z \;.$$

If the industry achieves a productivity target of X and experiences exogenous cost changes given by Z, the price change that keeps earnings constant is given by equation (5). This price change is given by:

1. the rate of inflation of national output prices dp^N,
2. less a fixed productivity offset, the X-factor, which represents a target productivity growth differential between the annual TFP growth of the industry and the whole economy,[49]
3. plus exogenous unit cost changes, written as the difference between the effects on the industry and economy-wide unit costs of the exogenous event.

To use the industry's productivity performance as a target for an individual company, rewrite equation (5) into the formula:

(6) $$PCI_t = PCI_{t-1} \times \left[1 + GDP\_PI_t - X \pm Z_t\right],$$

Where PCI_t is the value of the index used to update the price cap in year t, GDP_PI_t is the price index for Gross Domestic Product (or some other comparable index), and Z_t is the difference in the effects of exogenous changes on a specific company and on the rest of the economy.

A.2. Interpretation of the Formula

In words, using the above formula to limit price increases has the property that earnings remain the same if a company's achieved productivity differential just meets the historical target X-factor. Thus a company must perform as well against economy-wide average TFP growth today as the industry as a whole has historically performed in comparison with economy-wide average TFP growth. If a company's productivity growth falls short of the target, its earnings will fall; if it exceeds the target, its earnings will rise. The price adjustment formula that sets this target adjusts output prices by: (1) the change in a national index of output prices less (2) the TFP growth target, measured as the difference between the change in industry TFP and that of the nation as a whole,[50] plus (3) the difference between

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[49] This differential is equal to the difference between the electricity industry and economy-wide TFP growth rates only if the rates of input price growth are the same for the industry and the nation: i.e., if $dw = dw^N$.

[50] Adjusted for possible differences between input price growth rates for the industry and the nation.

the effect of exogenous changes on a company's costs and on the costs of the nation as a whole.

Thus the historical relative TFP growth of the industry and the whole economy is taken as the target for TFP growth relative to the whole economy. National output price growth and exogenous cost changes are measured annually, but the *X-factor* is fixed as the target amount by which TFP growth should exceed historical economy-wide TFP growth. If a company exceeds its productivity target, its earnings will rise, and if it falls short of its productivity target, its earnings will fall. This system of rewards and punishments sets up the same incentives as an unregulated firm would face in a competitive market, where failure to match industry-average productivity growth results in lower earnings and exceeding industry average productivity growth leads to increased earnings.

For discussing issues involving the empirical measurement of TFP, two issues remain core to this theoretical exposition: (1) the only relevant productivity measure is TFP *growth*, not the *level* of TFP (about which this exposition says nothing); and (2) it is only the *industry average* TFP growth mimics the constraints faced by firms in a competitive market.

Appendix B. Examples of Efficiency Indices

APPENDIX 4A (cont.)

TFP INDEX
FOR 39 ELECTRIC UTILITIES
BINARY INDEX COMPARISON
(DUQUESNE LIGHT 1980 = 1.0)

COMPANY	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
POTOMAC ELECTRIC POWER	0.967	1.103	1.164	1.080	1.021	0.985	1.017	0.930	1.007	0.952	0.946
GULF POWER COMPANY	1.212	1.211	1.109	1.242	1.174	1.119	1.047	1.015	1.051	1.092	0.968
TAMPA ELECTRIC COMPANY	1.161	1.168	1.180	1.221	1.129	1.071	1.107	1.176	1.180	1.182	1.272
SAVANNAH ELEC AND PWR CO	1.103	1.084	1.068	1.087	0.947	0.963	1.009	1.013	0.916	0.929	0.802
HAWAIIAN ELEC PWR CO	0.873	0.908	0.928	0.925	0.942	0.969	0.973	0.990	0.986	1.016	1.015
COMMONWEALTH EDISON	0.902	0.822	0.753	0.739	0.725	0.612	0.574	0.580	0.547	0.523	0.491
INDIANAPOLIS PWR AND LIGHT	1.185	1.121	1.063	1.103	1.091	1.019	1.032	0.927	1.046	1.058	1.090
PUB SERV OF INDIANA	1.042	1.058	1.122	1.126	1.074	1.104	1.153	1.134	1.074	1.110	1.073
KANSAS GAS AND ELECTRIC	1.244	1.165	1.103	1.073	1.131	1.171	1.103	1.214	1.354	1.223	1.279
KENTUCKY POWER COMPANY	1.411	1.506	1.507	1.365	1.447	1.300	1.477	1.386	1.312	1.223	1.385
KENTUCKY UTILITIES COMPANY	0.662	0.865	0.835	0.870	1.001	0.986	1.038	1.060	1.067	0.922	0.998
LOUISIANA PWR AND LIGHT	1.182	1.325	1.408	1.410	1.350	1.383	1.413	1.344	1.301	1.172	1.086
DETROIT EDISON COMPANY	1.021	1.013	0.995	1.006	1.005	0.973	0.928	0.926	0.915	0.891	0.838
MISSISSIPPI POWER CO	1.323	1.232	1.140	1.187	1.224	1.107	1.126	0.963	1.087	0.999	1.020
MISSISSIPPI PWR AND LIGHT	1.138	1.104	1.182	0.878	0.848	0.987	1.140	1.233	1.295	1.170	1.190
KANSAS CITY PWR AND LIGHT	0.946	0.943	0.920	0.884	0.786	0.745	0.721	0.674	0.701	0.491	0.635
UNION ELECTRIC COMPANY	0.825	0.839	0.840	0.936	0.875	0.965	1.001	1.065	1.042	0.997	0.948
NEVADA POWER COMPANY	1.082	1.199	1.151	1.143	1.235	1.204	1.332	1.525	1.333	1.338	1.316
PUB SERV OF NEW HAMPSHIRE	1.042	0.969	1.000	0.899	0.815	0.833	0.814	0.846	0.720	0.825	0.808
PUB SERV OF NEW MEXICO	0.923	0.969	0.970	0.918	0.941	0.935	0.778	0.817	0.538	0.538	0.544
OTTER TAIL POWER CO	0.680	0.622	0.638	0.693	0.650	0.745	0.807	0.800	0.736	0.651	0.701
CLEVELAND ELEC ILLUM CO	1.051	1.135	1.123	1.141	1.076	1.025	1.002	1.016	0.981	0.880	0.818
COLUMBUS AND SOUTHERN OHIO	0.865	0.874	0.944	1.002	0.974	0.899	0.939	0.924	0.861	0.994	0.926
OHIO EDISON COMPANY	1.200	1.123	1.199	1.193	0.916	0.837	0.912	0.772	0.850	0.883	0.882
OKLAHOMA GAS AND ELEC CO	1.133	1.144	1.194	1.264	1.250	1.225	1.171	1.114	1.219	1.200	1.209
PUB SERV CO OF OKLAHOMA	1.260	1.332	1.334	1.260	1.336	1.340	1.384	1.363	1.361	1.246	1.300
DUQUESNE LIGHT COMPANY	0.798	0.805	0.821	0.845	1.022	0.968	1.024	1.011	0.834	0.988	1.000
PENNSYLVANIA PWR AND LIGHT	0.873	0.922	1.048	1.155	1.099	1.169	1.148	1.202	1.136	1.132	1.093
CENTRAL POWER AND LIGHT	1.161	1.269	1.204	1.207	1.154	1.103	1.113	1.140	1.185	1.144	1.104
DALLAS POWER AND LIGHT CO	1.091	1.123	1.161	1.172	1.220	1.297	1.351	1.357	1.373	1.400	1.447
EL PASO ELECTRIC CO	1.121	1.124	1.182	1.211	1.218	1.242	1.180	1.184	1.072	1.145	1.023
HOUSTON LIGHTING AND PWR	1.405	1.422	1.444	1.422	1.363	1.341	1.358	1.323	1.279	1.287	1.238
SOUTHWESTERN ELEC PWR CO	1.194	1.197	1.331	1.202	1.241	1.225	1.176	1.182	1.189	1.203	1.177
SOUTHWESTERN PUB SERV CO	1.092	1.129	1.188	1.178	1.193	1.156	1.188	1.189	1.179	1.162	1.220
TEXAS ELEC SERV CO	1.295	1.279	1.286	1.260	1.324	1.347	1.369	1.352	1.430	1.472	1.486
TEXAS PWR AND LIGHT CO	1.236	1.249	1.221	1.199	1.087	0.999	0.941	0.997	0.990	0.932	0.949
WEST TEXAS UTILITIES CO	1.088	1.121	1.180	1.157	1.194	1.240	1.264	1.286	1.233	1.270	1.301
UTAH PWR AND LIGHT CO	0.673	0.583	0.710	0.859	0.817	0.873	0.665	0.876	1.008	0.988	1.132
APPALACHIAN PWR CO	1.029	1.137	1.436	1.394	1.227	1.115	1.169	1.096	1.082	1.100	1.114
AVERAGE	1.064	1.082	1.105	1.100	1.080	1.066	1.076	1.077	1.063	1.044	1.047
WEIGHTED AVERAGE	1.078	1.095	1.131	1.129	1.094	1.073	1.087	1.082	1.080	1.056	1.052

APPENDIX 4A (cont.)

YEARLY GROWTH RATES FOR
TFP INDEX
FOR 39 ELECTRIC UTILITIES

COMPANY	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	AVG.
POTOMAC ELECTRIC POWER	14.1%	5.5%	-7.2%	-5.4%	-3.6%	3.3%	-8.6%	8.3%	-5.5%	-0.6%	.0%
GULF POWER COMPANY	-0.1%	-8.4%	12.0%	-5.5%	-4.6%	-6.5%	-3.1%	3.5%	3.9%	-11.3%	-2.0%
TAMPA ELECTRIC COMPANY	0.6%	1.1%	3.5%	-7.5%	-5.2%	3.3%	6.2%	0.3%	0.2%	7.6%	1.0%
SAVANNAH ELEC AND PWR CO	-1.7%	-1.5%	1.8%	-12.9%	1.6%	4.8%	0.4%	-9.6%	1.4%	-13.8%	-2.9%
HAWAIIAN ELEC PWR CO	4.0%	2.2%	-0.3%	1.8%	2.9%	0.4%	1.7%	-0.4%	3.0%	-0.1%	1.5%
COMMONWEALTH EDISON	-8.8%	-8.4%	-1.9%	-2.0%	-15.6%	-6.1%	0.9%	-5.7%	-4.4%	-6.2%	-5.8%
INDIANAPOLIS PWR AND LIGHT	-5.5%	-5.1%	3.8%	-1.1%	-6.6%	1.3%	-10.2%	12.8%	1.2%	3.0%	-0.6%
PUB SERV OF INDIANA	1.6%	6.0%	0.4%	-4.7%	2.8%	4.5%	-1.7%	-5.3%	3.3%	-3.3%	0.4%
KANSAS GAS AND ELECTRIC	-6.3%	-5.4%	-2.7%	5.4%	3.6%	-5.8%	10.0%	11.6%	-9.7%	4.6%	0.5%
KENTUCKY POWER COMPANY	6.7%	0.1%	-9.4%	6.0%	-10.2%	13.6%	-6.2%	-5.3%	-6.8%	13.2%	0.2%
KENTUCKY UTILITIES COMPANY	30.5%	-3.4%	4.2%	15.0%	-1.5%	5.3%	2.1%	0.6%	-13.6%	8.3%	4.8%
LOUISIANA PWR AND LIGHT	12.1%	6.3%	0.2%	-4.3%	2.5%	2.1%	-4.9%	-3.2%	-9.9%	-7.4%	-0.6%
DETROIT EDISON COMPANY	-0.7%	-1.8%	1.1%	-0.2%	-3.2%	-4.6%	-0.2%	-1.2%	-2.6%	-6.0%	-1.9%
MISSISSIPPI POWER CO	-6.9%	-7.5%	4.1%	3.1%	-9.6%	1.8%	-14.5%	13.0%	-8.2%	2.1%	-2.3%
MISSISSIPPI PWR AND LIGHT	-3.0%	7.1%	-25.7%	-3.5%	16.4%	15.5%	8.1%	5.0%	-9.7%	1.7%	1.2%
KANSAS CITY PWR AND LIGHT	-0.3%	-2.5%	-3.9%	-11.1%	-5.2%	-3.2%	-6.5%	4.0%	-30.0%	29.4%	-2.9%
UNION ELECTRIC COMPANY	1.8%	.0%	11.5%	-6.5%	10.2%	3.8%	6.4%	-2.2%	-4.3%	-5.0%	1.6%
NEVADA POWER COMPANY	10.8%	-4.1%	-0.7%	8.1%	-2.6%	10.6%	14.5%	-12.6%	0.4%	-1.6%	2.3%
PUB SERV OF NEW HAMPSHIRE	-7.0%	3.2%	-10.1%	-9.4%	2.2%	-2.3%	3.9%	-14.8%	14.6%	-2.1%	-2.2%
PUB SERV OF NEW MEXICO	5.0%	0.1%	-5.4%	2.6%	-0.7%	-16.8%	5.0%	-34.1%	-0.1%	1.1%	-4.3%
OTTER TAIL POWER CO	-8.6%	2.6%	8.6%	-6.3%	14.6%	8.3%	-0.8%	-8.1%	-11.5%	7.8%	0.7%
CLEVELAND ELEC ILLUM CO	8.0%	-1.0%	1.6%	-5.7%	-4.7%	-2.3%	1.4%	-3.5%	-10.2%	-7.1%	-2.4%
COLUMBUS AND SOUTHERN OHIO	1.1%	8.0%	6.2%	-2.8%	-7.8%	4.5%	-1.6%	-6.9%	15.5%	-6.8%	0.9%
OHIO EDISON COMPANY	-6.4%	6.7%	-0.4%	-23.3%	-8.6%	9.0%	-15.4%	10.1%	3.9%	.0%	-2.4%
OKLAHOMA GAS AND ELEC CO	1.0%	4.3%	5.9%	-1.1%	-2.0%	-4.4%	-4.8%	9.4%	-1.6%	0.7%	0.7%
PUB SERV CO OF OKLAHOMA	5.7%	0.2%	-5.6%	6.0%	0.3%	3.3%	-1.5%	-0.2%	-8.4%	4.3%	0.4%
DUQUESNE LIGHT COMPANY	0.9%	2.0%	2.9%	20.9%	-5.2%	5.7%	-1.3%	-17.5%	18.5%	1.2%	2.8%
PENNSYLVANIA PWR AND LIGHT	5.6%	13.7%	10.2%	-4.9%	6.4%	-1.8%	4.7%	-5.5%	-0.4%	-3.4%	2.5%
CENTRAL POWER AND LIGHT	9.2%	-5.1%	0.2%	-4.4%	-4.4%	0.9%	2.5%	4.0%	-3.5%	-3.5%	-0.4%
DALLAS POWER AND LIGHT CO	3.0%	3.4%	0.9%	4.1%	6.3%	4.2%	0.4%	1.2%	2.0%	3.4%	2.9%
EL PASO ELECTRIC CO	0.2%	5.2%	2.5%	0.6%	2.0%	-5.0%	0.3%	-9.5%	6.8%	-10.7%	-0.8%
HOUSTON LIGHTING AND PWR	1.2%	1.5%	-1.5%	-4.1%	-1.6%	1.3%	-2.6%	-3.3%	0.6%	-3.8%	-1.2%
SOUTHWESTERN ELEC PWR CO	0.3%	11.1%	-9.7%	3.3%	-1.3%	-4.0%	0.6%	0.5%	1.2%	-2.2%	.0%
SOUTHWESTERN PUB SERV CO	3.4%	5.2%	-0.9%	1.3%	-3.1%	2.8%	0.1%	-0.9%	-1.4%	5.0%	1.2%
TEXAS ELEC SERV CO	-1.3%	0.6%	-2.1%	5.1%	1.7%	1.6%	-1.3%	5.8%	2.9%	1.0%	1.4%
TEXAS PWR AND LIGHT CO	1.1%	-2.3%	-1.8%	-9.4%	-8.1%	-5.8%	6.0%	-0.8%	-5.8%	1.9%	-2.5%
WEST TEXAS UTILITIES CO	3.0%	5.3%	-2.0%	3.2%	3.9%	1.9%	1.7%	-4.1%	3.0%	2.5%	1.8%
UTAH PWR AND LIGHT CO	-13.4%	21.7%	21.0%	-4.8%	6.9%	-23.8%	31.7%	15.1%	-2.1%	14.6%	6.7%
APPALACHIAN PWR CO	10.5%	26.3%	-3.0%	-11.9%	-9.1%	4.8%	-6.2%	-1.3%	1.7%	1.2%	1.3%
AVERAGE	1.8%	2.4%	0.2%	-1.7%	-1.0%	0.7%	0.4%	-1.3%	-1.7%	0.5%	.0%

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