USE OF TOTAL FACTOR PRODUCTIVITY ANALYSES IN NETWORK REGULATION

CASE STUDIES OF REGULATORY PRACTICE

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1 Introduction and observations from the case studies

The Australian Energy Markets Commission (AEMC) has asked us[1] to review the use by regulators of Total Factor Productivity (TFP) methodologies in setting price/revenue controls for network companies. In this report we describe the use of TFP in the context of regulating the following industries:

- electricity distribution in New Zealand;
- gas distribution in Ontario, Canada;
- energy networks in the UK;
- electricity distribution in the Netherlands; and (in less detail)
- uses of TFP in selected jurisdictions in North America.

We stress at the outset that this report is limited in scope. It describes two aspects of price control arrangements in other jurisdictions:

- How the regulator has gone about the process of undertaking a TFP study; and
- How they have used the results of such studies in determining the maximum allowed growth rate of regulated prices.

The descriptions provided are limited to those two points, and are purely factual. Thus we do not discuss broader issues around the setting of regulated prices under price cap regulation, of which there are many.[2] And the report is not in any sense a critical evaluation of the TFP analyses undertaken by the regulators, or of the use made of them in setting prices in those jurisdictions.

This introductory chapter is organised as follows. We first give some definitions and conceptual clarifications concerning productivity and efficiency. We then lay out a "typology" of TFP studies, i.e., a list of the main parameters that describe a given TFP study. We use this typology in the report, to provide a common format for summarising the different approaches seen to doing TFP studies. We go on to discuss different ways in which regulators can use the output of the TFP studies in determining price caps. Finally we provide some observations on the experience described in the case studies.

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[1] This report has been prepared by Toby Brown and Boaz Moselle of *The Brattle Group*, with input and advice from Professor Jeffrey Bernstein of Florida International University. For the avoidance of doubt, any views expressed in this report are those of the authors, and do not necessarily reflect the views of Professor Bernstein.

[2] For a more general theoretical discussion of the setting of price caps under price cap regulation, as well as of the merits of price cap regulation and other issues, see Handbook of Industrial Organisation ch. III, Chapter 1. Recent Developments in the Theory of Regulation (Mark Armstrong and David Sappington) and references therein.

1.1 Definitions and conceptual clarification

What is productivity, and how is it different from efficiency?

Productivity involves measuring actual outputs versus actual inputs. It is a relative concept, i.e., one can only really meaningfully take about changes or differences in productivity. In contrast, efficiency is about comparing the actual use made of inputs to produce outputs with the best that is possible with available technology. An example will help to clarify, and also shed light on the difference between productivity and efficiency.

Suppose that there are two firms, A and B, both active in a market, over two successive time periods. The two firms use the same kinds of input to produce the same kinds of output, with identical technology, and facing identical prices, which do not change from one period to the next. In the first time period suppose that the two firms behave identically: each produces the same quantity of output using the same quantity of input. Suppose also that in the first period both firms are technically efficient: neither could produce more output than it does, given the set of inputs it is using.[3]

Suppose that in the second period firm A behaves exactly as it did in the first period (same inputs and outputs). Suppose however that technology advanced between the first and the second period, so that in fact it is possible in the second period to produce more than in the first period with the same set of inputs. Suppose that firm B takes full advantage of this, increasing its output by the maximum amount made possible by the technological progress.

In this case we would say that:

a. Firm A's productivity was unchanged from period one to period two: it produced the same level of outputs from the same inputs. But,

b. Firm A's efficiency went down: in the first period it did as well as possible, in the second period it could have done better, producing more output with the same inputs, thanks to technological progress.

Conversely, firm B's productivity increased, but its efficiency remained unchanged.

What is total factor productivity?

Total factor productivity refers to a range of methodologies designed to make productivity comparisons of the kind described in the example above, in cases where the firm uses multiple inputs and/or produces multiple outputs. It can be contrasted with partial factor productivity measures (e.g., output per worker), which have a clear potential to be misleading if used for purposes of comparison (e.g., one firm may have higher output per worker than another because it is more productive overall, or because it has invested much more in capital).

[3] And the set of inputs is the best set of inputs available to produce the given set of outputs.

How is TFP growth calculated?

Typically there are two approaches to the calculation of TFP growth; 1) the index number approach and 2) the econometric approach. The index number approach applies an index number formula to construct TFP growth rates.[4] Input and output indices are constructed to aggregate all of the inputs used and the outputs produced, and the TFP growth rate is defined as the difference between the rate of output growth and input growth. The econometric approach specifies a functional form for a cost function (for all of the regulated firms under consideration) and then from the estimates measures TFP growth.[5]

There are a number of advantages, as well as, limitations to each approach. The index number approach does not involve any assumptions regarding the production process or producer behaviour. In addition, there is essentially no limitation on the number of outputs and inputs that can be considered in the analysis. However, with this approach no other features of the production process, such as the degree of economies of scale, can be gleaned from the analysis.

The econometric approach involves the specification of equations describing the production process, and firm behaviour, such as cost minimization. The econometric approach typically requires a more extensive set of assumptions compared to the index number approach, it also provides for a wide range of results. It is possible to determine TFP growth rates, but in addition scale and scope economies, for example. However, a practical constraint of the econometric approach is the limitation on the feasible number of outputs and inputs in the analysis. In addition, it is often difficult to disentangle scale effects from technological change effects in econometric models of firm behaviour.

Note that TFP indices make no attempt to measure whether the firm was producing as much as possible with the given inputs, or chose the right mix and quantity of inputs to produce its level of outputs. In other words, TFP indices do not (and do not purport to) provide any information about efficiency or changes in efficiency. At most one may get an indirect sense of changes in efficiency, if one firm's TFP growth is much different from that of its industry peers (although that could also be due to other reasons, such as changes in scale of production).

Other non-TFP methodologies are available that attempt to assess efficiency or changes in efficiency. As with the econometric approaches to TFP growth however, these typically require more extensive assumptions (e.g., about the nature of the available technologies), and rely on econometric approaches or other more complex mathematical methods (e.g., linear programming).

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[4] There are a number of different ways to select an index number formula. For a discussion of these issues see Jeffrey I. Bernstein and Charles Zarkadas, "Measurement of TFP Growth for U.S. Telecommunications", in R. Cooper and G. Madden ed., *Frontiers of Broadband, Electronic and Mobile Commerce*, Physica-Verlag Press, 2004.

[5] A reasonably elementary introduction to this highly technical topic can be found in Coelli, Prasad Rao, O'Donnell and Battese, *An Introduction to Efficiency and Productivity Analysis*, Springer.

1.2 Typology of TFP practice

In this section we present some key design features of how TFP growth can be measured and applied in practice.

1.2.1 *The choice of benchmark firms*

As discussed above, the regulated firm's price control should not depend only on its own historic TFP performance. Typically the sector-wide average TFP growth would be used (so that an individual firm's own performance would not readily influence the result). The benchmark firms should, however, be comparable to the firm(s) for which prices are being set. For example, when a firm or firms are substantially smaller in size (defined by revenues or numbers of customers) or operate in a distinctive environment (such as small rural areas) compared to the average firm, separate benchmarks could be used for these firms. Firms facing the same regulatory and operating environment but which are not regulated by the same authority could be included in the study, for example when there are so few firms in the "home" jurisdiction that the results be driven by individual firms, or be too noisy, or indeed if the "home" jurisdiction does not have enough data to carry out a robust study.

1.2.2 The time period for measurement

Since TFP growth rates fluctuate yearly, it is preferable to use the longest historical time period possible to conduct the TFP study. In particular, TFP growth rates averaged over the longer term mitigate the impact of short-run cyclical variations (including that of the business cycle), temporary and one-time events. In general it makes sense to use the most recent data, unless the recent past exhibits anomalous events. It may be necessary to exclude certain years if they are unlikely to be representative of future changes (for example, the impact of severe storms).

1.2.3 Impact of investment programmes

Large capital projects, embodying technological advances, may be required over some time period, followed by a period of relatively low investment. These discrete capital additions initially lead to higher costs and thereby lower measured productivity growth. In later periods, once the new capital is deployed, productivity growth increases. As a result industry TFP growth, and thereby also the X factor, may be initially understated, while overstated in later periods. Using long-term TFP growth rates helps to reduce the impact of year to year volatility.

1.2.4 The data and measurement of TFP Growth

Annual industry TFP growth rate measures the difference between the rate of growth of outputs and inputs. Different methods use different ways of aggregating inputs and outputs, and the necessary data may come from regulatory accounts or other sources.

1.2.5 Calculating X from the measured TFP

Under a "pure" TFP approach, the X factor is equal to the measured TFP growth in the regulated sector, plus an adjustment for any difference between the inflation index used in the price cap and the rate of input price inflation for the regulated sector. Other ways of using the measured TFP rate are also possible (see the case studies).

1.3 TFP methodologies from the case studies

Section 1.2 described a “typology” of TFP methodologies. We use this typology to summarise in Table 1 the characteristics of the methodologies used in the case studies we describe later in this report.

Table 1: TFP methodologies from the case studies

	New Zealand	Great Britain	The Netherlands	Ontario, Canada
The choice of benchmark firms	All 28 electricity distribution companies in New Zealand.	Various benchmark sectors, including international electricity distribution and other UK regulated sectors. For gas distribution, a "composite" benchmark made up of a combination of various sectors of the economy judged similar to gas distribution in terms of the operating environment and nature of the business.	All ten electricity distribution companies in the Netherlands.	36 gas distributors in the United States (or a subset of this group, selected to be appropriate comparators for the Canadian firms).
Time period	Preceding eight years (no data prior to this).	Eleven years for analysis of UK electricity distribution; back to 1973 for analysis of "composite" of various sectors.	Preceding 3 years for the latest price review. Before this period less efficient firms were assumed to have been increasing efficiency at an unsustainably rapid pace immediately following the introduction of price caps.	Preceding ten years.
Investment programmes	An issue is that the companies may now be investing to improve quality, which would depress TFP since quality is not part of the output index.	Not an issue because the productivity analysis was used only to forecast partial labour productivity. Capex was determined on a building-blocks basis.	Not an issue discussed by the regulator.	Not an issue discussed in the case.
Data: outputs	Customer numbers, units distributed, network capacity (MVA-km). Weights based on an econometric model.	For electricity distribution, a composite of customer numbers and units distributed, with the weights based on regulatory precedent derived from econometric work. A quality measure was also added, with the weights based on regulatory precedent.	Revenue-weighted customer numbers and units distributed (outputs based directly on the companies' charges).	Customer numbers and volume throughput, either weighted econometrically or by revenue shares.
Data: inputs	Operating costs divided by price indices; quantity measures of assets used (eg, installed kVA of transformers), multiplied by average proportions of asset base in the various asset classes, multiplied by assumed cost of capital and depreciation schedule. Opex and capex quantities weighted together by proportion of total costs.	Opex and capex, cost share weights.	Operating and capital costs, weighted by share of total costs.	Operating and capital costs, weighted by share of total costs.
Calculating X from the TFP	Economy-wide TFP growth subtracted from sector TFP growth. No inflation adjustment (ie, sector input prices assumed to be the same as economy-wide input prices).	A scale effect was assumed in calculating TFP. For gas distribution a significant issue was how to estimate sector-specific input price growth. This was estimated directly rather than by subtracting economy-wide TFP growth because of the importance of imports in determining UK RPI inflation. X factors not directly based on the TFP results.	X set at the measured TFP growth rate. Implicit assumption is therefore that electricity distribution input prices are increasing at the general rate of economy-wide CPI inflation.	Economy-wide TFP growth and difference between economy wide input inflation and sector specific input inflation both subtracted from the measured TFP to derive X. Under the econometric approach, a further factor was added to X to take account of declining average volumes per customer.
Assessing relative efficiency	An additional factor added to X based on a multilateral TFP analysis.	A separate regression analysis was used to identify relative efficiencies. Prices set on the basis of the general TFP growth plus firm-specific "catch-up".	An initial Data Envelopment Analysis was undertaken to assess relative efficiency. Firms judged inefficient were required to "catch up" during the first two regulatory periods. Subsequently all firms have the same X factor.	Not an issue in setting X.

Notes
The information in the table is taken from the text in sections 2 to 6 of this report and the sources cited therein.

1.4 Using TFP to set the X factor

Incentive regulation[6] (IR) places a cap on the regulated firm's prices, either directly or indirectly through capping the revenues that the regulated firm may earn. IR specifies an X factor, which measures the average rate at which the firm's inflation-adjusted prices or revenues may change.[7] IR replicates the discipline that market forces would impose on the regulated firm if they were present. These forces compel unregulated firms that realize productivity gains to pass these gains on to their customers in the form of lower prices, after accounting for changes in input prices. Thus, if all industries in an economy were competitive, output prices in the economy would grow at a rate equal to the growth rates of input prices net of TFP growth. If the regulated industry were just like the typical industry in a competitive economy, the discipline of competitive forces could be replicated by limiting the rate of growth of regulated prices to the economy-wide rate of input price inflation, less the economy-wide rate of TFP growth.[8]

"Pure TFP" approach to setting the X factor

In setting the X factor, regulators need to take account of the reasons why the prices of the regulated firms might change at a different rate from prices in the economy generally. Differences between the regulated sector and the rest of the economy arise because: input prices for the regulated sector may grow at a different rate from the economy-wide rate of inflation; and the regulated sector may not be able to improve its TFP at the same rate as the rest of the economy. Since the X factor is by definition the difference between output price growth for the regulated industry and the rest of the economy, it follows that a positive (respectively negative) X factor must reflect one or a combination of the following two conditions:

(1) The regulated industry is capable of increasing its productivity more rapidly (respectively less rapidly) than are other industries in the economy; and

(2) The prices of inputs employed in the regulated industry grow less rapidly (respectively more rapidly) than do the input prices faced by other industries in the economy.

In other words, the X factor consists of the following: (1) the productivity differential defined as the difference between industry and economy-wide total factor productivity (TFP) growth rates; and (2) the input price differential defined as the difference between economy-wide and industry input price growth rates.

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[6] The goal of incentive regulation is sometimes expressed as being to mimic through regulation the competitive forces that apply to unregulated (non-natural monopoly) firms. The conceptual framework applicable to the X factor generally used in IR plans relies on the development of the economic principles as outlined in Jeffrey I Bernstein and David E. M. Sappington, "Setting the X Factor in Price Cap Regulation Plans", *Journal of Regulatory Economics*, 16, 1999, p. 5-25.

[7] Incentive regulation typically caps the prices of the regulated firm at inflation less an X or "efficiency" factor. Hence it is often known as "CPI – X" or "RPI – X" regulation (CPI is Consumer Price Index, RPI is Retail Price Index).

[8] This is a simplified discussion of a complex topic. For a fuller discussion see Bernstein and Sappington, *op cit*.

Other ways TFP is used by regulators

An alternative to the "pure" approach described above is to use the historic TFP growth rate as a starting point for setting X. Other factors would also be taken into account: for example, the extent to which the business environment in the future is expected to be different from the past (eg, productivity might be expected to improve more rapidly after privatisation). It is beyond the scope of this report to analyse the advantages and disadvantages of different approaches to setting price controls, but some of the possibilities are discussed below in the case studies.

Standards for TFP measurement for purposes of incentive regulation

When measuring TFP for use in setting X, the TFP measurement should ideally be based on data that:

a. are immutable to the behaviour of the regulated firm and regulator;

b. represent comparable firms; and

c. reflect stable firm performance.

The immutability standard requires that the regulated firm's performance be evaluated with respect to an industry-wide benchmark, rather than the firm's own performance. The comparability standard requires that the operating characteristics of the firms used in the industry-wide benchmark must be similar to the regulated firm under consideration. Lastly, the stability standard prevents discontinuous events from misrepresenting industry performance (eg, a one-off cost shock).

The immutability standard is necessary to help maintain the desirable incentive properties of the price cap approach, and is recognized as follows: [9]

> When multiple firms operate in the regulated industry, it is generally preferable to base the performance standard that an individual firm faces under price-cap regulation on historic *industry* performance, rather than the historic performance of the individual *firm*. Doing so weakens the link between the current performance of an individual firm and the requirements imposed on that firm in the future, and thereby enhance incentives for superior current performance. (Emphasis added)

TFP growth measured in this way is a suitable benchmark for the future performance of the regulated firms only if the future conditions facing the regulated firm are assumed to be similar to historic conditions. If elements can be identified which will cause future TFP growth rates and as a consequence the resulting X factor to depart systematically from historical values then adjustments to the historical values must be made.[10]

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[9] Jeffrey I Bernstein and David E. M. Sappington, "Setting the X Factor in Price Cap Regulation Plans", Journal of Regulatory Economics, 16, 1999, p. 5-25.

[10] For a discussion of such issues, see Jeffrey I Bernstein and David E. M. Sappington, "Setting the X Factor in Price Cap Regulation Plans", *Journal of Regulatory Economics*, 16, 1999, p. 5-25 (hereafter Bernstein-Sappington).

Comparing TFP and "building blocks" approaches

By the "building blocks" approach to price controls we refer to the practice (for example, as applied in the UK) of making detailed firm-specific estimates of future efficient costs over a reasonably long (e.g., five-year) time period. The price control is set such that the total revenue over five years is equal to the estimate of total costs. The building blocks approach thus includes an implicit assumption of the rate at which productivity will change over the course of the price control.

If a TFP analysis is used alongside the traditional building-blocks approach to setting prices, it can be used as a cross-check of the reasonableness of company forecasts.

1.5 Discussion and observations from the case studies

1.5.1 Differences between jurisdictions make it difficult to identify the rationale for using TFP or the specific design of the method used

The institutional setting for the case studies we have reviewed is very different in the different cases. We would hesitate to draw strong conclusions about why different regulators have chosen to use TFP or why they have followed a particular methodology.

In none of the case studies has a pure TFP approach been adopted instead of a traditional "building blocks" approach, although in the New Zealand case the TFP approach could be regarded as a filter for identifying which companies have prices that are high enough to justify the cost of carrying out a full building block price review.

In North American jurisdictions TFP has been used as an alternative to "cost of service" or rate of return regulation. "Building block" type price controls are unknown in the US. In the UK, unlike in the US, the introduction of price-cap regulation coincided with privatisation and industry restructuring.

We are not aware of any jurisdiction in which a pure TFP methodology has been adopted to replace a building-blocks approach.

In none of the jurisdictions we have reviewed is the TFP methodology applied to only a subset of the firms, nor do firms have a choice about what methodology is to be used.

In none of the jurisdictions we have reviewed has the TFP methodology been specified in legislation, nor in fact is there a requirement that the regulator should use TFP. The legislative framework (the role and duties of the regulator) is similar in a jurisdiction which places relatively little emphasis on TFP (the UK) to that in jurisdictions that rely more heavily on TFP (New Zealand, the Netherlands).

1.5.2 TFP analysis can help set the rate at which prices change, but not where they should start from

It is important to emphasise that TFP analysis measures the rate at which firms might be expected to improve their productivity. It can therefore be used to set the *rate* at which the price cap should change. It does not measure firms' profitability, and it cannot help regulators to set initial prices at a level that gives the firms a reasonable profit.

1.5.3 The TFP approach is conceptually simple

A "pure" TFP index approach has strong conceptual foundations.[11] Because it avoids or minimises the use of company-specific cost data, it maximises the incentive properties of the price cap approach. If the regulator is able to avoid analysis of firm-specific cost projections, the task of the regulator is considerably simplified (and the firms have a much-reduced ability to influence the outcome). The New Zealand case best exemplifies this, where the regulatory documents relating to the "threshold" setting process are noticeably simpler than those produced in the other jurisdictions we have reviewed.

Nevertheless, it may be difficult for regulators in all jurisdictions to adopt a "pure" TFP approach, because to do so may not sit easily with the full set of objectives typically set for regulators, in particular a requirement to ensure that regulated firms can fund their activities. We note that although New Zealand has adopted TFP in close to a "pure" form, it is used there only on an indicative basis. In New Zealand, firms have the option to set prices above the thresholds, which would trigger a full "building blocks" review.

1.5.4 The TFP analysis can only be as relevant as the set of benchmark firms

The TFP analysis measures historic productivity growth in a benchmark set of firms. The historical growth rate is only relevant for setting prices if the benchmark set of firms is appropriate to the firms for which the regulator is setting prices. Thus the regulator must investigate whether this is the case. In New Zealand, for example, analysis was performed to check whether "rural" distributors had different TFP growth from "urban" ones.

If there are significant differences between firms, a "normalisation" may be applied to part of the cost base before carrying out the TFP analysis. The Netherlands regulator has adopted this approach.

1.5.5 Regulators sometimes set different targets for different firms

Often the TFP analysis measures productivity growth as an average across all firms in the regulated sector. In this case, by definition, the TFP growth of some firms is higher than the average, and that of the others is lower than the average. Regulators may be concerned that the better-performing firms may not be able to maintain even the average rate of productivity growth in the future, and that the less productive firms should be given tougher targets to drive improvement. Regulators may supplement the TFP analysis with a relative productivity analysis to identify which firms have performed better than average, and by how much. To do so requires using methodologies other than a TFP index (and as mentioned above, making stronger assumptions in doing so). In New Zealand it was done by using "multilateral TFP analysis", and

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[11] This is not to say that the method does not require good data: "Although in theory, the types of data required differ for different methods, they can often be the same or similar in practice. Good quality data, collected on an industry-wide basis over a long time period, underpins all methods." (*Resetting the Price Path Threshold, discussion paper*, Commerce Commission (May 2003).)

in the UK it was done via econometric methodologies. In these cases different efficiency targets were set for different firms.

1.5.6 TFP analysis does not identify "inefficiency"

As discussed earlier, a TFP index measures the rate at which the productivity of a group of firms changes over time. It does not identify whether the average firm or any particular firm is "technically efficient". Alternative methods (such as DEA or stochastic frontier methods) can identify such inefficiencies, and have been used to set higher X factors for "inefficient" firms, although it should be noted that the robustness of such methods is much debated. The Netherlands regulator used DEA analysis to set company-specific X factors during the first regulatory period.

1.5.7 Some regulators use TFP methods as part of the building-blocks approach

Some regulators perform TFP analysis, but do not use its results explicitly to set the X factor. In New Zealand, TFP is used to set an I – X type price. If this price is exceeded, the regulator undertakes a more detailed examination of individual firm costs, and is able to impose a price control (which could be based on a "building-block" approach). In the UK, Ofgem continues to use the building block approach to set prices, but TFP analyses are part of the evidence it uses in assessing the rate at which operating costs for the regulated firms might be expected to fall during the price control period. It uses cross-sectional regression analysis to identify the efficient level of operating costs for the start of the price control, but then needs to make an assumption about how this level may change. It has used evidence from TFP studies to help make this assumption.

Because Ofgem uses TFP only in respect of operating costs, the approach is probably better characterised as a partial productivity method. The studies commissioned by Ofgem acknowledge that measuring partial productivity is difficult because of the need to make assumptions about the impact of capital substitution (over time the mix of capital and labour inputs may change, so a study of either one of them in isolation must be corrected for this change). In some cases, the results of a partial productivity study are sensitive to the assumptions about capital substitution.

1.5.8 TFP methods can be technically difficult and controversial

In practice, TFP analysis seems to be an area where regulators rely heavily on outside expertise (consultants) to conduct the analysis and even to design the analytical method. All of the cases we have looked at have involved external consultants applying their preferred methodology. Particularly if an econometric model is involved, this can mean that the analysis becomes a "black box", making it difficult to be sure that the results are robust and hard to get agreement from the regulated firms or other stakeholders. The results can be sensitive to small changes in the method: for example, the choice of depreciation schedule to price the capital inputs can be significant (the Ontario case).

Technical choices in the design of the method can have significant impacts on the results. For example, in the Ontario case two different methods were proposed which resulted in X factors that differed by about 2%. In the TFP analysis for gas distribution (a case in which there was no detailed time series data for the regulated sector), Ofgem's consultants recommended using a TFP growth rate in the range of 0.1%–4.8%, in part because different TFP methods gave rather different results. This range is rather wide compared to the typical magnitude of X factors adopted by regulators.

Particular controversies/difficulties seem to arise with constructing a composite output measure, with pricing the capital input component of the composite input measure, in specifying appropriate capital input quantity measures and in adjusting for operating environment differences. The difficulty with weighting outputs is sometimes that a relevant output may not be directly sold, so cannot be assigned a revenue weight. For example, in New Zealand the “capacity” of the network was used as part of the composite output. Incorporating service quality has also proven problematic: if service quality is not measured as part of the TFP analysis, companies which invest to improve service quality are penalised with a low TFP score. Including service quality in the analysis is difficult because it is hard to value.

2 New Zealand electricity distribution[12]

2.1 Industry structure

The major reform to New Zealand's electricity industry was corporatisation as a result of the *Energy Companies Act 1992*. Further reforms were enacted through the *Energy Industry Reform Act 1998*, which required vertically-integrated companies to sell off generation and retail supply arms. As a result of these reforms there are now 28 stand-alone distribution companies of various sizes and various ownership types. They range from 5,000 to 500,000 customers, and from a few publicly-listed companies to a large number of companies owned by community trusts.[13] Legislative and regulatory framework

New Zealand's approach to its electricity industry post corporatisation was relatively unusual in that there was initially no explicit control of the monopoly parts of the industry. Information disclosure requirements were then applied from 1995 onwards.[14] The underlying logic was a belief that disclosure itself would act to control the extent to which the monopoly parts of the industry exercised their dominant positions to the detriment of their customers.[15] This "hands-off" approach continued until 2001, when the Commerce Commission was given regulatory authority over the monopoly parts of the industry, under part 4A of the *Commerce Act 1986*.[16,17]

The objective of the regulatory framework as set out in the relevant legislation is:

> "to promote the efficient operation of markets directly related to electricity distribution and transmission services through targeted control for the long-term benefit of consumers by ensuring that suppliers
>
> a) are limited in their ability to extract excessive profits; and
>
> b) face strong incentives to improve efficiency and provide services at a quality that reflects consumer demands; and

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[12] Our description of arrangements in New Zealand benefited from helpful discussions with Brattle Senior Advisor Professor Geoff Bertram of the Victoria University of Wellington. Any errors or omissions remain the responsibility of the authors.

[13] Taken from Commerce Commission webpage (http://www.comcom.govt.nz/IndustryRegulation/Electricity/ElectricityLinesBusinesses/Overview.aspx).

[14] The requirements are set out in the *Electricity (Information Disclosure) Regulations 1994* and *1999*.

[15] See discussion in Geoff Bertram and Dan Twaddle, *Journal of Regulatory Economics*, 27:3 281–307, 2005.

[16] Part 4A was added by the *Commerce Amendment Act (No 2) 2001*.

[17] The *Commerce Act* has been modified by the recently enacted *Commerce Amendment Act 2008*, enacted on 16th September 2008. This report describes the regulatory framework prior to this legislative change.

c) share the benefits of efficiency gains with consumers, including through lower prices."[18]

The legislation allows the regulator to apply price, revenue, or other controls to individual electricity distribution and transmission companies, but these controls are only to apply if the regulator first finds that the relevant company has breached certain "thresholds". The regulator has wide discretion on the nature of the thresholds, but in practice the system operates as follows:

1. The regulated companies are required to produce detailed regulatory accounting information in a form set out by the regulator. This information is publicly available.
2. The regulator sets threshold levels of revenues and "quality" (defined quantitatively in terms of interruptions). The revenue thresholds are broadly equivalent to a CPI –X control (and are described in detail below).
3. Each year the regulator assesses whether any of the companies have breached these thresholds—ie, charged too much, or delivered low quality.
4. If there is a breach, the regulator can impose detailed control of prices, revenue, and quality, and can also require the payment of compensation if the controls are not respected.

The thresholds approach is seen as a way of reducing the cost of regulating a relatively large number of small companies (in comparison to a full building-blocks type approach):

The thresholds are, in effect, a screening mechanism to identify lines businesses whose performance may warrant further examination through a postbreach inquiry and, if required, control by the Commission.[19]

There have been several findings of breaches of the thresholds. Following a breach, the regulator conducts a more detailed investigation of prices, more along the lines of a "building-block" approach.[20] The outcome of a post-breach inquiry can be a negotiated settlement between the company and the regulator, such that the thresholds would in future be respected. None of the distribution companies are currently formally subject to "control" by the regulator.

2.2 Development of TFP in this jurisdiction

2.2.1 Choosing a TFP approach

Prior to the introduction of the current arrangements (in 2001), the electricity distribution sector was essentially un-regulated.

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[18] *Commerce Act 1986* s. 57E.

[19] *Resetting the Price Path Threshold, draft decision*, Commerce Commission (September 2003).

[20] See, for example, *Reasons for Not Declaring Control, Unison Networks Limited*, Commerce Commission (May 2007).

TFP is not mandated by the current legislative framework, which gives the regulator broad discretion in the kind of thresholds it sets and how it goes about setting them. In regulating the industry in accordance with the objectives quoted above, the Commerce Commission has chosen to set thresholds in line with an CPI–X regime, where X is based (in part) on a TFP analysis. To date, the regulator has not directly assessed the absolute level of prices—it has set price thresholds expressed as annual rates of change in price starting from the then current levels.[21] It has not imposed any one-off "P_0" change in prices (which are typically used to reset prices to a level more reasonably in line with costs at the start of a price control period).[22]

In deciding how to implement the regulatory framework (for the 2001–2004 period) the regulator started by considering two possible approaches to setting an CPI–X regime:

a) a cost-based building-block approach; or

b) an approach based on estimating the rates at which prices should change to reflect underlying productivity growth (which would involve TFP analysis).

The Commission considered that the latter approach would be preferable, because it is less resource intensive—unlike the building-block approach, a TFP analysis does not involve forecasting costs for each regulated company. This is possibly a particular concern in New Zealand which has 28 electricity distributors, most of which are small. However, it also initially concluded that the quality of data available was insufficient to make the second approach workable.[23] In the event, it is not clear what methodology was used in setting X for the first threshold period of 2001 to 2004.

Ahead of setting new thresholds for the 2004–2009 period, the regulator considered two broad options, both of which would include industry-wide productivity changes as a component of X.[24] The first method ("comparative approach") would base X on the sum of sector-wide productivity changes and firm-specific "price efficiency". Under this method, X is equal to the sum of three factors: "B", the sector-wide productivity change; "C_1", which is positive for firms with low relative productivity (relative to the sector-wide average) and negative for firms with high relative productivity; and "C_2", which is positive for firms with above sector-average profitability and negative for less profitable firms. The second method ("partial building-block")

[21] The thresholds regime is, however, designed such that all the firms should converge on the average level of profitability.

[22] However, the Commerce Commission has signalled an intention to make "P_0" cuts in the next threshold reset.

[23] *Regulation of Electricity Lines Businesses, discussion paper*, Commerce Commission (May 2002).

[24] The regulator also set separate quality thresholds, and it considered setting profitability thresholds also. The latter idea was dropped because of its poor incentive properties. (See *Targeted Control Regime Implementation Details, draft decisions*, Commerce Commission, January 2003.)

would base X on the sum of sector-wide productivity changes, firm-specific analysis of costs, and firm-specific analysis of price/service quality trade-offs.[25]

The key difference between the two approaches is that the first does not look in detail at firm-specific costs, whereas the second does.

The regulator chose to use the "comparative" method, using TFP both to assess the rate of sector-wide productivity growth, and (multilateral) TFP to class individual companies into three groups according to productivity. Both TFP analyses are described below.

As considered by the New Zealand Commerce Commission, both the "comparative" and the "partial building-block" approach would involve TFP analysis to assess the prospects for sector-wide improvements in efficiency. The regulator has therefore not explicitly considered methods that do not rely on TFP. However, the regulator did comment that index methods may be better when firms are similar and are earning similar profits, and that building-block methods have typically been used at the start of the regulatory regime and where there was a risk that initial prices might have been unreasonable.[26] In choosing the comparative approach over the partial building-block, the regulator states that one reason for preferring the former is that it is less resource-intensive. Crucially, given the "two-level" approach to controlling prices in New Zealand, the regulator considers that it does not matter too much if the comparative approach results in a threshold that is too low for a given firm: the process that is triggered by a breach of the thresholds gives the regulator (and the firm) an opportunity to explore in detail the extent to which the firm's prices may be excessive—presumably including at this stage an analysis of firm-specific costs.

The administrative cost of the building-blocks approach seems to have been a factor behind the Commission's preference for a top-down comparative approach given the number of businesses and the relatively small size of some of the businesses. The fact that many of the businesses are small and publicly-owned may also have been a factor.

The costs and complexity of regulatory arrangements should be commensurate with the relatively small size of New Zealand's electricity industry and the Commission therefore has reached an initial view that benchmarking [ie, the comparative efficiency approach] *should continue to be used as the primary approach to set the thresholds.*[27]

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[25] *Resetting the Price Path Threshold, discussion paper,* Commerce Commission (May 2003).

[26] *Resetting the Price Path Threshold, discussion paper,* Commerce Commission (May 2003), pp. 19–22.

[27] *Threshold Reset 2009, discussion paper*, Commerce Commission (December 2007).

The existence of a dataset of regulatory accounts was crucial in allowing a TFP approach to be implemented. However, the regulator also stressed that any method for assessing likely future improvements in productivity would require a good dataset:

Although in theory, the types of data required differ for different methods, they can often be the same or similar in practice. Good quality data, collected on an industry-wide basis over a long time period, underpins all methods.[28]

2.2.2 Impact of TFP on prices

In the New Zealand regulatory framework the regulator does not directly control prices: it sets a threshold for prices which, if breached, triggers a detailed investigation that could result in either price controls or negotiated settlement. We can therefore only examine the extent to which TFP is used in setting the thresholds.

For the first period (2001 to 2004) the thresholds were set at CPI–X with X equal to CPI (ie, constant nominal prices). TFP studies were not explicitly used.

For the second period (2004 to 2009) the thresholds were set at CPI–X with X equal to the sum of three components B, C_1 and C_2. The B factor is the sector-wide relative productivity growth estimate, and was set at 1% (equal to the difference between the sector TFP of 2.1% less the economy-wide TFP of 1.1%). The regulator decided not to make any adjustment for differences in input-price inflation because the data was not clear. The C_1 factor adjusts for relative productivity levels by allocating firms to one of three groups based on high, average and low productivity levels, determined through a “multilateral TFP analysis”, and it took on values of +1%, 0% and –1%. The rational for the C_1 factor was to force the productivity of each firm to converge with the average, on the assumption that the less productive firms would be able to increase productivity more rapidly than the more productive firms. The C_2 factor (profitability) did not depend on TFP (although it was calculated from the same input data), and also took on values of +1%, 0% and –1%. The rationale for the C_2 factor was to force the profitability of each firm to converge with the average. The X factors for the 28 companies thus took on values of –1%, 0%, +1% and +2%.[29] One might therefore say that the price threshold fell by up to 10% over five years as a result of the TFP analysis.[30]

2.2.3 Evolution of the TFP approach

For the third threshold period (2009–2014) it appears that the regulator will adopt a similar methodology, although it is additionally considering a “P_0” reduction in prices to deal with possible firm-specific excess profitability. To date, quality of service has not been included

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[28] *Resetting the Price Path Threshold, discussion paper*, Commerce Commission (May 2003), p. 21.

[29] It is interesting to note that the regulator began the process of setting the 2004–9 thresholds by publishing its intention to class firms into three groups on the basis of relative efficiency and relative profitability, with the three groups to have X-factors of 1%, 3%, and 5%.

[30] The overall threshold changed by between –10% and +5% taking into account the TFP elements and the profitability element.

within the TFP methodology (although a separate quality "threshold" is set). As a result, expenditure to improve quality would appear as reduced productivity, and expenditure cuts that reduced quality would appear as productivity improvements. In the most recent productivity study for the period 2009–2014 this is identified as a significant issue. In 2004 and 2005 TFP growth across the sector as a whole was negative, due to significant cost increases.[31] In light of this the consultants recommended further work to understand the drivers of these increased costs.

2.3 Measuring TFP growth

The New Zealand Commerce Commission used TFP to set components of the X factor in its CPI–X "thresholds" for the period 2004–9. The regulator's conclusions mirror those of its consultants who conducted the analysis.

2.3.1 Sector productivity measurement

Scope

The Meyrick report[32] uses the Fisher TFP index formula to calculate TFP growth rates and a multilateral TFP index to calculate TFP levels, applied to all 28 electricity distributors in New Zealand. Eight years of data were used, 1996–2003. The results of the analysis were compared with a number of earlier studies, including studies from other jurisdictions, but results from elsewhere were not directly used in the analysis.

Inputs and weighting

The approach taken to measuring capital inputs is the "direct" one, whereby the physical quantities of inputs (number of transformers, etc) are measured rather than their cost. This approach was preferred for a number of reasons, including that it is not sensitive to changes in valuation methods over time.

The TFP analysis used five inputs.

1. Operating expenditure, measured as the reported direct operating cost per km and indirect cost per customer, multiplied by the number of km and customers, respectively, divided by an index of labour costs in the electricity, water and gas sectors.
2. Overhead lines, measured as total line length multiplied by a weighting factor for each voltage (from an engineering study), resulting in total overhead "MVA–km".
3. Underground cables, measured in the same way.

[31] *Electricity Distribution Business Productivity and Profitability Update*, Meyrick and Associates (December 2007).

[32] The work is described in two studies: *Resetting the Price Path Threshold—Comparative Option* (September 2003); and *Analysis of Lines Business Performance —1996–2003* (December 2003). The second report incorporated changes to the data and the methodology following feedback on the first.

4. Transformers, measured as total installed kVA.
5. Other assets, measured by classing each distributor as urban or rural, and high or low density, and assigning to the companies in each class the average value for the companies in each class (not all of the companies report the necessary data). The average value is the proportion of assets falling in the "other" class, measured on an "optimised deprival value" basis.[33] The unit price of the assets was assumed to be invariant.

No direct measure of labour inputs could be used because the necessary data was not available.

The total cost was constructed by adding to the operating expenditure a capital cost equal to 12.5% of total asset value, the 12.5% figure being based on an assumed depreciation of 4.5% and a cost of capital of 8%. Not all distributors published the breakdown of ODV over asset classes 2–5 above, and the data that was available was of variable quality. The approach taken was to classify the companies according to whether they were urban or rural and whether they were high or low density, and to construct average proportions of ODV per asset class within each of the four groups. The five inputs were then weighted by their share of total costs.

Outputs and weighting

Three output measures were used.

1. Throughput, measured in kWh supplied.
2. Capacity, measured as total MVA–km. This measure takes the length of line at each voltage and weights it by a factor designed to capture the capacity of the line.
3. Connections, measured as the number of connections.

In constructing the output measure for a TFP index one option is to use revenue shares to weight the component outputs. In this case revenue weights could not be used because network capacity is not a purchased output. Econometric weights were used, determined by fitting a cost function (ie, total cost as a function of the three component outputs) separately for each of the companies and taking a weighted average of the results.[34] The results of fitting the cost model were weights of 22% on throughput, 32% on capacity, and 46% on connections.

Comparing with economy-wide productivity

The usual approach would be to subtract economy-wide TFP growth from sector TFP growth, and also to adjust for the difference between sector input price inflation and input price inflation

[33] "Other assets" are assets such as computers and control systems. The proportion of assets in this class ranged from 2%–4% of the total.

[34] The cost function had cost as a linear function of output quantities times a time trend representing technical change (one per input, but the same for a given input across the three outputs), subject to the constraint that the weights on the outputs had to be positive.

in the wider economy.[35] In this case Meyrick subtracted economy-wide TFP growth but did not make an inflation adjustment. The report looked at two measures of whether adjustment for input price inflation differences was required: first, a comparison between various published labour and capital price indices (some relating to the economy as a whole, others relating only to electricity distribution); and second, a comparison between economy-wide price indices and an index calculated from the TFP analysis of the electricity distribution sector (total costs divided by the TFP input index). This analysis did not yield robust results, in part because the published input price indices seemed to be unreliable, so Meyrick adopted an approach "of minimising risks by setting the price differential to zero".

Thus the economy-wide TFP growth of 1.1% was subtracted from the measured electricity distribution sector TFP growth of 2.1% to give a "B" factor of 1%.

2.3.2 Data

Information disclosure requirements applied to electricity distributors prior to the introduction of the current regulatory regime, as described above. Data was therefore available back to 1995, and the existence of this data was a pre-requisite for being able to apply the chosen TFP methodology. Note, however, that the data disclosure rules were not designed to enable a TFP methodology to be applied: the original intention seems to have been that the requirement to disclose detailed regulatory accounts would itself constrain excessive pricing.

The first year of data was discarded because of "apparent teething problems", so information on all 28 firms from the eight years 1996 to 2003 was used to derive the sector-wide "B" factor. For the multilateral TFP analysis used to divide the companies into high, medium, and low relative productivity bands only the data from the five years 1999 to 2003, because changes introduced in 1999 meant that the data was more consistent from then on.

A number of adjustments were made to the data following consultation with the industry.

2.3.3 Economy-wide productivity measurement

The economy-wide measure was taken from the results of a then recent New Zealand Treasury working paper. Meyrick used the published TFP index figures from the period 1993 to 2002 and estimated a trend growth rate of 1.1%.[36] This figure was consistent with other studies. The report does not say why the rate was measured over a ten-year period.

2.3.4 Measuring relative productivity

As discussed above, Meyrick also use a TFP method to estimate relative productivity of the 28 firms. In order to estimate relative productivity a different TFP index method must be used

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[35] Or, equivalently, to adjust the measured sector TFP directly for the difference between economy wide output price inflation and sector-specific input price inflation.

[36] In the Meyrick reports growth rates are measured by fitting a straight line to a plot of index values over time using OLS regression. The report rejected a suggested alternative of geometric averaging because this method places excessive weight on the start and end values.

from that used to estimate sector-wide TFP, but otherwise the output and input specification is the same as that described above to estimate the sector-wide TFP.

On the basis of the relative TFP analysis, companies were ranked according to their average TFP level (over the period 1999 to 2003). There was no apparent correlation between ranking and measures such as density, whether rural or urban, scale of operations, or rate of load growth (in part because the specification of the output index already captures some density effects).

The companies were divided into groups with high, medium, and low TFP levels. The difference between the average TFP of the “high” group and the average TFP of the “medium” group in the last year of the dataset was about 15%. There was a similar gap between the “medium” and the “low” group. Meyrick recommended setting “C_1” factors on the following basis:

- a ten-year adjustment period is prudent for a capital-intensive industry with long-lived assets;
- this implies C_1 factors of ±1.5% to bring the high- and low-productivity groups back to the average level; and
- to be prudent, the C_1 factors are reduced to ±1%.

2.4 Observations

One factor behind the decision to use a TFP method in this case seems to have been a desire to reduce the regulatory effort required to set price controls for 28 companies: the TFP method is used to set a “threshold price”, and if the threshold is breached the regulator conducts a traditional “building blocks” review.

The New Zealand methodology generates company-specific X factors. In addition to the industry-wide TFP growth rate, X is higher for companies with below average relative TFP levels, and higher for companies with above average profitability.

The New Zealand electricity distributors had been required to publish regulatory accounts for a number of years prior to the introduction of the price thresholds regime. Without this data the TFP method adopted could not have been used.

It is recognised that the current TFP method in New Zealand needs to be modified to take into account quality of service (eg, reliability of the distribution networks), but this has not so far been achieved. Without such a modification, the method risks penalising firms that invest to improve service quality.

Neither the use of TFP nor the details of the methodology are specified in the legislation governing regulation of electricity distribution companies in New Zealand.

3 Great Britain energy network regulation

This case study describes how Ofgem, the energy regulatory in Great Britain, has used TFP analyses in setting network price controls. We describe examples from electricity and gas distribution and gas transmission.

3.1 Industry structure

The gas sector in Great Britain was privatised in 1986, and the electricity sector in 1989. The networks have been subject to price regulation of the CPI–X form[37] ever since. Initially the high-pressure gas transmission network and the lower-pressure distribution networks were owned and operated by the same company under a single licence and a single price control. Separate price controls for the eight gas distribution networks were introduced in 2003, and in 2005 four of the networks were sold. The gas sector thus now consists of one transmission network and eight distribution networks (the transmission network and four of the eight distribution networks are owned by the same group). Electricity distribution and transmission have always been subject to separate price controls (although the transmission network was originally owned by the fourteen distribution companies). The electricity and gas transmission networks are owned by the same corporate group, and a number of the electricity distribution networks are under common group ownership.

3.2 Legislative and regulatory framework

The system for regulating the gas and electricity industry in Great Britain has been in place since privatisation. It consists of a mixture of ex-ante economic regulation (primarily of the networks) and ex-post general competition law (applied primarily to generation and supply). Charges for use of the networks are reviewed and controlled by the regulator, Ofgem, which also sets a cap on the total revenues which the network businesses can earn.

The main functions of the regulator are set out in the *Gas Act 1986* and the *Electricity Act 1989*, as modified by the *Utilities Act 2000*.[38] Ofgem's duties are "to protect the interests of consumers of gas and electricity, wherever appropriate by promoting effective competition". It also has subsidiary duties, including the duty to ensure that the network companies can attract sufficient finance to continue operating, and to protect the interests of future as well as current consumers. Ofgem's powers include the ability to fine the companies up to 10% of annual turnover for a breach of competition law or for a breach of the regulatory rules. Ofgem's board is appointed by the government but it is not otherwise under the control of the executive: Ofgem is funded by a levy on the industry which is (formally) approved annually by the UK legislature. Its

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[37] In the UK the term RPI – X is used but we refer to CPI – X for consistency with the rest of our report.

[38] Other relevant legislation is the *Competition Act 1998*, the *Enterprise Act 2002*, the *Sustainable Energy Act 2003*, and the *Energy Act 2004*.

decisions are subject to appeal to the UK Competition Commission (which conducts a merits review).

All companies in the industry are required by law to hold a "licence" to operate, issued by Ofgem.[39] The licences are made up of "conditions" which set out the detail of the companies' responsibilities (for example, the requirement to set tariffs in line with a methodology that has been approved by Ofgem), and state how much revenue the companies may earn by charging for the use of the network. The licence conditions evolve over time because Ofgem has the power to alter them (subject to agreement by the company or appeal to the Competition Commission).

Price controls of the basic CPI–X form have typically been re-set every five years. The outcome of each price review (a multi-step process involving extensive consultation, lasting about two years) is new caps on the maximum revenue that the companies can earn. The caps are implemented through changing the relevant licence condition.

The regulatory framework gives Ofgem wide discretion over how it sets price controls. In fact there are no prescriptions at all on the form of the price control or how Ofgem should go about setting the level of prices. Ofgem's duties are engaged in two main ways: protecting consumers' interests means making sure that prices are not too high, but that they are high enough to allow the companies to deliver a good quality service; and ensuring that companies can finance their functions (and protecting the interest of future consumers) means ensuring that prices are not too low.

In practice, Ofgem has always set price caps of the CPI–X form on a "building-blocks" basis—ie, involving a forward-looking estimate of costs for each regulated firm. Each firm submits detailed forward-looking business plans to Ofgem, which are reviewed by technical experts, and are the starting point for Ofgem's estimate. Ofgem also makes use, where possible, of comparisons between companies to assess what level of costs might be efficient. It also looks at evidence on the rate at which efficiency might be expected to improve. It has explicitly considered evidence from TFP studies within the "building-blocks" framework on a number of occasions.

The relationship between the building-blocks and the TFP approach is basically as follows: the building-block approach, including comparison between the companies, is used to determine a reasonable level of operating costs for the start of the price control period. Past capital expenditure (with rare exceptions) forms the basis of the regulated asset base, on which the companies will receive depreciation and the cost of capital during the price control period. The companies' investment plans are reviewed for reasonableness and are used as the basis for company-specific allowances for additions to the RAB during the price control (the companies receive depreciation and the cost of capital on these allowances). A productivity growth assumption is applied to the starting level of operating costs, to determine the allowed level of

[39] The texts of the licences are available from Ofgem's "Electronic Public Register" at http://epr.ofgem.gov.uk.

operating costs for the duration of the price control. Ofgem has used TFP analyses as evidence in setting the last of these building blocks.[40]

3.3 Development of TFP in this jurisdiction

Within the "building-blocks" approach, Ofgem has typically combined two main approaches to assessing the future level of costs: bottom-up studies, which require the companies to submit detailed business plans which are then reviewed by Ofgem and its technical experts; and top-down studies that may involve examining trends in various cost measures over time, and may also include TFP methods. Ofgem typically uses evidence from both approaches in resetting the price control.

TFP is not mandated by the legislative framework, which in fact does not specify anything about the method for determining prices.

The technical details of the methods used seem to have been developed by Ofgem's external consultants: Ofgem has commissioned work on productivity trends to inform its decisions in the price controls.

3.3.1 How the regulator uses the results of TFP analysis

At least in some cases, Ofgem is explicit that its final decision on the level of price caps involves a significant degree of judgement. There is no direct (ie, mathematical) link between the results of TFP (or, indeed, any other analysis) and the choice of X factor and P_0. Rather, the final numbers are chosen in light of various quantitative and qualitative evidence. Although it is not explicit, a degree of "negotiation" with the regulated companies is also involved: the regulator's decision on the price controls is not binding without the agreement of the companies, who can otherwise make an appeal to the Competition Commission. Any such appeal would be on the substance as well as the process of the regulator's decision.[41]

An example of how the regulator uses the results of TFP analysis is described in the quote below. In this case, TFP was used as evidence in the discussion of future levels of "controllable operating costs".[42] Capital expenditure was separately assessed.

> *both a total factor productivity study commissioned by Ofgem and the business plans of several DNOs suggest that ongoing efficiency savings will be achievable in the next price control period. Considering the available evidence, Ofgem has set operating cost allowances for the period 2005/06 to 2009/10 based on a 1.5 percent per annum*

[40] Ofgem has used *total* factor productivity analyses even though this building block clearly requires a partial factor analysis (since capital allowances are being set separately).

[41] There have been no appeals of Ofgem's price control decisions since 1995.

[42] Operating costs excluding certain items deemed to be outside management control.

reduction in underlying efficient costs over this period, before additional costs are considered. [43]

Ofgem discussed in detail in the first 26 paragraphs of this section of its decision how it was proposing to change prices for each company by analysing the level of current efficient operating costs (on the basis of various regressions of operating and total costs for all the companies against a composite output measure). Its discussion of expected future efficiency changes, which, together with its capital expenditure assessments, determined the X factors, was limited to the single paragraph quoted above. Note also that in this case the TFP analysis was used as evidence only in respect of forecasting future changes in operating cost efficiencies (ie, it was really used in a partial productivity fashion).

3.3.2 Impact of the TFP analysis on prices

Electricity distribution

Ofgem appears to have been relatively conservative in using the TFP analysis. The TFP study itself[44] concluded that the electricity distribution companies had been improving their productivity relatively rapidly (around 4.5% per annum). The report concluded that this past performance might not be repeatable in future, so used evidence from other sectors to estimate a sustainable future rate of growth (the upper end of the range was the *lowest* TFP growth rate measured in other regulated UK utilities, and the bottom end of the range was the lowest rate of growth measured internationally). The mid-point of the range was 2.4%, 1.1% above the economy-wide TFP measure. Similarly, on operating cost partial productivity the study concluded that the future rate of growth might be around 2.2% above the economy-wide growth rate. Ofgem’s final decision used a 1.5% per annum increase in operating cost efficiency to set prices (ie, a fall in real unit operating costs of 1.5% per annum).

Note that Ofgem’s experts did not discuss the need to adjust for the difference between electricity distribution input price inflation and economy-wide CPI (ie, implicitly they assumed that this difference is zero). The issue was, however, discussed extensively in the context of the more recent gas distribution price control review.

Gas distribution

On the basis of the study described below, Ofgem concluded that operating cost productivity should be able to improve by 2.5% per annum. However, it also concluded (based on other evidence not described here) that the prices of the main inputs driving operating costs would increase faster than inflation: contract labour costs at CPI+2.5%, direct labour costs at CPI+1.5%, and material costs at CPI+3%. The net effect of these assumptions, together with additional allowances for certain categories of costs where Ofgem was requiring specific additional expenditure, was an increase in real unit operating costs of about 0.8% per annum.

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[43] *Electricity Distribution Price Control Review, final proposals*, Ofgem 2004, paragraph 7.27.

[44] *Productivity Improvements in Electricity Distribution Network Operators*, Cambridge Economic Policy Associates (2003).

3.4 The TFP methodology—electricity distribution

We describe two different TFP methodologies that Ofgem has used: one in electricity distribution (this section),[45] and one in gas distribution (section 3.5).[46] The second methodology is the more recent, and has apparently evolved from earlier work in gas transmission, partly in response to criticism from industry.[47] However, in gas distribution there are no detailed historic regulatory accounts, unlike in electricity distribution.

The study Ofgem commissioned for the fourth electricity distribution price control review examined a number of different productivity measures:

- TFP and partial productivity analyses of the GB distribution companies, based on Ofgem's regulatory accounts data;
- TFP in other regulated networks in GB, based on regulated accounts (which are published);
- a "nature of work" TFP analysis, which involves constructing a composite of various sectors for which published TFP indices[48] are available, where the composite was designed to represent electricity distribution;
- electricity distribution in other countries, based on regulatory accounts published or otherwise made available to the researchers, and on published TFP indices; and
- surveys of investment analysts and companies in similar sectors, designed to discover expert estimates of future productivity changes.

We describe below the methodology for estimating the total and partial productivity changes in GB electricity distribution. The methodology for estimating productivity changes in a "composite" based on published estimates is similar to that described below in the context of gas distribution (section 3.5).

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[45] *Productivity Improvements in Electricity Distribution Network Operators*, Cambridge Economic Policy Associates (2003).

[46] See *Gas distribution price control review: Update of analysis of productivity improvement trends,* Reckon LLP (September 2007).

[47] The earlier studies were carried out by Europe Economics in 2001 and 2007. See Appendix D of *Transco Price Control Review 2002-2007, report to Ofgem by Mazars Neville Russell*, September 2001 (Europe Economics were responsible for the top-down component of the study); and *Top-down Benchmarking of UK Gas Distribution Network Operators, a report by Europe Economics to Ofgem*, April 2007. The 2007 report was criticised in reports commissioned by the industry, written by First Economics. This prompted Ofgem to commission further work from a third group of experts (Reckon LLP).

[48] Based on indices compiled by the National Institute of Economic and Social Research, which includes national and sectoral data for the UK over the period 1950 to 1999, as well as data for other countries.

3.4.1 Sector productivity measurement

Scope

The analysis was based on constructing Tornqvist indices of TFP and partial productivity in electricity distribution, and covered all fourteen networks over a period from 1990/1 to 2001/2.

Inputs and weighting

Two inputs were used to construct the index: operating costs and capital costs, both measured on a current cost basis and taken from regulatory accounts. The two were weighted by the proportion of each cost element in total costs.[49]

Outputs and weighting

The study considered three output measures: network length (km of wire), volume of energy distributed, and number of customers served. However, the first of these was only available for a short time period, so was not included. The weights for the output measures were two-thirds customer numbers and one-third energy distributed. These weights reflected previous Ofgem econometric work rather than any direct analysis of the structure of distribution charges.[50]

The analysis also included a quality output measure, because over the period studied there were indications that the companies had invested to improve quality. The regulatory quality measure (customer minutes lost) had approximately halved over the period. The quality output used was the reciprocal of customer minutes lost.[51] The study used a weight of 4% on the quality measure, because this is the amount of allowed revenue under the price control which depends on the results of service quality assessment under Ofgem's quality incentive scheme. An alternative weighting, based on a "value of lost load" measure, gave an even lower weight. Because the weighting on quality was small, including the quality measure in the analysis had relatively little impact on the results (estimated TFP increased by around 0.1%).

Scale effects

Scale effects can be important in a TFP analysis because strong scale economies would mean that when output is increasing over time, unit costs should decrease even in the absence of any change in productivity. The study considered various evidence on the extent to which there are scale economies in electricity distribution. The study used a scale elasticity of 0.85 (ie, average unit costs should fall by 0.15% if output increases by 1%). Including the scale effect reduced the estimated TFP growth by 0.2%–0.3%.

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[49] The published documents imply that an average figure over all companies and all years was used.

[50] An alternative approach might be to weight outputs by revenue shares (ie, according to how the companies structure their charges between the annual connection or "standing charge" and charges per unit distributed). To the extent that the structure of charges reflects the underlying cost structure, the two approaches may be similar.

[51] The reciprocal was used so that the measure was increasing rather than decreasing in improving quality.

3.4.2 Data

The data was taken from published regulatory accounts and was unadjusted except for the capital input data for one year of the series, where figures had been reported on a historic cost basis only. They were adjusted to current cost. No other adjustments were discussed.

The report did identify that one year of the period covered appeared to be exceptional, in that there were large reductions in operating costs in one year. The exceptional year was retained in the analysis because the reports' authors considered that the cost reductions were likely to have been real.

3.4.3 Economy-wide productivity measurement

The economy-wide TFP growth rate was taken from the NIESR dataset. The study considered adjustments for scale effects in the economy as a whole, but these were not significant. After checking for possible structural breaks, the study concluded that the most recent ten years of the dataset were the best period to choose because this represented the most recent complete business cycle. Over this period TFP growth was around 1.3%.

3.4.4 Measuring relative productivity levels

Ofgem's methodology already includes a relative productivity analysis as part of determining P_0 changes. Although its decision discussed the possibility of allowing less efficient companies some time to "catch up" to an efficient level of costs, it did not in fact make any such adjustment. All of the companies were assumed to be able to make future improvements to TFP at the same rate.

3.5 The TFP methodology—gas distribution

Ofgem's use of TFP analysis in the most recent gas distribution price control review proved to be controversial: following an initial report from Ofgem's experts, the industry commissioned its own research, prompting Ofgem to hire a third set of experts to review both earlier studies. We summarise here the use made by Ofgem of the advice from the third set of experts.

As in electricity distribution, Ofgem used the TFP analysis to help set the rate at which operating cost allowances would change during the course of the price control. As described above, the gas sector in GB has recently been restructured so that at the time of the price control review, there were only two years of data relating to the period in which (some of) the distribution businesses were separately owned from the gas transmission network. Although the gas distribution businesses had been preparing regulatory accounts on a standalone basis for a slightly longer period (four years), the possibility of using information from the gas distribution sector itself to estimate TFP growth was not discussed. Instead, a "nature of work" or "composite" analysis was undertaken. The methodology is based on taking a number of sectors of the economy for which TFP indices are available, and constructing a composite of these where the composite is designed to represent the gas distribution sector. Typically, the composite is constructed by dividing the distribution sector cost base into components which are then taken to be similar to sectors or sub-sectors of the economy.

Note that in this case Ofgem's experts explicitly recognised that they were carrying out a partial productivity analysis, although the overall discussion within Ofgem's decision was referred to as TFP analysis.

3.5.1 Sector productivity measurement

Scope

Since there was no useful data from the gas distribution sector, the analysis focussed on other sectors of the economy which should be comparable in some way. Five sectors were chosen: Construction; Financial intermediation; Manufacture of chemicals, chemical products and man-made fibres; Sale, maintenance and repair of motor vehicles and motorcycles, and retail sale of automotive fuel; and Transport and storage.[52] These sectors were chosen because "the main activities are similar in terms of their use of labour and materials to the operating activities of gas distribution network operators", and were combined in proportions that reflected the degree of similarity.[53]

Detailed methodology

The analysis of the comparator sectors was based on estimating the change in gross output due to changes in value added through the use of intermediate outputs (energy, materials and services). The residual is the change in value added due to the use of labour and capital. From the latter the labour productivity growth could be calculated, assuming constant proportion (and quality) of capital inputs.

This measure of labour productivity growth, adjusted for capital substitution, was estimated for the five comparator sectors, and the experts recommended that Ofgem should select a value from within this range (saying that this was a matter for regulatory judgement, and that they therefore would not propose simply taking an average of the comparator sectors). The range was from 0.1% to 4.8%.[54]

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[52] Data for these sectors was obtained from the EU KLEMS dataset.

[53] *Gas distribution price control review: Update of analysis of productivity improvement trends*, Reckon LLP (September 2007), paragraph 3.8.

[54] The experts said: "We do not think that it is correct to take a weighted average of the range [0.1% to 4.8%] as a point estimate to be applied to gas distribution networks. Doing so would amount to placing excessive reliance on a loose concept of similarity between the components of the gas distribution networks' activities and the chosen comparators for each component. Instead, we take the view that we cannot know for certain to what extent the operation of gas distribution networks in the next decade will share relevant features of the comparator industries between 1973 and 2004. All we can hope for is that the spread of trends between the sectors shown in Table 1 represents a reasonable distribution of possible outcomes for gas distribution over the next control period… …It is for Ofgem to choose a figure to use in price control calculations in the face of the inherent uncertainty about future costs. In doing so, it will need to take into account the balance of risks and remuneration in the whole price control settlement in order to determine the appropriate trend to use for operating expenditure." (*Gas distribution price control review: Update of analysis of productivity improvement trends*, Reckon LLP (September 2007), paragraphs 1.34–1.36.)

3.5.2 Data

The dataset was the “EU KLEMS” dataset. The period 1973 to 2004 was chosen: the period before 1973 had earlier been rejected because of the impact of the oil price shock, and 2004 was the end of the dataset.

3.5.3 Economy-wide productivity measurement

Ofgem’s experts recommended against subtracting an economy-wide TFP measure. Instead they recommended adjusting for the difference between CPI and gas distribution input price inflation directly. In part this was because of evidence that imports were playing a significant role in the determination of CPI in the UK.

3.6 Observations

Ofgem does not use the results of its TFP analyses to set the X factor. Rather, in the context of a building-blocks approach to setting prices, where the price cap for each firm is based on a firm-specific forecast of costs for the whole of the five-year price control period, the TFP analysis is part of the evidence Ofgem uses to review the companies’ cost forecasts. Specifically, the TFP analysis is used in deciding the rate at which controllable unit operating costs might be expected to fall over the course of the price control.

In addition to making an assumption about the rate at which unit operating costs might fall during the price control, Ofgem also makes firm-specific assumptions about the rate at which firms with relatively low productivity will be able to “catch up” with the more productive firms.

Ofgem has used evidence from various different TFP methodologies, including both index-number measurements of the UK electricity distribution sector based on regulatory accounts, measurements from sectors in other countries based on published high-level statistics, and “nature of work” comparisons.

Since Ofgem uses TFP analysis in respect of its assumptions about operating costs but not investment requirements, its approach is better characterised as being a “partial factor productivity” approach.

The evidence from TFP analysis is a small part of the total evidence Ofgem uses to set prices. There is no clear formulaic method by which Ofgem uses the TFP evidence in reaching its final conclusion on the level of prices.

4 The Netherlands electricity distribution

4.1 Industry structure

The *1998 Dutch Electricity Act* established that the Dutch electricity market would be liberalised, and the Dutch electricity market was fully liberalised on 1 July 2004. There are ten electricity distribution companies, with a range of sizes and ownership structures (ownership by local government entities is a common feature). [55]

4.2 Legislative and regulatory framework

The main regulatory reform in the Dutch electricity sector is the *1998 Dutch Electricity Act*.[56]

Before liberalisation, electricity tariffs in the Netherlands were set by a system that closely resembled cost-plus. The *1998 Dutch Electricity Act* introduced a completely new approach towards price regulation. As set out in the relevant legislation:

> *The Director of DTe shall determine the tariffs, which may differ in the case of the various* [network companies], *taking into consideration the importance of promoting efficient operations and cost reductions to the advantage of customers and by means of market forces.*

In explaining its most recent tariff decision, the DTe summarised its views of its duties under the legislation. It quoted various statements from the minister responsible for introducing the relevant legislation in which the minister explained his intentions.

> *The purpose of the regulatory system… …is to give companies which find themselves in a monopolistic situation an incentive to operate as efficiently as companies in a competitive market. This is also expressed in the reference to the concept of "operation of market forces" in the aforementioned articles 41(1) and 80(1). This means, in the first place, that any surplus profit which, with regard to its size, exceeds a fair level of return (monopoly profit) must be reduced in the case of these companies to a fair return. In the second place, the companies will have to strive to operate as efficiently as the most efficient company in the sector. Thirdly, of course, the sector as a whole will have to increase its level of efficiency… …The provision, namely that the price cap is intended partly to promote equivalence in the efficiency of the grid managers' operations, can be explained further as follows. In order to give the companies an incentive to realise the desired improvements in efficiency, the Act provides for a discount on tariffs (the x factor).Companies which outperform the efficiency objective may retain the additional*

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[55] *2006 Annual Report by the Office of Energy Regulation (DTe) to the European Commission* at http://www.ceer-eu.org/portal/page/portal/ERGEG_HOME/ERGEG_DOCS/NATIONAL_REPORTS/ National%20Reporting%202007/E07_NR_Netherlands-EN.doc

[56] *1998 Dutch Electricity Act Providing Rules in Relation to the Production, Transmission and Supply of Electricity*, Section 41.

return realised. To ensure that the various companies have an equal opportunity to achieve the efficiency objective, it is important that efficiency differences between the companies are first eliminated. After all, a company which is very inefficient can achieve a greater improvement in efficiency than a company which is efficient. In the history of the legislation, it was therefore stated at the time that a transitional period is required to eliminate these efficiency differences.[57]

Since 2000, distribution network tariffs have been regulated on a CPI–X price-cap basis. Tariffs levels are annually adjusted by CPI–X, in which CPI is the consumer price index and the X factor is the regulator's estimate of future efficiency improvements. DTe explicitly describes the X factor as the efficiency incentive, and states that the main objective of the price-cap system is to improve efficiency by rewarding good performance.[58]

A peculiar feature of the implementation of the regulatory system in the Netherlands is that the price caps attracted very significant resistance from the industry, resulting in a large number of legal challenges to DTe's decisions. Furthermore, apparently due to poor drafting of the original legislation, the courts determined that for the initial regulatory period, the X factor had to be the same for all companies (whereas the legislators had intended, and DTe did in fact originally set different factors for each company, in order to return each companies' profits to a normal level based on efficient costs). As a result of the time taken to decide the various legal challenges, the final price caps for the first period were not set until just before the second period began. The history of the DTe's initial price controls and the various legal challenges is described in *The 2001-3 electricity distribution price control review in the Netherlands: regulatory process and consumer welfare*.[59] The authors of this paper speculate that the intensity of the legal challenge may have been due, in part, to the DTe's TFP methodology and the fact that it was applied in a rather mechanistic way to set prices, without sufficient industry consultation:

The results [of the analysis] *were subsequently mechanically applied to the cost structures without considering potential errors in the data that could distort the efficiency scores… …There was no attempt to apply the results pragmatically as has been done in the UK… …A more balanced approach whereby the benchmarking results were based on several techniques would have potentially made the results more acceptable, because (a) the results are less vulnerable to the idiosyncrasies of each method giving a more balanced (less extreme) picture, (b) the weighting of the different approaches allows DTe some discretion to incorporate specific company-related factors, and (c) consistency across different models makes results more acceptable to those companies involved. Most companies are more interested in the outcome than*

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[57] Netherlands Competition Authority, Number: 102106-89, Case: *Decision in relation to the method for determining the price cap to promote efficient operations and the volume parameter of each cost driver for which a tariff is determined, pursuant to section 41(1) of the Electricity Act 1998 for the years 2007 up to and including 2009,* paragraph 23.

[58] In fact, the price control is of the form CPI – X + Q, where Q is a "quality factor", based on measuring the number of customer minutes lost. In this report we concentrate on the method used to set X.

[59] Nillesen, P. H. L. and Pollitt, M. G., *Journal of Regulatory Economics* (2007) 31:261–287.

whether a methodology is balanced. However, DTe would have had a more credible case to defend.

4.3 Development of TFP in this jurisdiction

4.3.1 Choosing a TFP approach

Before liberalisation, electricity tariffs in the Netherlands were set by a system that closely resembled cost-plus: tariffs were primarily based on observed costs, plus a reasonable rate of return. Under the new price-cap system, DTe has chosen to apply "yardstick competition", so called because using comparisons between different network operators to set prices creates a regime that simulates competitive markets. Yardstick competition essentially means that companies' tariffs are set with reference to some external benchmark, such as the average costs of all the companies in the sector, rather than each company's own costs. This process, explained below, was chosen because:

> *DTe is of the opinion that a system of yardstick competition is the best way of providing the regulated grid managers with sufficient incentives to operate efficiently. Companies which perform better than other grid managers achieve above-average profitability, while companies which perform below average achieve lower profitability. Every grid manager experiences a continuous incentive to operate as efficiently as possible and by doing so to keep abreast of or outperform the competition. In addition, any sector-wide cost increases result in a lower x factor, as a result of which grid managers are compensated for such sector-wide additional costs in the tariffs.*[60]

DTe considered several possible methods for implementing the "yardstick" approach, including an index-type analysis (measuring average productivity growth over time), as well as regression analysis and Data Envelopment Analysis (DEA). The approach implemented was to use a DEA analysis to assess initial relative efficiency among the companies, and simple TFP indexing process thereafter to measure subsequent changes in average productivity.

DTe made several statements to the effect that it preferred a TFP methodology rather than a building-blocks approach because it gives the regulator less influence over the companies' management decisions (such as the trade-off between capital and operating expenditure) than does the building-blocks approach.

The process of setting X factors was so derailed by legal disputes that it makes more sense to focus on the overall outcomes than the details of the process as it actually happened. This is what we describe below. Nevertheless, it is possible that the need to get the whole regulatory mechanism back on track may have influenced later DTe decision-making.

[60] DTE (2003), Number 100947-82, *Annex B to the decision approving the method for determining the price cap to promote efficient operations, pursuant to section 41 (4) of the Electricity Act of 1998.*

4.3.2 Evolution of the TFP approach

There have been three regulatory periods: 2001 to 2003; 2004 to 2006; and 2007 to 2009. During the first period each company had the same X factor of 2% (because incorrect drafting of the relevant legislation meant that the regulator could not do otherwise). During the second period, each company had different X factors, which were intended to force the tariffs of each company to converge on the average (ie, to "catch up" with the efficient firms), and were based on the initial DEA analysis plus an average improvement of 1.5% per year. During the third period, each company has the same X, since it is assumed that each company's tariffs have by then converged to the average. This X is based on the average rate of TFP growth during the period 2003 to 2005.[61,62]

For the third period one change was made to DTe's TFP methodology: DTe had recognised the possibility that some companies might face fundamentally higher costs than the others (so-called "objectifiable regional differences"). DTe and the industry commissioned independent research to assess whether any such cost drivers beyond the control of the companies could be identified.[63] The number of "water crossings" and certain local tax issues were identified, and, as a result, companies with a cost disadvantage because of these issues receive an extra allowance (their "standardised" costs are adjusted for these factors before the TFP methodology is applied).

The general intention behind the method was to use the initial period to require inefficient firms to bring their tariffs down to an efficient level. Once the initial differences had been removed, tariffs would then change in line with the average rate of improvement in efficiency, as measured by a simple TFP index.

4.4 The TFP methodology

4.4.1 Sector productivity measurement

Scope

DTe's method is based on simple TFP index calculation. The rate of TFP growth across the whole sector is measured, and X is set at this average growth rate. All of the electricity distribution companies in the Netherlands are subject to regulation and included. The TFP index is constructed as the ratio of standardised costs to composite output, and the growth rate is the annual percentage change in the index. The time period used to derive X for the third regulatory period is 2003 to 2005.

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[61] Technically, the X factors for the third period are not the same for all companies, because tariffs also include an "equalisation factor", which effectively makes an *ex post* adjustment to tariffs to take into account actual realised efficiency changes, rather than forecast changes, for the second period. (DTe, *Op. cit.*)

[62] The X factor in the third period also takes into account the *ex post* adjustments mentioned above, together with a further modification to reflect an assumed reduction in the cost of capital.

[63] This research was carried out by *The Brattle Group* (see Annex E to the third method decision: NMa Nummer: 102106-89, 2006).

Inputs and weighting

The inputs are the "standardised economic costs". Operating costs are measured in accordance with the regulatory accounting rules. Capital costs are the sum of a cost of capital allowance and depreciation.[64]

Corrections are made as described above for the "objectifiable regional differences" (in practice, this seems to mean that one company in particular has some of its costs removed from the analysis because they are associated with above-average numbers of wires that have to cross water).

Outputs and weighting

A "composite output" is constructed: for each firm, the output is the revenue it charges each customer group associated with each component of its tariff (basically, fixed charges plus charges per unit), weighted by the proportion of its total revenue in 2000 associated with that customer group and tariff element, but excluding initial and annual connection charges. Initial connection charges are ignored completely (because the volume of new connections changes unpredictably from year to year). Ongoing annual connection charges are included as the proportion of total revenues in year 2000 associated with annual connection charges, multiplied by total actual revenues each year. The calculation of the composite output can be changed if new tariff elements are introduced.

4.4.2 Data

The data is taken from regulatory accounts. Since the data for determining X for the third period comes from the second period, and since during the second period some inefficient companies were required to "catch up" with the efficient firms (as described above), an adjustment was made to remove the impact of this "catch up" from the analysis, so that only the underlying rate of improvement would be measured.[65]

4.4.3 Economy-wide productivity measurement

DTe makes no adjustment to the measured growth rate before using it to set X. It is thus implicitly assuming that the electricity distribution sector's costs can be expected to rise at the rate of CPI inflation generally in the Dutch economy.

4.4.4 Measuring relative productivity

Relative productivity was assessed by means of a DEA study at the beginning of the first regulatory period (since a DEA method was used, technical inefficiency is also measured). DTe

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[64] Depreciation rules are different for pre-liberalisation assets.

[65] NMA, addendum A to the method decision, Number: 102106-89, *Decision in relation to the X factor and volume parameters for regional electricity grid managers in the third regulatory period, description of the method for determining the X factor and the volume parameters.*

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and its advisers chose to implement a DEA approach, in part because there was so little data available at the beginning of the first regulatory period that an index method (examining trends over time) could not be implemented.[66] A DEA analysis attempts to determine the efficiency of each firm relative to a notional "efficiency frontier", which shows how technically efficient firms would operate. Depending on the details of the method, one or more of the firms may appear to be fully efficient, or the frontier may alternatively be defined by a "combination" of several of the firms, such that no single firm is fully efficient.[67]

4.5 Observations

In the initial[68] regulatory period the regulator set firm-specific X factors on the basis of a DEA analysis. This required the less productive firms to reduce their prices more quickly than the more productive firms. For subsequent periods, all the firms had the same X factor, based on a pure TFP analysis.

The TFP methodology uses only a short time-span of data, starting from the beginning of the first regulatory period. Each TFP growth rate measurement is based on at most three years of data.

The regulation of electricity distribution companies in the Netherlands has been characterised by very significant legal challenges from the regulated companies. Most of the regulator's decisions on X factors have been challenged and subsequently revised on appeal. It is possible that these challenges may have resulted in part from the regulator's failure to consult widely on its approach to setting X, and because of the formulaic way in which the results of the TFP analysis were used directly to set X.

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[66] DTe (2000), *Choice of model and availability of data for the efficiency analysis of Dutch network and supply businesses in the electricity sector: Background report accompanying 'Guidelines for price cap regulation in the Dutch electricity sector'*.

[67] For example, two firms may produce the same output with different combinations of capital and labour inputs. A notional "combined" firm, made up of a linear combination of the two real firms, could produce the same output for less capital input than firm A and less labour input than firm B. Hence neither A nor B are fully cost efficient on this definition.

[68] The regulator intended that this would happen in the first regulatory period, but due to the legal challenges described above the "catch-up" actually took place in the second regulatory period.

5 Gas distribution in Ontario, Canada

5.1 Industry structure

Ontario's two major gas utilities are Enbridge Gas Distribution Inc. (Enbridge) and Union Gas Limited (Union). Enbridge is Canada's largest natural gas distribution utility and serves about 1.9 million residential, commercial, and industrial customers. More than half of these customers buy their natural gas directly from Enbridge, while the rest buy directly from a marketer. Enbridge holds some interest in natural gas transportation which includes Enbridge's 50% interest in the U.S. portion of the Alliance Pipeline, its 60% interest in the Vector Pipeline, and its 100% interest in the Enbridge Offshore Pipelines.[69] Union Gas Limited is a major Canadian natural gas utility that provides natural gas delivery and related services to about 1.3 million residential, commercial and industrial customers in northern, south-western and eastern Ontario. Union also provides natural gas transportation and storage services for other utilities and energy market participants in Ontario, Quebec, and United States.[70]

Union and Enbridge notably differ in two respects. First, Enbridge serves the customers in the Toronto metropolitan area which is much denser than the less-urban service territory of Union. Second, Union is extensively involved in major gas storage and transmission business unlike Enbridge. Both companies, however, have been experiencing a decline in the average use of gas by customers in their service territories.

5.2 Legislative and regulatory history and objectives

The recent history of natural gas regulation in Ontario has had two major phases, and is undergoing the third restructuring phase.

The first of these phases covered the period 1985–96, when the Ontario Energy Board ("Board" or "OEB") reformed its regulatory structure to facilitate the deregulation of wellhead natural gas prices in Canada. These changes allowed large-volume Ontario customers to access their own arrangements for gas supply and transportation.

The second major phase of gas regulation was meant to enhance retail competition in Ontario. It commenced in 1996 with the *Report on the Ten-Year Market Review of Natural Gas Deregulation*, and led to an advisory report from Board to minister of Energy. The legislative changes recommended in this advisory report were largely realized in the *Ontario Energy Board Act, 1998*, which removed the legislative restrictions on gas sales within Ontario.

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[69] http://www.enbridge.com/about/enbridgeCompanies/

[70] http://www.uniongas.com/aboutus/

Ontario is currently undergoing its third restructuring phase with the goal of implementing a multiyear incentive regulation plan, and policy choices and processes developed through the NGF Report.[71]

For many years, the Board has employed the traditional cost-of-service ratemaking (COSR) methodology to set the rates for the gas utilities under its jurisdiction. In the late 1990s, performance based regulation (PBR) plans were introduced on a three-year trial basis for both companies. Enbridge's plan covered only the operations and maintenance portion of its costs and was termed a "targeted" PBR, while Union's plan provided comprehensive PBR coverage for its full revenue requirement, with a price cap. After the end of the trial PBR plans, the companies had been expected to request new PBR proposals. However, both companies instead resumed filing applications based on traditional COS methods.[72]

In the NGF Report, the Board stated that the PBR framework should meet the following criteria: establish incentives for sustainable efficiency improvements that benefit both customers and shareholders; ensure appropriate quality of service for customers; and create an environment that is conducive to investment, to the benefit of both customers and shareholders. The Board believed that a ratemaking framework that meets these criteria would ensure that the statutory objectives of consumer protection, infrastructure development and financial viability are met, and that rates would be just and reasonable. The Board, in the NGF Report, stated that an earnings sharing mechanism (under which prices would fall faster if companies improve their efficiency more rapidly than expected) should not form part of the IR plan because it believed that the utility's efficiency incentives would otherwise be reduced.

On January 5 2007 Board staff issued a report[73] on an initial proposal for a five-year price-cap IR approach.

5.3 Development of TFP in this jurisdiction

TFP methodologies are not mandated by the legislative framework. The process of developing a TFP methodology was initiated by the regulator and continued through the rate-setting process.

5.4 TFP methodologies

The OEB Staff consulted an outside advisor[74] to undertake input price and productivity research to support the development of an X factor, and to provide recommendations for the

[71] *Natural Gas Regulation in Ontario: A Renewed Policy Framework,* Report on the Ontario Energy Board Natural Gas Forum, March 30, 2005, p. 82-83. ("NGF Report")

[72] *Ibid.*, p. 14.

[73] Staff Discussion Paper *On an Incentive Regulation Framework for Natural Gas Utilities*, Ontario Energy Board (2007).

[74] Pacific Economics Group ("PEG")

design of rate and revenue cap indexes for Enbridge and Union. This study was first released on March 30, 2007.[75]

We discuss below the two major TFP proposals considered by the Board during the rate setting process:[76] 1) the TFP proposal developed by the Board staff and their external adviser ("Proposal A"), and 2) the TFP proposal developed by Enbridge and its external advisers.[77]

Both proposals were that X should be set as the sum of two terms:[78]

1. Input Price Differential ("IPD", the difference between the input price trends of the economy and the gas utility industry); and
2. Productivity Differential ("PD", the difference between the productivity trends of the gas utility industry and the economy).

The two proposals differed in a number of respects, but both suggested that the PD term should be based on an estimate of historic TFP growth taken from a group of US gas distribution companies. The most significant differences were that Proposal A used an econometric approach to estimating TFP, whereas Proposal B used an index number approach. The differences between the two approaches are described below.

It is noteworthy that the Board was not able to accept the findings of its advisors—criticism of the advisors' report from the companies resulted in a settlement agreement that was significantly different from the recommendation of the Board's advisors.[79]

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[75] The original report underwent several updates in the later months which incorporated some changes suggested by other parties in the proceeding, but the fundamental TFP methodology proposed in the original report remained reasonably unchanged.

[76] In addition to the competing TFP proposals described here, there were other interventions recommending alternative methods of setting the X factor, Dr. Loube (an expert intervening on behalf of various customer groups) recommended an earnings sharing mechanism, and that the X-factor should equal the inflation factor (ie, that prices should be held constant in nominal terms).

[77] Enbridge's advisers were Dr Paul Carpenter of *The Brattle Group* and Professor Jeffrey Bernstein of the Florida International University. AEMC has retained *The Brattle Group* to carry out the present study, which has been prepared with input and advice from Professor Jeffrey Bernstein. For the avoidance of doubt, any views expressed in this report are those of the authors, Dr Toby Brown and Dr Boaz Moselle, and do not necessarily reflect the views of Professor Bernstein.

[78] Proposal A also included an "Average Use" term, not required under proposal B.

[79] In fact, in the case of Enbridge, the final settlement was of the form RPI x F—ie, prices will change by a fraction of RPI inflation. The settlement agreement explains that if RPI turns out to be 2.04% the settlement is equivalent to RPI – X where X averages 0.96% over the five years of the settlement. This figure is about half way between the X factors in proposal A and proposal B (2.04% and –0.14% respectively). See *Enbridge Gas Distribution revised settlement agreement EB-2007-0615*, Ontario Energy Board (February 2008).

5.4.1 Sector productivity measurement

Scope

Future TFP growth for the Ontario gas distribution sector was estimated by analysing productivity changes among 36 US gas distributors. There are insufficient firms in the Ontario gas distribution sector to use data from the regulated firms to make a reliable TFP estimate.

Proposal B measured TFP growth across all 36 companies.

Proposal A computed benchmarks based on a sub-set of companies that were similar to the Ontario companies in terms of their "returns to scale", with the latter parameter being estimated using an econometric model. This approach was criticised on a number of grounds, including that:

- minor modifications[80] to the econometric model dramatically changes which companies are chosen for the comparator sub-set;
- the comparator sub-set is chosen on the basis of a single parameter (returns to scale), whereas any number of other characteristics might be expected to have an important influence on costs and not be subject to management's ability to influence them; and
- the econometric model was estimated using the 36 US firms, but was then applied to the Ontario firms (in order to estimate the target "returns to scale" to select the comparator sub-set), but without presenting evidence that the econometric model was a valid description of the Ontario firms.

Inputs and weighting

The same inputs and weights were used in both proposals. The trends in input (quantity) indexes were defined as cost-share weighted averages of quantity indices for labour, material and supply ("M&S"), capital, and gas use. The quantity indices for labour, M&S and gas use were calculated as total expenses for each item, divided by a suitable price index. The capital index was calculated on two different bases, with different depreciation and valuation assumptions.[81]

Outputs and weighting

For the econometric model (proposal A), the outputs were customer numbers, and volume of gas (sometime split between different customer groups). Total network length could also be included. The econometric model was used to determine the dependence of total distribution cost on each of these parameters, and hence the appropriate weights in the output index. Thus proposal

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[80] Including whether geometric decay or cost-of-service methods were used to calculate the capital input index for the TFP analysis (see following footnote).

[81] Two methods of calculating the capital index were used: 1) geometric decay (GD): This approach features replacement (current dollar) valuation of utility plant and a constant rate of depreciation. The value of plant increases each year at the same rate as construction costs; and 2) cost-of-service (COS): book (historic dollar) valuation of plant and straight line depreciation.

A used an “elasticity-weighted” output index. The elasticity weights were estimated using all 36 companies in the dataset.

For proposal B the output index was based on volumes distributed (divided into three groups for different customer types), weighed by the share in total distribution revenues. The revenue share weight takes into account the two main drivers of output (number of customers and volume of gas), because customers are charged both per unit of gas delivered and a fixed charge for their connection to the network.

5.4.2 Data

This research considered the input price, productivity, and usage trends of Enbridge and Union (2000-2005) and of 36 U.S. utilities (1994-2004).

The primary source of the data used in the U.S. gas utility cost research was *Uniform Statistical Reports* (“USRs”). Many U.S. gas utilities file these annual reports with the American Gas Association. Due to unavailability of this data for some utilities in later years, operating data was also obtained from alternative sources including, reports to state regulators. The 2004 operating data for this study was obtained from the Platts *GasDat* package.

Data on the delivery volumes and customers served by U.S. gas utilities were obtained from Energy Information Administration’s (“EIA”) Form EIA-176. Data on input prices were collected from several sources.[82]

5.4.3 Economy-wide productivity measurement

The productivity trend of private business sector of the Canadian economy (1992-2003), published by Statistics Canada, was used as the economy-wide TFP trend in both proposals. In both proposals this was subtracted from the estimate of gas distribution productivity growth.

5.4.4 *Input price inflation*

Both proposals required that a component of the X factor relate to the difference between economy-wide input price inflation and the input price inflation of the regulated sector.

Proposal A used input price inflation from the Canadian gas distribution companies. This choice was criticised on the grounds that US input prices were used in the determination of TFP growth for the US distribution sector, and that to use different input prices to determine the inflation correction would introduce distortions.

Proposal B used input price inflation from the US comparators.

Both proposals estimated economy-wide input price inflation as an CPI-type index plus the economy-wide rate of productivity growth.

[82] Whitman, Requardt & Associates prepare Handy Whitman Indexes of trends in the construction costs of U.S. gas and electric utilities. Other sources of input price data include R.S. Means and Associates; the Bureau of Labor Statistics (“BLS”) of the U.S. Department of Labor; and the EIA.

5.5 Observations

This case illustrates the disagreements that can arise over the detail of TFP methodologies. Two competing methodologies were proposed—one developed by advisors to the regulator and one by advisors to the company. The two approaches resulted in X factor proposals that differed by several percent, though they were based almost entirely on the same input datasets.

The case also illustrates a particular problem with econometric-based TFP methods: the results can be sensitive to the precise specification of the model, which means that the results may not be robust, and can be difficult or impossible for other parties to reproduce, which makes it less likely that agreement can be reached on the results.

6 Observations on TFP in other North American jurisdictions

In this section we make some high-level observations on the use of TFP methodologies in other jurisdictions in North America. We have not attempted to give a comprehensive description of the methods used or the details of the regulatory framework. However, in the case of energy distribution in the US, it is important to note that the legislative framework was designed around traditional “cost of service” regulation. In the relatively rare instances where price cap regulation has been used as an alternative, it is by agreement with the regulated firm (presumably, the regulated firm accepts the price cap because of the prospect of out-performing the regulator’s efficiency assumptions).

6.1 Energy regulation in Massachusetts

Here we describe briefly the use made of TFP in regulating gas distributors in Massachusetts. By way of illustration, we refer to rate decisions for Boston Gas.

The Massachusetts Department of Public Utilities (DPU) first approved an incentive regulation plan for Boston Gas in 1996.[83] Under the 1996 plan, Boston Gas’ distribution rates were initially set using standard cost of service principles. They were then adjusted on an annual basis over a term of five years according to an CPI-X price cap formula. Specifically, Boston Gas’ rates were escalated annually by the rate of inflation (measured using the gross domestic product price index) minus an overall productivity offset of 2 percent. This two percent offset was calculated as:

- a productivity differential of 0.1 percent (representing the difference in total factor productivity for the U.S. economy and U.S. gas distributors),
- minus an input price differential of 0.1 percent (representing he difference in input price growth for the U.S. economy and regional gas distributors),
- plus a one percent offset for accumulated inefficiencies (representing the expectation that accumulated inefficiencies would be removed and that the resulting gains should be shared with customers), and
- plus a consumer dividend of one percent (representing the expectation that, under the price cap, efficiency would improve more rapidly than the historical rate achieved under cost-of-service regulation).

The rate decision refers to TFP studies conducted by Boston Gas as part of its rate case. These studies were similar to the econometric analyses described above in section 5,[84] and estimated TFP growth over a ten-year period for US gas distributors. Two estimates were made, one referring to the average across all distributors, the second referring only to the sub-set of distributors in the Northeast of the US (“national” and “regional” estimates). The econometric

[83] D.P.U. 96-50 (Phase I).

[84] We understand that they were carried out by the same external advisers, Pacific Economics Group.

analysis was criticised because in this case the output measure was only the number of customers. No account was taken of the volume of gas delivered, and, because this had been increasing over the period studied, TFP growth was underestimated. As a result, the rate decision was based on the higher of two TFP estimates presented (referring to a group of "national" rather than "regional" companies).[85]

The DPU approved a new incentive regulation plan for Boston Gas in 2003, which again included an X factor based on a TFP analysis. This time the "regional" figure could be used because the analysis included both customer numbers and throughput as components of a composite output measure.[86]

6.2 Energy regulation in California

Price controls for gas distributors in California have also been set using TFP analyses as a component in the X-factor. For example, the price cap rate case for Sothern California Gas set in 1997 set X including a term based on a TFP study of 49 gas distributors across the US.[87] In more recent submissions, the company has produced evidence from similar econometric studies to those we have described above.[88]

In these cases, unlike the others discussed above, the TFP analysis received relatively little criticism during the proceedings, and the results of the studies were as adopted in the final decisions. The proceedings focused on other issues (including elements of the X factor other than the TFP study).

6.3 US telecommunications regulation

The U.S. telecommunications industry underwent a rapid evolution from traditional cost-of-service regulation to price cap regulation (PCR). In roughly the first half of the 1990s, well over half of state regulators and the Federal Communications Commission (FCC) had transitioned to PCR for pricing the services of incumbent local exchange carriers (ILECs).

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[85] In rate-making litigation of this kind in the US, the final decision must be justified with reference to evidence presented by parties to the litigation, so even though both of the studies had the same flaw, the "national" figure was used because it was the higher one and there was no other alternative.

[86] D.T.E. 03-40.

[87] See *Re Southern California Gas Company*, 179 P.U.R.4th 237, 1997 WL 449667 (Cal.P.U.C.). In this case the consultants for the TFP study were Christiansen Associates.

[88] Pacific Economics Group was the company's expert, producing TFP analyses of gas distributors across the US based on its econometric model. (See *Application of Southern California Gas Company for authority to update its gas revenue requirement and base rate effective January 1, 2008* (U 904-G) Application No. 06-12-010 Exhibit No.: (SCG-30-E) ___.)

Index number methods proved superior to econometric methods

As discussed above, compared to index number methods, the econometric approach to TFP growth calculation can encounter practical problems: the limitation on the feasible number of outputs and inputs in the analysis, and the difficulty of disentangling scale effects from technological change effects in econometric models of firm behaviour. These difficulties often lead to disagreements over i) model specification, ii) estimation procedure, and iii) robustness of results. The index number approach was applied almost universally in U.S. telecommunications.

Fisher index number formulas are usually used

Based on the advantages of the chained Fisher-type index, this index number formula was used to construct TFP growth rates for the U.S. telecommunications industry.[89] In constructing indices of TFP over multiple time periods requires period-to-period comparisons. This involves the selection of the base period with which all other periods are compared. The base period can be fixed, or chained. As its name suggests, for a fixed-base index the comparison, or base, period does not change with each component in the index. In a chained index the comparison period is moved forward by one period for each component in the chain. During periods when prices are relatively stable fixed-base and chained indexes will yield similar results. However, a chained index is preferable during periods of relatively extensive price changes because the quantity index is calculated using the price-weights of adjacent years. Thus a chained quantity index avoids the problem of arbitrarily updating the weights in a fixed-base index, in order to accommodate significant price changes. As a consequence, chained Fisher TFP indices are generally used in the U.S. telecommunications industry.[90]

6.4 Observations

TFP has been used in setting price caps for energy distribution in North America in a number of jurisdictions. However, in no case has this been specified in the relevant legislation, but rather the approach has been developed through the rate setting process and evolving regulatory practice in each jurisdiction.

In the case of gas and electricity distribution in the US, where the companies are regulated by the state public utility commissions, the legislative framework provides only for cost of service / rate of return type regulation. In a minority of cases in the 1990s price caps were introduced as an alternative to rate of return regulation, by agreement between the regulator and the regulated companies. Price caps were the exception rather than the rule in electricity distribution (for example, in 2001 around 28 companies out of 100 were subject to some form of price cap).[91] Of these 28, the majority used methods other than TFP to set price caps, or simply opted for a "rate

[89] See the reference to Bernstein and Zarkadas (2004).

[90] Actual calculation of index number based on such formulas as Tornqvist and Fisher do not often result in significant differences in results.

[91] See Sappington, Pfeiffenberger, Hanser and Basheda, *The Electricity Journal* (2001) 71–79.

freeze". Since the 1990s, many states have abandoned price cap regulation, in the face of rising costs in part triggered by the need for asset renewals. A recent survey published as part of a regulatory proceeding in Canada reported four North American jurisdictions in which TFP was used to set prices for energy distribution: Ontario, Massachusetts, California and Maine.[92] In US jurisdictions each company has its own rate case, and there is no reason for several cases to be heard at once. As a result, in jurisdictions where price caps have been used there is no issue of whether to use an "industry-wide" X factor or a company-specific one, because each rate case involves only one company.

"Building block" type price controls based on multi-year forecasts of costs are not common in North American jurisdictions. The overwhelming majority of rate cases involve resetting prices with reference to costs in a single "test year", which is usually the most recent year for which actual data is available, or may be a forecast for the year following the rate case. Once prices are determined with reference to costs in the test year, the normal arrangement would be for prices to remain at this level until either the company or customer representatives requests a new rate case.

TFP has been almost universally adopted for setting prices of the regulated part of US telecommunications businesses. A major issue in this sector was applying price controls to only part of the companies' business (which brought associated difficulties such as dealing with shared costs). The regulated part of these businesses is now relatively small, due to technological change and the introduction of competition.

[92] *Second-Generation Incentive Regulation for Ontario Power Distributors*, PEG (June 2006).