A CRITIQUE OF CEPA'S REPORT ON "PRODUCTIVITY IMPROVEMENTS IN DISTRIBUTION NETWORK OPERATORS"

A Report for EDF Energy

Prepared by NERA

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Authors:
Graham Shuttleworth
Jeff Makholm

n/e/r/a
National Economic Research Associates
Economic Consultants

15 Stratford Place
London W1N 9AF
Tel: (+44) 20 7659 8500
Fax: (+44) 20 7659 8501
Web: http://www.nera.com

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1. OVERALL

CEPA concludes that a central estimate for Total Factor Productivity (TFP) growth by British DNOs would be 2.4% per annum. CEPA translates this estimate into an X-factor of about 1%, after deducting economy-wide TFP growth of 1.3% (which is already captured by the inclusion of the RPI in the RPI-X formula).

CEPA's report is a step forward, since it represents an attempt to provide an objective analytical basis for setting the future rate of cost reduction. It is vastly better than the old style of analysis that CEPA discusses on page 4, mostly because it gives something objective and analytical that can act as the focus of informed discussion. However, close inspection reveals that CEPA has laid a relatively thick veneer of apparent objectivity onto a study that has lots of problems:

(1) CEPA uses cost data directly from the regulatory accounts that are not a reliable basis for estimating TFP;

(2) CEPA's methodology is non-standard and so sufficiently subjective that Ofgem has wide leeway to interpret the results quite differently from CEPA;

(3) CEPA tries to limit the applicability of the TFP estimate and to suggest a need for additional X-factors associated with "catch-up", even though the estimation of X-factors does not require this additional factor, and there is no objective basis for measuring it.

As an indication of the problems with the report, CEPA's own analysis produced a "headline" estimate of past TFP growth of 4.3% for all DNOs on average, and CEPA only downgraded this to 2.4% by making a subjective assessment of estimates made from other sources. That does not suggest that Ofgem will feel bound by CEPA's "central estimate".

"On the record" work in the US, Canada and New Zealand has estimated electricity distribution TFP growth rates in mature markets of approximately 1.0% per annum, which produces very small positive X-factors (after deducting economy-wide TFP growth). The numbers resulting from CEPA's study are therefore a major overstatement of the likely figures.

Lest anyone believes that the effect of this overstatement may be small, we reproduce the following table and associated discussion which NERA presented before the Commerce Commission in New Zealand in October 2003:[1]

[1] Makholm, J.D. (2003) "Unacceptable Electricity Distribution Productivity Measures for Resetting the Price Path Threshold", NERA, 17 October 2003.

> "This matter of the quality of Disclosure Data is not to be taken lightly. The Commission should avoid basing its approved price path on a reckless TFP estimate—one that is highly sensitive to a short time series of questionable data. The value of the approved [X-factor] is of critical importance to all regulated electricity distributors who are subject to this price path, and the calculation should be given the attention that it deserves. For illustrative purposes, I estimate in Table 1 the effect that a one percent increase in the [X-factor] will have on the industry over the course of the plan period. Each percentage point increase will cost New Zealand's electricity distributors roughly NZ$157 million (net present value) over the next five years."

Table 1: Cost of each 1% Increase in the [X-]Factor Over the Next Five Years

	Projected Revenues (NZ$ Million)[1]		
Year	X=1%	X=2%	Difference
2004	$1,300	$1,287	$13
2005	$1,366	$1,339	$27
2006	$1,436	$1,393	$43
2007	$1,510	$1,450	$60
2008	$1,587	$1,509	$79
Total Difference (NPV at 10%)			$157

[1] Assuming 1996-2002 demand growth

In other words, even with a comparatively tiny industry (as in New Zealand), the present value of the consequences of employing an inflated X-factor is huge. The consequences in the UK will be larger. Moreover, if CEPA's report stands unchallenged, it will provide a basis for Ofgem's decision-making which lacks accuracy, credibility and robustness, thereby allowing (or even requiring) Ofgem to exercise a high degree of discretion.

In the following report, we comment on several aspects of CEPA's work:

- In section 2, we discuss certain flaws in CEPA's description of TFP and its applicability as an estimate of the X-factor;
- In section 3, we highlight problems with CEPA's methodology; and
- In section 4, by comparing like estimates of TFP growth in the US distribution sector, we provide some indication of the possible overstatement of TFP in CEPA's report.

2. APPLICABILITY OF TFP GROWTH RATES

Sections 2.3 and 11.4 of the CEPA report are particularly troubling, because they presage an attempt to penalise the DNOs for not being on the "efficiency frontier." Analyses that purport to distinguish between "frontier shifts" and "distances from the frontier" among various distributors have a superficial appeal. Ultimately, however, there is no substance to any study that seeks to separate those two effects empirically, as we noted in our earlier report on CEPA's review of benchmarking.[2]

2.1. Conceptual Problems

Section 2.3 ("The Role of TFP in Utility Regulation") misses out, by way of background, any recognition that the X factor in RPI-X formulae is supposed to replace the role of productivity in the prices that confront price-takers in competitive markets. Forgetting this ultimate grounding to RPI-X regulation allows CEPA to embark on a discussion of "convergence" issues that are not relevant to the task facing Ofgem.

The initial prices set at the start of a regulatory review period serve to match prices with a realistic cost of service. The roles of the RPI and X factor are then to provide a moving, exogenous competitive-like constraint. Competitive constraints don't distinguish between movements ***of*** frontiers and movements of particular terms ***toward*** frontiers. Competitive constraints simply reflect the broad trend in productivity growth in the industry, from whatever source, and objective regulatory constraints can only do the same.

As explained in NERA's critique of CEPA's earlier report, no economist or engineer can possibly identify a company's "efficiency" (over those elements that it can effectively control) based on a measure of its "distance" from a "frontier".[3] Many important factors can influence a company's cost performance, and unless we account fully for ***all*** these factors, the differences in "distance" scores ***cannot*** be interpreted as truly measuring company efficiency. For instance, a company's operating costs may appear relatively higher not because its management is more inefficient but because some unmeasured aspect of its operating conditions raises its costs more than those of other companies. Deciding what aspects to include in the analysis is a purely ***subjective*** process of selection. Therefore, in a regulatory system based on ***objective*** analysis, one cannot assign any relevance to "efficiency scores", to an "efficiency frontier", or to the prospect of "catch-up".

Making a distinction between movements in a frontier and movements towards a frontier inevitably invites regulators to "judge" which firms are efficient and which are playing catch-up to the frontier. Besides there being no conceptual grounding for such a pursuit,

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[2] Shuttleworth G and Lieb-Doczy E (2003), ***Commentary on CEPA Benchmarking Paper***, NERA, 13 November 2003.

[3] For a concise statement of the reasons why fronter-type benchmarking has no place in objective regulatory decisions, see also Shuttleworth G, "Firm-Specific Productivity: A Response", ***Electricity Journal***, April 2003.

there is absolutely no way to deal with the issue empirically. As a result, accepting this non-observable distinction creates a reliance on subjective judgment that undermines any attempt to place regulation on a stable and predictable basis.

The point of a TFP estimate based on past average trends is to set the X-factor equal to the ***expected*** rate of productivity growth. In the absence of any objective, useful information about the factors that caused past productivity growth, it is impossible to estimate a better expected rate of productivity growth than the past average rate, because it is rarely possible to "model" objectively the development of the causative factors. The only exception would be the observation that the regulatory regime is about to change in ways that strengthen incentives for efficiency compared with the past. Such an observation would provide the (sole) rational justification for imposing a "stretch factor" on top of historical average TFP growth.

2.2. Empirical Problems

Measuring productivity ***growth*** is a totally different exercise from measuring productivity ***levels***. Economists have reasonably good tools to measure the former, given high quality data, a number of companies and years (the more the better). No economist using numerical techniques has any ability whatsoever to do the latter. In testimony before the Commerce Commission in New Zealand in November 2003, Dr Makholm offered the following comment:

> "Economists who study productivity do not know the source of TFP levels for individual companies—and have no realistic tools to investigate the matter. Different companies are simply too idiosyncratically different from each other for the relatively blunt accounting and statistical tools at our disposal.
>
> We can, however, measure TFP growth, over long periods of time, with some accuracy given high quality data.
>
> And luckily, TFP growth is the only concept that matters in price cap regulation."[4]

The point of this discussion was to rebut the claim by the Commerce Commission consultant that he could distinguish between the relative efficiency ***levels*** between NZ electricity distributors. That implication is totally false. The TFP literature on productivity deals exclusively with productivity ***growth***—the analysts knowing full well that the basic data on TFP ***levels*** that underlie their calculations of TFP growth are useless in evaluating the relative productivity of particular firms.

[4] Makholm J. D. (2003).

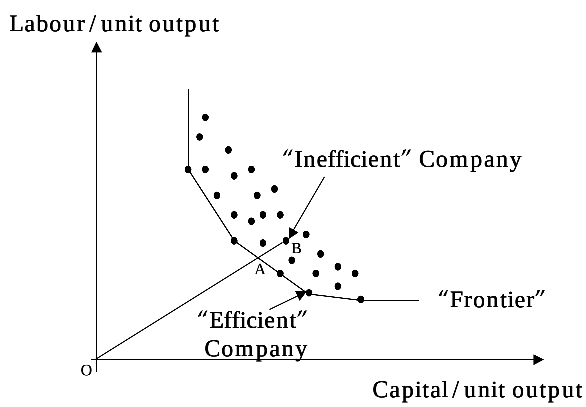
2.3. Other Analysts' Discussion of "Frontier" and "Catch-up"

There are two issues here. Some analysts elsewhere try to estimate the "catch-up" potential using Malmquist indexes. Others refer to "stretch factors."

2.3.1. Malmquist Indexes

Most of the discussion of these two concepts comes from those who utilize Malmquist index number methods—as opposed to the Tornquist methods used by CEPA. The Malmquist method produces an "efficiency frontier" and any particular company may lie on the frontier or a certain distance away from it, as shown in Figure 2.1.

Figure 2.1: Typical Relationship Between Frontier and Actual Performance



Certain analysts have taken the relative positions on such a graph as indicative of what the X factor should be for a particular firm, for instance by calculating an "efficiency score" for each company equal to the ratio of OA to OB. Such conclusions are wrong, because they overlook the incontrovertible fact that measuring relative productivity levels is a futile exercise for economists—particularly those dealing with idiosyncratic utilities. The gap between the company and the frontier (AB) could be due to any factor not recognised in the analysis, and is not necessarily a measure of "inefficiency" or "productivity ***levels***". The graph in Figure 2.1 is therefore only one step of a two-step process to estimate productivity ***growth***. The first step is to estimate an index; the second is to calculate the growth rate of the index over a period of several years. Taking the second step will produce a number for Malmquist TFP growth reasonably close to the number for Tornquist TFP growth.

CEPA seems to imply that TFP can be properly applied only when the industry has "converged" to the frontier so that there is no room for "catching up". However, it is extremely unlikely that a group of companies would ever "converge" on a frontier, so measurements of productivity growth always represent a mixture of "frontier shift" and "catch-up". Since it is impossible to estimate a frontier with any objectivity, it would be impossible to know whether or not "convergence" had taken place, or how much of past growth was due to "catch-up".

Moreover, some regulators regularly set X-factors using the Tornquist index, which measures average TFP growth from whatever source, without checking for "convergence". Other regulators use the Malmquist index, which incorporates both "frontier shift" and "catch-up", without discussing the difference between the two components. Hence, the practical experience of regulation contradicts CEPA's argument that "convergence", or the separation of "frontier shift" from potential "catch-up", is a necessary condition for using TFP growth to set X-Factors.[5]

2.3.2. Stretch Factors

In North America, believing that price regulation should make the industry increase its productivity at a faster rate in the future, regulators typically endeavour to add to the historically observed productivity factor a "stretch factor," also referred to as a "consumer dividend" or an "accumulated inefficiency factor". This stretch factor has a positive value, i.e. it increases the X-factor in the price cap formula. It is meant to reflect the belief that regulated companies facing ***a new set of incentives*** under price cap regulation may achieve faster productivity growth than they did under traditional cost of service regulation. Thus, it only applies when the regulator can demonstrate that incentives for efficiency are stronger than in the past (i.e. over the period for which the TFP growth rate was estimated).

In some cases, the stretch factor increases over the term of the price cap plan. Increasing stretch factors are implemented when a regulator does not realistically expect the regulated company or companies to realize all of their potential efficiency gains in the first year of the plan, but expects the company or companies to continue to "stretch" further each year under the new price cap plan. The stretch factor is intended to account for inefficiencies that have accumulated in the industry and which (it is now reasonable to expect) will be eliminated due to a strengthening of incentives. It is not justified by the mere assertion that a company lies some distance from the frontier (as has often been suggested in the UK), or to "levelise" allowed costs (as attempted in New Zealand recently).

In the British context, there are no reasons to expect faster productivity growth in the future than has been observed in the past. Privatisation provided a major impetus to increase the rate of productivity growth, compared with the position under state ownership. However, this effect is already incorporated in any analysis of the period since 1990; indeed, it might be reasonable to adjust the X-factor downwards, to correct for short-term, non-reproducible effects present in past data.

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5 As far as we are aware, in the U.S. the TFP discussions related to the utility industry do not focus on frontier shift or catching up issues, but instead on input growth and output growth components. The reason of course is that virtually all TFP studies here are based on a Tornquist index, and not the Malmquist index. The Tornquist and Malmquist indexes measure some type of average productivity growth. Only the latter index allows for the kind of decomposition that CEPA is talking about.

3. OTHER COMMENTS

The theoretical basis for studying TFP can be traced back to original work on production functions (i.e. on the mathematical relationship between inputs and outputs) undertaken by the Harvard University economist Dale Jorgensen and his associates in the 1960s. By analysing production functions in detail, Jorgensen was able to derive the appropriate methodology for measuring and weighting all a company's inputs ("factors") and outputs in order to measure total factor productivity growth. This methodology has now been standardised through repeated use in theoretical and regulatory applications, both in the US and in other countries.

The theoretical work on productivity measurement feeds directly into the role of the X-factor in price cap regulation. Appendix A presents the mathematical derivation of the price adjustment mechanisms forming the base of RPI-X regulation, showing the role of TFP within that derivation.

However, CEPA departs from this standard methodology (both in measuring productivity and applying it in an RPI-X context) in a number of ways that are not explicable by reference to a sound theory of the production function. These departures from standard methodology will therefore bias the results and/or inject considerable subjectivity into what otherwise should be a largely objective exercise of measuring productivity growth. Some of the biases will be unpredictable, but the individual biases are not negligible and they may not necessarily cancel each other out. Some of the biases clearly lead to an overstatement of past TFP growth. CEPA's departures from the standard, objective practice therefore lack a theoretical justification and undermine the credibility of the results.

3.1. Executive Summary

The table on page v of the Executive Summary repeats a summary table of results from chapter 11 on page 55. ***In both versions,*** CEPA reports TFP growth for NGC of 4.3%, even though CEPA's own analysis only awards NGC a trend growth rate in TFP of 2.4%-2.6% per annum. Although this difference is undoubtedly only a typing error, it distorts the presentation of the results. After making this correction, the estimates of TFP growth in other sectors and companies all lie in the same narrow range (1.4%-3.4%, apart from the Norwegian distribution sector at 0.2%). Then, CEPA's estimate of 4.2% for the DNOs stands out as a definite outlier, which should be a cause for concern.

In fact, CEPA apparently gives very little credence to its own estimate of past TFP growth by DNOs, setting its estimate of future TFP growth for British DNOs in the same range (1.4%-3.4%) as shown by the other cases, with 2.4% as a "central estimate". As CEPA correctly reports, TFP growth for the economy as a whole (1.3%) should be deducted from any such estimate, when setting the X-factor (leaving 1.1%).

3.2. Section 2.1: "Monetised Inputs"

CEPA's study does not conform to standard practice regarding the choice of inputs and weighing scheme. TFP studies are supposed to compare physical outputs to physical inputs. Outputs are generally physical (miles of lines, kWh sales, numbers of customers) and some inputs are as well (e.g. numbers of employees). Other inputs are harder to identify physically (especially capital), so it is conventional to convert monetary measures into quantity measures by mean of a price index adjustment. For instance, an index of capital stock can be obtained by dividing the value of physical plant at a given period by a price index that accounts for the different vintages of capital that the physical plant embodies. We would be wary of any study that started with a general "monetization" of all of inputs.

Using accounting values for all inputs can cause significant data deficiencies and empirical problems. The details matter greatly in forming input indexes. Most often, operating cost information from regulatory accounts (outside the US and standardised reporting as per Form 1) is not sufficiently disaggregated to prevent sizeable biases to creep into the analysis. Below, we identify just a few of the possible biases, judging by CEPA's description of its method.

3.2.1. Input values, rather than quantities

Using input ***values*** (i.e. costs) introduces the possibility of double counting in the price cap formula. If the production of inputs becomes more efficient over time, the real cost of inputs will decline, suggesting (falsely) that the DNOs were becoming efficient more rapidly. Since CEPA does not adjust for this effect in its calculation (or by proposing an alternative price cap formula that offsets the effect), it is likely that this departure from standard practice has led CEPA to overestimate the DNO's historical TFP growth.

3.2.2. Regulatory accounts data, rather than stable time series

CEPA draws information on the operating expenditures of each DNO from the regulatory accounts for 1990/92-2001/02 made available by Ofgem (see section 5.1 of CEPA report). The DNOs have not compiled such information on a consistent basis over the years. Some of the accounting changes made by DNOs will have raised costs over time and some will have reduced them. However, in its 1999 distribution review, Ofgem signalled that large amounts of cost should be allocated to supply rather than distribution, and many DNOs will have reflected this requirement in their regulatory accounts. CEPA's analysis will have interpreted such a reallocation of costs out of distribution as a reduction in costs and as a consequent increase in the historic rate of productivity growth.

As CEPA admits, the 30% opex reduction observed in 2000/01 is sufficient by itself to raise the estimated trend rate of TFP growth from 3.4% (Figure 7) to 4.3% (Figure 3). CEPA discussed this apparent cost reduction with Ofgem and concluded from those discussions (which somewhat undermines the independence of CEPA's estimate) that an opex reduction of 30% in one year "could realistically be the result of improved productivity".[6] We find it extremely unlikely that such a large reduction in costs would represent a genuine productivity increase and is not, at least in part, due to an accounting change. However, the DNOs themselves can advise on the source of this apparent change in costs.

Similar issues arise over the definition of capital costs, for which CEPA claims to have used "current cost" asset values. (See below.)

3.2.3. Fixed revenue weights, rather than variable cost shares

Another major flaw of CEPA's analysis is the way they determined input and output weights. The standard practice is to use cost shares to weight the different input quantities (labor, capital stock materials, etc).

Since CEPA decided to use operating and capital expenditures as inputs, they deflate these by revenue numbers in order to derive cost shares. We are not aware of other studies that adopt this approach.

Additionally, CEPA's use of fixed output/input weights does not conform to usual practice and is highly problematic. On the input side, cost shares will normally vary over time, thereby reflecting the relative importance of each input category in determining the aggregate input index. Using fixed shares can distort the aggregation process. If an input type initially had a small cost share but its utilization grew very rapidly, the use of fixed weights will tend to underestimate its real contribution to input quantity growth. In turn, if the input quantity growth is ***under***estimated, then an obvious result is that TFP growth will be ***over***estimated. Given CEPA's application of fixed weights, there is a real possibility that their TFP estimates might be inflated.

On the output side, CEPA relies on commonly used quantity measures but it aggregates them using somewhat ad-hoc assumptions, particularly in the case of the quality variable. The approach in other studies is to combine output measures using weights derived either from revenue data (which CEPA uses instead to derive the input shares) or from an econometric analysis of cost functions. The approach used by CEPA is clearly deficient in light of the usual practice of TFP measurement. It appears that CEPA has not reviewed previous studies and built on established foundation, but chose instead to adopt a fairly discretionary approach for their measurement of TFP growth.

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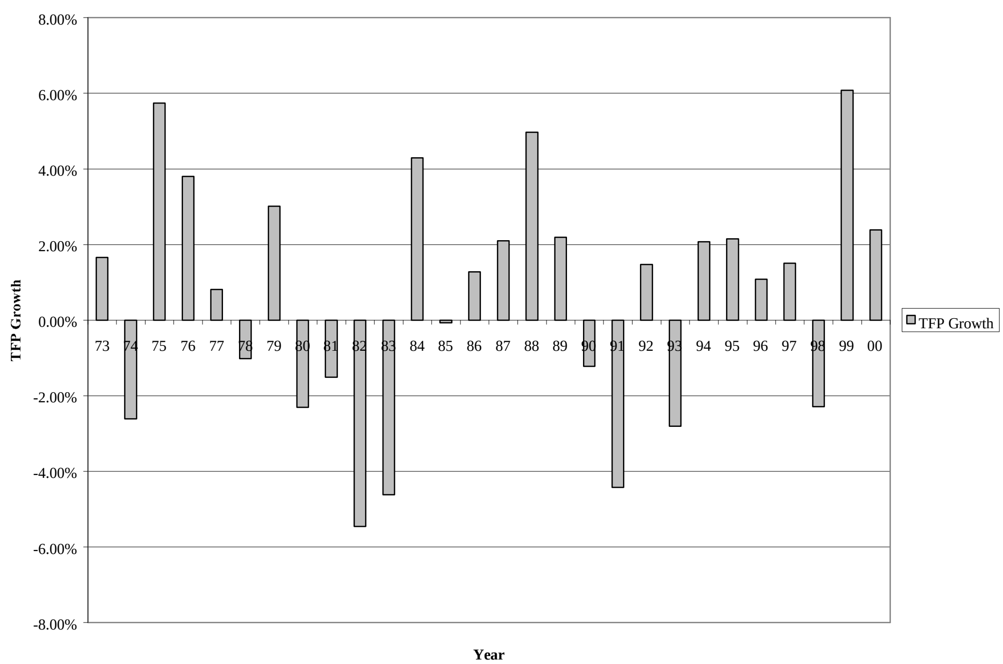
6 CEPA, page 22.

3.3. Section 3.2.1 "Change in Trend"

Short-term trends do not represent a proper source for an X-factor that is supposed to mimic a competitive constraint. The problems with relying on periods as brief as five years are two: (1) productivity-based movements in competitive prices do not respond to short-term trends; and (2) productivity measurements are excessively unstable over short time periods reflecting both short-term accounting trends that have nothing to do with productivity, as such (such as booking costs before regulatory or tax law changes) and vagueness in how companies report costs generally.

Regarding the latter point, the following figure shows annual TFP growth rates for 13 large US utilities for the TFP study we did for Utilicorp in Alberta. It demonstrates the prevalence of yearly variability even under the best of conditions.

Figure 3.1: TFP Growth in 13 Western US Electricity Distributors, 1973 to 2000



Ultimately, the issue of breaks in trend, known as "structural breaks" in the economic literature, becomes a contentious topic, as regulators and others struggle to find a way to move a calculated number subjectively. It is easy to see how the selective use of an arbitrary period, rather than ***the largest time period possible given available data*** (the only objective standard—as illustrated by the graph above) gives great leeway to move the result. CEPA considers many different time periods, some quite short, in Chapter 5, and the resulting estimates of TFP growth vary widely as a result. This forces CEPA to review reasons why the future may be expected to the different from the (recent) past, and to make subjective judgments about which rate of growth is likely to be applicable in the future.

3.4. Section 4.4 "Economies of Scale"

Neither NERA's Energy nor Telecommunications professionals, working with the X-factor, have ever confronted the formula on page 10 (in the literature or in our work).[7] There is a reason for this—it is a mistaken concept with no particular theoretical/empirical grounding and no point in RPI-X regulation. That is to say, it looks to us like a subjective way of discounting valid TFP estimates without any principle or empirical evidence in support. TFP index numbers based on trend data pick up productivity growth from all sources, scale economies included.

The subject of the production technology implied by a Tornquist index number aggregation is interesting to productivity analysts (i.e., it is "exact" to a Translog cost function, which is a linear-in-logarithmic local approximation to any arbitrary cost function). Indeed, the translog functional form was the first that allowed estimated cost functions to be U-shaped, which permitted meaningful estimations of the presence of scale economies. To the extent that scale economies exist in a growing industry, a Tornquist index number study will pick up this source of productivity growth.

As CEPA rightly points out, there is no empirical basis for hypothesizing a change in scale economies over the outputs, firms and time periods involved in a TFP study. However, this lack of empirical basis did not stop CEPA from injecting an unnecessary scale factor into the process anyway, thereby producing a result that is dependent on subjective judgment.

Any regulatory commission will be concerned about the final result of TFP estimates, so any downward adjustment to X for such a subjective purpose will probably be countervailed elsewhere by other, equally subjective interpretations of the results. In any case, whilst CEPA's scale adjustment reduces the estimate of DNOs' trend TFP growth by 0.2% (Figure 3), it also reduces the trend rate of TFP growth for the UK economy by about 0.1% or more (Figuure 11). The impact on CEPA's recommended X-factors of allowing for economies of scale is therefore only the difference between these two figures or about 0.1% per annum. As such, this kind of adjustment, whether up or down, seems both subjective and pointless, needlessly complicates the study and serves to hand the initiative to those exercising a power of arbitrary judgment over the final result.

3.5. Section 4.5 "Capital Inputs"

The best productivity studies use techniques developed by Dale Jorgenson and his students that serve to measure all of the various effects described in this section of the CEPA report. However, due to a lack of adequate information, some analysts do not use the conventional and reliable approach (***e.g.*** the perpetual inventory formula developed by Jorgensen) to

[7] The formula appears inconsistent with the first sentence of Section 4.4, when it says: "unadjusted estimates of TFP growth will overstate…." The formula implies that "understate" would have been CEPA's intended term.

compute a reliable capital quantity index. Instead, they use only what they appear to have at hand. Simply using current cost accounts is liable to understate the growth in the capital stock and overstate the growth in TFP. Technical progress in the production of capital inputs will moderate the inflation of prices for new capital equipment, giving the impression that current cost capital inputs have risen more slowly than the actual quantities involved. As with opex, using total cost figures, instead of the underlying quantities, will contaminate the measure of inputs with the price of inputs and impose additional trends on the data. As a result, estimated trends in TFP will overstate the rate of productivity growth.

CEPA does not describe in detail the method used to calculate the capital stock for British DNOs. Nevertheless, a TFP study is only as good as its capital input measure, and we are reasonably sure that the various measures relied upon by CEPA are inadequate to the task.

3.6. Section 4.8 "Weights"

"How to aggregate?" is the core question in index number studies. Tornquist and Malmquist became famous for discovering new ways to aggregate inputs using, respectively, (a) non-firm-specific or (b) optimally-determined cost shares. The issue of weighting is critical to a TFP study, for when different inputs (or outputs) grow at different rates, the share weights assigned to each input (or output) will be a critical determining factor in the resulting estimate of TFP.

In that respect, as difficult a problem as changing share weights pose, it is not reasonable to fix the share weights, once and for all, as CEPA has done. Failing to allow weights to change will dampen the weighted average effect of the fastest-growing input quantities, which will understate inputs over time and is likely to overstate TFP growth. The effect of fixed weights is complex, however, and we would have to examine CEPA's data to judge the bias more fully.

Suffice to say that the one-paragraph Section 4.8 reveals a huge corner-cutting exercise, which makes the CEPA results very suspect.

3.7. Section 5.1 "Data"

3.7.1. Outputs

CEPA discusses the normal outputs that we can measure (miles of lines, number of customers and kWh sold). Nevertheless, CEPA's discussion of output growth should not be trusted as being based on ***ex ante*** criteria. There is no good reason simply to use the weights from the 1999 Ofgem study.

3.7.2. Economies of Scale

The scale adjustment remains out of touch with what the X-factor is supposed to represent, and ignores the fact that Tornquist TFP growth calculations already embody the desired scale effects.

The point of the exercise is ***not*** to predict costs, as CEPA implicitly posits on page 10. The point of the exercise is to obtain a reliable and objective (and stable) long-term estimate of productivity growth that will impose a competitive-like constraint on prices. Productivity analysts really know very little about the source of TFP growth—good empirical estimates are rare and often unstable. Furthermore, there are other "economies" and (capital utilization, density, etc.) that interact with scale. As such, this whole discussion merely adds a highly subjective element to a procedure whose purpose is to remove or reduce the need for subjective judgment by the regulator.

3.7.3. Quality

A Tornquist index can include any factor: capital, labor, materials, quality, regulatory reliability, etc. Some analysts do include a wide range of variables in a "kitchen sink" TFP studies. However, we know of no credible study that has included quality parameters into a TFP study. It is hard enough to measure the basic inputs and outputs. Treating "quality" as another output would appear to be a subjective morass which no method of resolution.

Overall, CEPA's adjustment for quality appears to be a somewhat shallow piece of work, at least when compared with some other recent work (for instance, that submitted in the New Zealand proceedings).[8] However, the effect of such an addition to the methodology is clear: increasing quality means more outputs with the same inputs, higher TFP measurement and X-factor.

CEPA does not discuss whether there has been any similar (unmeasured) increase in the quality of output in the economy as a whole. If so, the impact of including quality measures on the X-Factor would be partly offset. Since the overall impact is only 0.1% (Figures 3-5), it seems unnecessary and unduly subjective to include such an effect.

3.7.4. Mid-year estimates of stock variables

In theory, we are dealing with ***growth rates*** from year to year. We have never heard it said in credible circles that year-end balance sheets and other year-end data are not suitable when measuring year-to-year growth. Anyone who has wrestled with hugely more critical capital stock questions would marvel at any time spent searching out mid-year stock data. Even CEPA says that this manipulation of the data doesn't matter, so we do not think that this aspect is worth considering.

3.8. Section 5.3: Assessment

In this section, the effect of including or omitting 2000/01 data is notable and should have dictated some caution in accepting TFP estimates that are so far out of line with estimates for other companies and sectors. However, CEPA suggests that they were persuaded to accept the higher estimate by discussions with Ofgem, which undermines the ***a priori*** objectivity of the exercise. DNOs may be able to bring other evidence to bear on the fall in distribution business costs observed in the regulatory accounts for 2000/01, and in particular of the reallocation of costs to other businesses.

In this section, CEPA seems undecided as to how to appraise its own results. It describes the result of 4.2% (quality adjusted TFP growth) as its "central case" (perhaps of past TFP growth), whereas the executive summary names 2.4% as CEPA's "central estimate" (apparently of future TFP growth). Such a lack of clarity requires the regulatory to exercise an unnecessary degree of discretion over the interpretation of CEPA's results.

3.9. Section 6: TFP Growth in the UK Economy

CEPA is right to acknowledge that the X-Factor must exclude (i.e. be reduced by) economy-wide TFP growth and this item ought not to provoke much dispute. CEPA quotes estimates of TFP growth for the UK economy derived from NIESR data that are remarkable for their stability. Leaving aside the estimate for 1995-99 (which is too short to provide an unbiased estimate), the values range form 1.36% to 1.43%, or 1.4% to one decimal place (i.e. to one tenth of a percent). Even after allowing for CEPA's unorthodox and subjective treatment of scale economies, the range only widens to 1.28% to 1.43%, i.e. 1.3-1.4%. Further debate of this number would be unnecessary, were it not for CEPA's omission of a quality adjustment in parallel to the equivalent adjustment to the TFP growth of DNOs. In practice, it would be more objective to omit any consideration of quality from both numbers and to accept the NIESR's numbers without debate.

3.10. Section 7: TFP Growth in Other UK Sectors

3.10.1. NGC

CEPA's analysis of NGC is subject to the same biases as the DNO figures (assuming a common methodology and use of similar data sets). However, CEPA's estimate for NGC's TFP growth (excluding volume and quality effects) is only 2.6% - much lower than for DNOs. This difference would be surprising, given that DNOs and NGC faced similar opportunities and incentives for cost reduction after privatisation. However, part of the difference is due to CEPA overestimate of DNOs' TFP growth, due to the effect of costs

[8] Meyrick and Associates, "Regulation of Electricity Lines Businesses; Resetting the Price Path Threshold -- Comparative Option", Report prepared for the Commerce Commission, Wellington, NZ, 3 September 2003

being ***reallocated*** to other businesses, principally supply and metering. NGC has fewer opportunities to reallocate costs and so its regulatory accounts figures are less prone to such biases.

As noted above, CEPA mis-report the estimated TFP growth of NGC in the summary tables and the start and end of the report. This error is important, since it hides the extent to which the DNO figure is anomalous.

3.10.2. Water and Sewerage

CEPA's estimates of TFP growth for the water and sewerage sectors seem to omit a number of quality improvements in the treatment of sewage, which would raise TFP figures for the sewerage businesses, and the quality adjusted trend figures for the water-only business of 10% seem too high to be credible, given the long-term nature of investment in the industry. However, CEPA's estimates of TFP growth are so sensitive to subjective assessments of quality improvement as to be practically useless in the current debate.

3.10.3. Telecoms

The telecommunication TFP numbers (over 13%) are vastly higher than anything credible that NERA has seen in that industry (which tend toward the range of 3-4%, at the highest). It is not credible to assert that the difference is due to British conditions of privatisation or regulation.

3.10.4. Railtrack

The period (1995/96-2000/01) for which CEPA estimates Railtrack's TFP growth is too short to provide any indication of a trend figure; CEPA is also reluctant to place much weight on the resulting estimate.

3.11. Section 8: US TFP Estimates

There are a few problems with CEPA's estimate of TFP growth numbers for the US distribution sector:

- FERC Form 1 does not, by itself, segregate distribution activities effectively. Dissecting ***pro forma*** distribution companies from the integrated companies that report the numbers takes much more work than CEPA indicates that it has done. Depreciation is handled incorrectly and CEPA has made no attempt to adjust for the tax consequences of holding capital.
- We presume that CEPA used fixed share weights, which will corrupt their results in unpredictable ways.

- The description of CEPA's method of estimating capital inputs seems to contain some typographical errors which make it difficult to follow.[9] However, simply converting HCA to CCA does not reflect a true capital quantity for TFP purposes. Sufficient data exists with Form 1 to do "perpetual inventory" capital stock measures, as per the standard methodology for calculating TFP growth.

- At over 2.0%, CEPA's estimates of TFP growth are considerably higher than current estimates from a number of sources (including our own), which tend to be around 1.0%. The "volume adjustment" brings the numbers more in line, but that adjustment has no basis, as we have said, in RPI-X regulation.

9 On page 43, in the discussion of US data, the words "convert" and "derive" seem to have been transposed inadvertently in the seventh and eighth bullets. The reference to a 1997 inventory of assets seems inconsistent with the previous reference to 1977.

4. ESTIMATE OF THE RESULTING BIAS

The overall impact of these methodological flaws might be to create an upward bias in CEPA's TFP estimates. To give an idea of the potential gap, we review a TFP study that NERA did for a sample of US electric distribution companies for the period 1972-2000.

Our data set included 45 companies with more than half a million customers, a group comparable to largest 50 companies studied by CEPA. Both TFP estimates rely on the same source (FERC Form 1) and apply a Tornquist index, but differ substantially in terms of the input and output measures used. In particular, our study performs a rigorous measurement of quantity indexes. In the case of capital, we apply the standard and reliable perpetual inventory method and we also derive an appropriate measure of the price of capital.

We found that the annual TFP growth rate of U.S. power distributors was 1.4% during the 1972-2000, while CEPA came up with 2.6% for the 1992-2001 sub-period. This comparison gives some indication that CEPA's TFP estimates may be inflated by 1% or more, due to the weakness of their output/input measurements.

This difference applies only to the estimate of TFP growth for US distribution companies using Form 1 data. The difference would be compounded by biased downward trends in the cost figures shown in regulatory accounts for British DNOs, e.g. because of costs being reallocated to other businesses over time. A further 1% difference arises out of the treatment of cost data for 1999/2000.

Hence, CEPA's method appears to overestimate TFP growth, even when applied to a (roughly) common data set, and to suffer from additional upward biases due to the use of regulatory accounts data. Overall, CEPA's work appears to be too unreliable for direct use for setting X-factors, as it is biased upwards. Moreover, although CEPA discusses the difference between "frontier shift" and "catch-up", there is in practice no objective basis for measuring these components separately, and no theoretical basis for adding them to an unbiased estimate of TFP growth.

APPENDIX A. DERIVATION OF THE ANNUAL PRICE CAP ADJUSTMENT FORMULA[10]

The annual RPI-X price cap adjustment formula is designed to emulate competitive markets in that, if a company exceeds industry average productivity growth, its earnings will increase above the average rate (i.e. the cost of capital), and if it falls short of industry average productivity growth, its earnings will decline below the average rate. 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. In other words, prices are set at a level sufficient to recover costs (including the cost of capital) and no more. For the industry, we can write this relationship as:

$$\sum_{i=1}^{N} p_i Q_i = \sum_{j=1}^{M} w_j \ R_j \quad , \quad \text{(Equation 1)}$$

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.

Differentiating this identity with respect to time yields

$$\sum_{i=1}^{N} \dot{p}_i Q_i + \sum_{i=1}^{N} p_i \dot{Q}_i = \sum_{j=1}^{M} \dot{w}_j R_j + \sum_{j=1}^{M} w_j \dot{R}_j \quad , \quad \text{(Equation 2)}$$

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

$$\sum \dot{p}_i \left(\frac{Q_i}{REV} \right) + \sum \dot{Q}_i \left(\frac{p_i}{REV} \right) = \sum \dot{w}_j \left(\frac{R_j}{C} \right) + \sum \dot{R}_j \left(\frac{w_j}{C} \right), \quad \text{(Equation 3)}$$

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

$$\sum_i rev_i dp_i = \sum_j c_j dw_j - \left[\sum_i rev_i dQ_i - \sum_j c_j dR_j \right], \quad \text{(Equation 4)}$$

[10] This is a reproduction of Appendix A from: Makholm, J.D., and Quinn, M.J., "Price Cap Plans for Electricity Distribution Companies using TFP analysis,: NERA Working Paper, April 1997.

where ***d*** denotes a percentage growth rate: $dp_i = \dot{p}_i / p_i$. The left-hand term in Equation 4 is the revenue-weighted average of the rates of growth of output prices, and the first right-hand term in Equation 4 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

$$dp = dw - dTFP \,. \quad \text{(Equation 5)}$$

In words, the theory underlying the annual 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 demonstrates that TFP is the appropriate foundation for a productivity target in the RPI-X price cap plan: if the plan begins with revenues which just match costs—and if a company attains the same productivity growth as the industry—measured in terms of TFP—then the company's revenues will continue to match its costs.

Applying this rule, we write

$$dp^* = dw - dTFP \quad \text{(Equation 6)}$$

where dp^* represents the annual percentage change in industry output prices, 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

$$dp = dw - dTFP + Z^* \quad \text{(Equation 7)}$$

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.[11] 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 7 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 taken as a measure of the industry's input price growth and X was its TFP growth target, Equation 7 would indeed be the basis for the ideal price adjustment formula. However, there are two errors in this interpretation:

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

1. 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.[12]
2. X 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 7 is the absolute TFP growth for the industry. Again, unless economy-wide TFP growth is zero, X is not equal to $dTFP$.

To get from Equation 7 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. 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, the difficulty of measuring input price growth is avoided.

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 7 above

$$dp^N = dw^N - dTFP^N + Z^{*N} \quad \text{(Equation 8)}$$

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 8. Subtracting Equation 8 from Equation 7 gives

$$dp - dp^N = \left[dw - dw^N\right] - \left[dTFP - dTFP^N\right] + \left[Z^* - Z^{*N}\right] \quad \text{, (Equation 9)}$$

or

$$dp = dp^N - \left[dTFP - dTFP^N + dw^N - dw\right] + \left[Z^* - Z^{*N}\right] \quad \text{, (Equation 10)}$$

which simplifies to

$$dp = dp^N - X + Z \text{ . (Equation 11)}$$

12 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.

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 11. This price change is given by:

1. the rate of inflation of national output prices dp^N ,
2. less a fixed productivity offset, ***X***, which represents a target productivity growth differential between the annual TFP growth of the industry and the whole economy,[13]
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 11 into the formula (expressed as a change in the price cap index over time):

$$PCI_t = PCI_{t-1} \times \left[1 + GDP\_PI_t - X \pm Z_t\right] \quad \text{, (Equation 12)}$$

where PCI_t is the value of the RPI-X price cap index in year ***t***, and Z_t is the difference in the effects of exogenous changes on a specific company and on the rest of the economy.

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***. 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,[14] ***plus*** (3) the difference between 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 reported by government agencies annually, but ***X*** 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

13 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 $dw = dw^N$. Over reasonably long periods of time, measured input price growth rates for the gas industry and the rest of the economy are likely to be the same.

14 Adjusted for possible differences between input price growth rates for the industry and the nation.

productivity target, its earnings will fall. This system of rewards and punishments sets up the same incentives as an unregulated company 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.