REPORT

# *Rail Access Regulation CPI-X Review*

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*by*

**The Institute for Research into International Competitiveness (IRIC)**

Curtin Business School, Curtin University of Technology

*for*

**The Office of the Rail Access Regulator**

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# *Contents*



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# 1 Introduction

This report presents a brief analysis of issues surrounding the price adjustment component of revenue cap regulation employed by the Western Australian Office of the Rail Access Regulator (ORAR) by the Institute for Research into International Competitiveness (IRIC) at Curtin University. It is intended to be a strategic review, to discuss economic principles that can guide the Rail Access Regulator (the Regulator) and suggest directions for further research, rather than an attempt to calculate the appropriate adjustment variables directly. As it is a strategic paper, where other literature summarises a particular issue tangential to the main argument well, we direct the reader to that paper rather than replicating its arguments here.

Chapter Two of the paper provides some background by outlining the broad principles behind price adjustment mechanisms in regulation, and what they are intended to achieve. It also highlights the close inter-relationship between the choice of 'X-factors' in the most common method of price adjustment (CPI-X) and the methodology used in calculating the capital base. Chapter Three outlines the way in which regulators around the world apply the CPI-X price adjustment mechanism, examining issues associated with both the CPI and X-factor components. In Chapter Four, we present a methodology which takes into account differences in relative prices, and which calculates productivity for an efficient benchmark firm. We discuss both the theoretical background, and the relevant issues in implementation. Chapter Five provides some conclusions and recommendations for steps forward.

# 2 Broad Principles Underlying Price Adjustments in Regulation

Before examining in detail the various facets of price adjustment regulation, it is important to summarise precisely why a regulated price cap (or revenue cap), set in the first year of a regulatory period, is subsequently adjusted at all during the regulatory period. The simple answer is inflation. In a competitive market, firms would be able to increase their prices according to the overall movement in prices without making any changes to either the market structure or to the welfare of the consumers they serve. In fact, firms must increase the prices of their outputs, as the prices of their inputs are rising with inflation, and failure to change output prices would result in losses in profitability or, in the extreme, even bankruptcy.

A regulator seeks to emulate how price adjusts in a competitive market for the regulated firm, and indeed, must do so if it is to prevent the regulated firm from facing the risk of real price reductions in the face of inflation due to inflexible regulation. However, a regulator does not adjust prices solely (or even primarily) to assist the regulated firm. From the perspective of the community at large if the price of regulated goods do not adjust with inflation, the prices of the regulated goods become cheaper relative to non-regulated goods, and hence the community as a whole will devote too many resources to the purchase of regulated goods, resulting in allocative inefficiencies.[1]

Price adjustment mechanisms rarely involve adjustment based only on inflation, however, because productivity is not static. As a firm improves its productivity, it is able to use fewer resources to produce the same output and hence may be able to maintain its output and profitability in the face of rising input prices, providing that its productivity is rising as fast or faster than input prices.

In competitive sectors of the economy, if a firm improves its productivity relative to a rival, it can lower prices and increase market share. Survival of a competitive firm requires that it not be 'out-innovated' by a rival, and hence competition provides a strong incentive for innovation. Monopolists have weaker incentives, as they have no rivals to

[1] We implicitly assume here that the regulated sector is small relative to the rest of the economy. If it is large, then regulatory decisions can drive inflation, rather than the converse.

threaten their survival.[2] A regulator seeks to emulate the 'survival pressures' of a competitive market and hence bring forth productivity improvements by the regulated monopolist. This occurs through the pricing mechanism: a regulator does not regulate productivity directly, but rather takes the productivity improvements which it considers should be achievable, and translates these into a price or revenue cap. The correspondence between productivity improvements and price changes is not necessarily one-to-one, however. This is the crux of the problem facing a regulator when determining a price or revenue adjustment mechanism under regulation.

## *2.1 The Relationship Between CPI-X and the Way in Which the Capital Base is Calculated*

To consider the relationship between the X-factor in CPI-X regulation and decisions in regards to the capital base, consider the way in which a regulator determines a relevant price or revenue cap. Basically, a regulator determines a reasonable initial asset value, reasonable depreciation and reasonable capital and operational expenditure over the regulatory period. We refer to these three components as the 'capital base'.[3] The per unit price cap (or revenue cap) of the regulated good is then the capital base divided by forecast demand (or just the capital base in the case of a revenue cap). Thus, alterations to the capital base will alter the price which the firm can charge just as an X-factor does, and can have similar incentives for productivity improvement.

If a regulator believes that a regulated firm is not as productive or efficient as it 'should be' given efficiencies achieved elsewhere in the industry, it has three options:

- To lower the capital base to reflect only the costs of an efficient benchmark firm.
- To lower the price adjustment mechanism by some X-factor.
- To combine both approaches.

The difference between the first two options is essentially one of timing. If the capital base is reduced, the firm must increase productivity the entire extent of the gap between its current productivity and that of the efficient benchmark firm straight away as its initial

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[2] This does not imply that a monopolist has no incentives, as an increase in productivity with fixed prices leads to an increase in profits.

[3] We acknowledge that the 'capital base' is often taken to incorporate just the value of the asset at the outset of regulation. We include allowed capital and operational expenditures and depreciation for ease of exposition only.

price cap (or revenue cap) will only generate revenues sufficient to cover the costs of an efficient benchmark firm. Adjustment in the X-factor allows revenues to be above those required to cover the costs of the efficient benchmark firm initially, and hence provides time for productivity improvements to occur. The mix chosen by a regulator will (or should) reflect the speed at which a regulator believes it is reasonable to expect productivity improvement by the firm.

The mix chosen by a regulator must conform to a consistency requirement. Note that productivity has two components. The 'static-gap' component reflects the current gap between the productivity of the regulated firm and that of the efficient firm benchmark. The 'dynamic-change' component reflects the growth in productivity over time, possibly of the actual firm, but generally, and throughout this report, taken to be that of the efficient benchmark firm. If a regulator chooses a capital base consistent with the actual price paid by the firm for its assets (for example, a DAC value), then the choice of X factor should include both the dynamic-change and static-gap components of productivity. If a regulator chooses a capital base consistent with some optimised value, reflecting an efficient benchmark firm (for example, DORC, or ORAR's GRV methodology), then the X factor should only include the dynamic-change component of productivity. Each point on the continuity of values of capital base between the two extremes mentioned above will generate a unique X factor which contains the dynamic-change component of productivity and a unique proportion of the static-gap component.

Failure, on the part of a regulator, to choose appropriate combinations of capital base and X-factor could result in unsustainability for the firm (in the case of a DORC or GRV value paired with an X-factor incorporating both the dynamic-change and static-gap components of productivity), or monopoly rents (in the case of a DAC value combined with an X-factor incorporating only the dynamic-change component of productivity). Put simply, decisions on capital base and on the X-factor cannot be taken in isolation. For ORAR, committed by Schedule 4 of the *Railways Access Code (2000)* to its GRV approach towards the capital base, the X factor should thus reflect only the dynamic-change component of productivity; that is, the growth in productivity of the efficient benchmark firm.

# 3 Price Adjustment Mechanisms Used by Other Regulators

In terms of the broad type of price adjustment mechanism used, all of the regulators we examined utilised some variant of the CPI-X adjustment mechanism. Although improvements might be made in its application, it is difficult to conceive of a basic framework more well suited to adjusting prices to account for inflation and productivity improvements than a CPI-X mechanism.[4]

It should be noted that, just because different regulators use the same basic CPI-X methodology, it does not follow that the values for the X factor chosen will be the same in each case. In fact, the Australian experience shows a wide variety of values used as X-factors. This occurs partially due to the interaction between the capital base and the X-factor discussed in the previous chapter, and partially due to the differences in static-gap and dynamic-change productivity between industries. Given the diverse nature of regulated industries in Australia, it would be unlikely that many regulatory decisions would have similar X-factors. Moreover, focussing on the values chosen for X clouds the key underlying issues. For these reasons, we have not constructed a 'league table' of results, which often accompany reports of this nature.

Section 3.1 summarises some of the approaches taken in estimating the X-factor, whilst Section 3.2 highlights some issues associated with the estimation of CPI, both generally, and in the context of a single regulated firm.

## 3.1 Different Methods of Calculating the X-Factor

The different approaches towards estimating X-factors, and their advantages and disadvantages are discussed in detail in a recent paper for the Utility Regulators' Forum (Farrier-Swier, 2002). To avoid replication, the discussion below is brief and focuses mainly on the appropriateness of each methodology within the context of rail access regulation in WA.

[4] We do not consider various additions to the CPI-X framework intended to allow for exogenous shocks (such as Z-factors, earnings share mechanisms, dead-bands or off-ramps) as these cloud the fundamental issues discussed here. Farrier-Swier (2002) provide a summary of these additions, and their use.

### 3.1.1 Building Block Approaches

The building block approach is essentially input-based; it relies on calculating the 'right' values for all of the inputs to revenue determination (such as operational expenditure, capital expenditure, depreciation and WACC) for each year of the regulatory period, and then using these to determine the relevant X-factor. Two approaches are possible:

- Determine the 'target' revenue at the end of the regulatory period and the starting price, then set the X factor to adjust starting prices so that they will meet the target end period revenues, given demand forecasts.
- Determine the NPV of efficient revenues for each period. Once the starting price is determined, 'back-solve' to find an X which generates the NPV of target revenues.

According to Farrier-Swier, the building block approach is widespread amongst Australian regulators. It is also used in gas and electricity regulation in the UK. In order to calculate appropriate levels for the various inputs, many of the methods discussed below (such as TFP, benchmarking and engineering-economic studies) can be used, so the building block approach is not completely distinct from other approaches. What distinguishes it is its focus on inputs, rather than outputs.

The building block approach is highly firm-specific, which means that it is most useful when firm-specific factors are important or where little is known about appropriate values for factors such as productivity, which may be the case early on in a regulatory regime, for example. However, the approach has been criticised by many, including the Productivity Commission (2002) who note that:

- It is information intensive and intrusive for firms.
- The need to forecast future costs and validate proposed capital and operational expenditure could result in a regulator having substantial influence over operational aspects of the business.
- It blurs the distinction between price (or revenue) cap and rate of return regulation, and efforts by a regulator to reduce Averch-Johnson effects associated with rate of return regulation could lead to more intrusive regulation.

In the context of regulation generally, we would concur with the general flavour of the Productivity Commission's comments. The interventionist nature of a building block approach seems unnecessary, and does not appear to offer any real advantages in terms of incentive compatibility, particularly as the regulatory regime matures. Specific to the regulation of the rail infrastructure industry in WA, the use of a GRV based on an efficient benchmark firm means that firm-specific factors are not important, and hence there would be little value in the use of building blocks to determine the X-factor.

Decisions concerning the X-factor have an analogue in depreciation decisions. The building block approach involves establishing appropriate components of the capital base, one of which is depreciation. Allowing more depreciation would have the same fact as a smaller (or negative) X factor, as it would increase the amount of real revenues which could be earned in a particular year. Allowing less depreciation has a similar effect to requiring a larger X-factor.[5] Davis (2002) takes this analysis one step further, and suggests that the use of 'economic depreciation' (essentially the difference between the NPV of expected returns to the asset at different points in time) necessitates an X-factor of zero. This would clearly be the case, as it would involve optimising the capital base at each point in time, and hence requiring that the firm be at the efficiency benchmark level of productivity on a continual basis. However, it is not clear how helpful this approach would be for regulators, as predicting the NPV of expected returns is fraught with difficulty. In any case, ORAR does not use 'economic depreciation' but straight line depreciation, and hence an X-factor must still be calculated.[6]

### 3.1.2 Partial and Total Factor Productivity

Partial and total factor productivity (PFP and TFP respectively) measure the amount of output(s) which is produced per unit of input(s). Perhaps the most common PFP measure is the productivity of labour. In general, TFP is preferred to PFP because it is difficult to associate output changes with particular inputs; an increase in output may be due both to increasing labour productivity and a productivity increasing improvement in another factor, for example, the use of new capital equipment. The standard formula for TFP is:

$$TFP = \Sigma r_i \dot{y}_i - \Sigma s_i \dot{x}_i$$

[5] The difference, however, is that a change in the depreciation schedule necessitates an offsetting change at some later point in time, if the asset is to be fully depreciated over its economic life.

[6] From a certain perspective, ORAR's GRV approach is akin to applying economic depreciation, but on a triennial, rather than annual basis. Thus, given the likely small value of the X-factor, ORAR may wish to consider following Davis' advice, and set X at zero.

where $y_i$, are outputs, $x_i$, inputs, the $r_i$, are revenue shares, the $s_i$, cost shares, and the dots above letters indicate instantaneous growth rates. However, there are numerous methods used to adjust this basic framework to a given situation. Farrier-Swier outline some, and Bitzan (2000) outlines more, within the context of the US rail industry.

When TFP is used to determine the productivity of the efficient benchmark firm, it has the advantage of not being tied to firm-specific factors, and hence provides a greater incentive for the regulated firm to approach the efficient benchmark firm in productivity. If it does not, then it will experience losses in profit. For this reason, and because the use of TFP to calculate the X-factor matches the method used by ORAR to calculate the capital base, we suggest that using a TFP to estimate the dynamic-change component of productivity is the best approach for calculating the X-factor.

However, TFP can be difficult to calculate and controversy may arise in the choice of both the cost functions underpinning its construction and in the choice of an efficient firm benchmark. In their case study of a number of US and Canadian gas distribution firms who utilise this method, Farrier-Swier (2002) note that part of the reason for its success in these regimes is the fact that the Federal Energy Regulatory Commission in the US undertakes its own audits of TFP on a regular basis (thus obviating the need for the calculation of TFP for each regulatory decision) and that the results are well accepted amongst industry.

### 3.1.3 Frontier Analysis

Frontier analysis involves collecting a set of firms, examining the productivity of their various factors, and constructing an ‘envelope’ (or frontier) of the most efficient factors for all of the firms. The inefficiency of a particular firm is then the ‘distance’ of the firm from the frontier. The two main methodologies are Data Envelopment Analysis and Stochastic Frontier Analysis, and the major difference between the two is that the former is deterministic and does not specify a functional form, whilst the latter involves both a functional form and is stochastic, which means that it can accommodate statistical variability. London Economics (1999) recently conducted a comprehensive review of frontier analysis and its use in regulation for IPART. It is used in the Netherlands and Norway to determine X-factors, according to Farrier-Swier (2002).

Frontier analysis can provide a more holistic picture of which factors are the ones driving the inefficiency of a firm. However, it is much more computationally intensive and requires much more data than a TFP approach. Perhaps the biggest disadvantage from the perspective of the rail infrastructure industry in WA is that frontier analysis measures only the static-gap component of productivity; it measures how far a given firm is from the efficient frontier at a point in time. To measure the dynamic-change component, one would have to re-calculate the efficiency frontier every year, and track its movement. Not only would this be very time consuming, but 'movement' may be difficult to interpret if the frontier is moving at different speeds in different input dimensions. For this reason, we would suggest that, despite its greater accuracy in pinpointing sources of inefficiency, frontier analysis would be too costly and cumbersome to use in determining X-factors for the WA rail infrastructure industry.

### 3.1.4 Benchmarking and Engineering-Economic Analysis

Benchmarking (or the use of 'yardsticks') and engineering-economic analyses are very similar conceptually, as both involve a comparison between the relevant firm and some 'ideal firm'. Of the two, benchmarking is the cruder, as it examines certain aspects of the regulated firm chosen by a regulator (such as price of outputs) and compares them with other firms, whilst the engineering-economic approach basically models an 'idealised' firm, and compares its structure, prices and outputs with the idealised firm. It is particularly useful when the set of available comparator firms is small, and hence it is difficult to determine what an efficient firm looks like.

Engineering-economic analysis is utilised by the ACCC in telecommunications regulation, and in Spain and Chile for electricity regulation. Due to its crudity as a measure, benchmarking is generally used in cases where the variable of interest is difficult to quantify and compare. For example, the performance of government departments is often benchmarked according to various indices, as is the performance of firms in 'triple-bottom-line' accounts.

The rail infrastructure industry is one where the set of comparable firms is not large, and hence we would suggest that a form of engineering-economic analysis would be useful for ORAR to consider. However, the means of comparison are important to consider. As will become clear in Chapter Four, our methodology essentially involves an engineering-economic analysis, with TFP being the means of comparison.

## *3.2 Issues Associated with the Use of CPI as an Indicator*

The CPI component of the CPI-X mechanism has long been known to be an imperfect measure of inflation. When considering its use as a forecast of inflation in WACC calculations, the ACCC notes that it is inevitably out of date, may be subject to some institutional bias and does not necessarily relate to the access arrangement period under consideration (ACCC, 2001). However, more fundamental issues exist.

As an index, the CPI is intended to measure increases in the overall cost of living, but measures it only imperfectly. Shultze (2003) considers three reasons why the CPI overstates true changes in the cost of living (by about one percent per annum in the US):

- It fails to account for consumer substitution in the face of relative price changes.
- It fails to account adequately for changes in the quality of existing goods.
- It fails to account adequately for the introduction of new goods (particularly their timing).

Hausman (2003) adds a fourth factor; the CPI fails to take into account the changes in shopping patterns. As people substitute relatively more expensive department stores for less expensive discount stores (he uses the example of Wal-Mart in the US), their mix of shops changes even though their basket of goods does not. As the CPI rotates the shops chosen for its survey on a formulaic basis, not necessarily in tune with changing shopping tastes, it may overstate inflation for a time.

In the Australian context, a variant on Hausman's observation also occurs, due to the oligopolistic nature of retailing in this country. This can perhaps best be appreciated by way of an example. Recently, Coles announced that it would begin to compete more on price with Woolworths. In economic terms, the retailing duopoly is moving to a new equilibrium, consistent with lower rents for both players. As these two duopolists account for such a large share of national retail spending, this may in fact lead to slower growth in the CPI, compared to the status quo market structure. Over time, in a general equilibrium sense, these changes would disperse throughout the economy, but this movement towards a new economy-wide equilibrium is unlikely to be as fast as the change in CPI suggests. Certainly, for the factors used by rail infrastructure companies, changes in retail competition are unlikely to have a substantial impact in the short term commensurate with that suggested by changes in the growth of CPI.

In a recent issue of the *Journal of Economic Perspectives*, (which contain the articles by Shultze and Hausman referenced above) the findings of a symposium on the CPI and its shortcomings are detailed. It is not our intent to summarise these findings here, suffice to say that the issues raised by Shultze and Hausman can be addressed, and the two authors offer a number of suggestions. Thus, it is possible for issues inherent in the calculation of CPI to be ameliorated. We would not suggest, however, that this rather expensive exercise be undertaken by ORAR alone. Rather, since all regulators use CPI measures, and the biases mentioned above would affect all regulators equally, it may be more appropriate for the amelioration to occur as part of a joint effort by Australian regulators, perhaps in conjunction with the Australian Bureau of Statistics.

#### 3.2.1.1 Issues Related to CPI Specific to its Use in Regulated Industries

The purpose of the CPI component in the CPI-X mechanism of price adjustment is to act as an independent proxy for changes in the price of the basket of input goods used by the regulated firm (in the sense that it does not require firm-specific data for its calculation). To the extent that prices of inputs used by the regulated firm move with CPI, CPI remains an appropriate proxy. However, if relative prices change, then the CPI may produce a biased estimate of the actual change in input prices for the regulated firm, particularly if relative price changes persist for a number of periods. For this reason, if CPI is to be used as the basis for price adjustment, a means of incorporating such relative price changes into the analysis needs to be found. We discuss such a methodology in Chapter Four.

# 4 A Suitable Framework for Price Adjustment in the Rail Industry

As we have shown in previous chapters, given the way in which ORAR regulates the capital base, its choice of X-factor should reflect only the dynamic-change component of productivity (see Section 2.1). For this reason, we have suggested that changes in TFP at the efficient benchmark firm level should be used in calculating the X-factor. It is also important to ensure changes in relative prices can be incorporated into the analysis.[7] The first section of this chapter outlines a methodology by which relative prices can be incorporated. The second outlines a useful methodology to use a basis for calculating TFP for the efficient benchmark firm. The third section concludes with some implementation issues.

## 4.1 Theoretical Principles

Bernstein and Sappington (1999) provide a theoretical basis for the calculation of a CPI-X adjustment mechanism which allows for changes in relative prices.[8] We summarise the approach below. Firstly, consider the profits ($\Pi$) of a firm, which are equal to the difference between its revenues ($R$) and its costs ($C$). Assume the firm produces $n$ outputs with $m$ inputs, and let the price of each output be denoted by $p$ and its quantity by $q$. Let $v$ denote the quantity of an input, and $w$ the share of that input in overall costs. This can be summarised as follows:

$$\Pi = R - C = \sum_{i=1}^{n} p_i q_i - \sum_{j=1}^{m} w_j v_j$$

Now, examine how profits change with changes in inputs, input prices, outputs and output prices by taking derivatives of the above expression, thus:

[7] We do not discuss solutions to potential bias in CPI measures due to changing product quality, the appearance of new products or similar issues, as we have indicated these issues should be addressed at a national level.

[8] We present the 'base case', which is suitable for the rail infrastructure industry in WA. Bernstein and Sappington go on to make a number of refinements, which could be appropriate in a different regulatory setting.

$$\Pi \frac{d\Pi}{\Pi} = \sum_{i=1}^{n} p_i q_i \frac{dq_i}{q_i} + \sum_{i=1}^{n} p_i q_i \frac{dp_i}{p_i} - \sum_{j=1}^{m} w_j v_j \frac{dv_j}{v_j} - \sum_{j=1}^{m} w_j v_j \frac{dw_j}{w_j}$$

In order to express everything in common units and provide greater tractability in results, the above equation is normalised by dividing the whole expression by *R* or equivalently, by *Π-C*, and then simplifying the results thus:

$$\sum_{i=1}^{n} r_i \dot{p}_i = \frac{C}{C+\Pi} \left\{ \sum_{j=1}^{m} s_j \dot{w}_j - \sum_{i=1}^{n} r_i \dot{q}_i + \sum_{j=1}^{m} s_j \dot{v}_j + \frac{\Pi}{C}\dot{\Pi} - \frac{\Pi}{C} \sum_{i=1}^{n} r_i \dot{q}_i \right\} \quad \textbf{(1)}$$

where

$r_i \equiv \dfrac{p_i q_i}{R}$ denotes the total revenue derived from the sale of the I$^{th}$ service,

$s_j \equiv \dfrac{w_j v_j}{C}$ denotes the share of total cost accounted for by the j$^{th}$ input, and

$\dot{x} \equiv \dfrac{dx}{x}$ denotes the change in the variable *x* (for $x=p_i, q_i, w_j$ and $v_j$).

Now, to simplify expression one further, let

$$\dot{P} = \sum_{i=1}^{n} r_i \dot{p}_i \,,\ \dot{W} = \sum_{j=1}^{m} s_j \dot{w}_j \,,\ \dot{Q} = \sum_{i=1}^{n} r_i \dot{q}_i \ \text{ and } \ \dot{V} = \sum_{j=1}^{m} s_j \dot{v}_j$$

which means that expression one can be re-written as:

$$\dot{P} = \left( \frac{C}{C+\Pi} \right) \left\{ \dot{W} - \left[ \dot{Q} - \dot{V} \right] + \frac{\Pi}{C} \left[ \dot{\Pi} - \dot{Q} \right] \right\} \quad \textbf{(2)}$$

Note that $\left[\dot{Q} - \dot{V}\right]$, the change in outputs minus the change in inputs is simply the TFP growth of the regulated firm, and can be expressed as $\dot{T}$. Aggregating the changes in input and output quantities through the use of prices and cost shares respectively results in:

$\dot{V} = \sum_{j=1}^{m} s_j \dot{v}_j$ and $\dot{Q} = \sum_{i=1}^{n} r_i \dot{q}_i$ , which means that equation two can be expressed as:

$$\dot{P} = \left(\frac{C}{C+\Pi}\right)\left\{\dot{W} - \dot{T} + \frac{\Pi}{C}\left[\dot{\Pi} - \dot{Q}\right]\right\} \quad \textbf{(3)}$$

Expression three, then, shows how prices change as a function of changes in TFP, input prices, output quantities and profits. However, it is a little cumbersome, and can readily be simplified by the application of some simple assumptions from economic theory. If a regulator aims to keep the regulated firm in a long-term equilibrium with zero economic profits,[9] this also means that the change in profits will also be zero, and equation three reduces to:

$$\dot{P} = \dot{W} - \dot{T}$$

This says that the change in price should equal the change in input prices minus the TFP of the firm, and is very similar to the familiar CPI-X equation. If there are no relative price changes, and the input prices of the firm change at the same rate as those in the economy generally, the above expression will provide exactly the same results as the CPI-X equation. However, if this is not the case, the using the CPI as a proxy for the change in input prices will result in errors, and these will increase over time. To account for this fact, Bernstein and Sappington now repeat the same process undertaken above for the 'rest of the economy', which they denote with a superscript of *E*. The 'rest of the economy' analogue to equation three is:

$$\dot{P}^E = \left[\frac{C^E}{\Pi^E + C^E}\right]\left\{\dot{W}^E - \dot{T}^E + \frac{\Pi^E}{C^E}\left[\dot{\Pi}^E - \dot{Q}^E\right]\right\} \quad \textbf{(4)}$$

Subtracting equation four from equation three (to determine the difference in the two price changes brought about by relative price changes) and re-arranging terms yields:

[9] 'Zero economic profits' are defined in their standard economic sense, and hence include the opportunity cost of capital. They are *not* the same as zero accounting profits.

$$\dot{P} = \dot{P}^E - \left[\left(\frac{C}{C+\Pi}\right)\dot{T} - \left(\frac{C^E}{C^E+\Pi^E}\right)\dot{T}^E\right] - \left[\left(\frac{C^E}{C^E+\Pi^E}\right)\dot{W}^E - \left(\frac{C}{C+\Pi}\right)\dot{W}\right]$$
$$-\left[\left(\frac{\Pi^E}{C^E+\Pi^E}\right)\dot{\Pi}^E - \left(\frac{\Pi}{C+\Pi}\right)\dot{\Pi}\right] - \left[\left(\frac{\Pi}{C+\Pi}\right)\dot{Q} - \left(\frac{\Pi^E}{C^E+\Pi^E}\right)\dot{Q}^E\right] \quad \textbf{(5)}$$

This looks rather cumbersome, but can in fact be simplified into a more familiar framework. Define the basic X-factor $X_1^b$ as follows:

$$X_1^b = \left[\left(\frac{C}{C+\Pi}\right)\dot{T} - \left(\frac{C^E}{C^E+\Pi^E}\right)\dot{T}^E\right] - \left[\left(\frac{C^E}{C^E+\Pi^E}\right)\dot{W}^E - \left(\frac{C}{C+\Pi}\right)\dot{W}\right]$$
$$-\left[\left(\frac{\Pi^E}{C^E+\Pi^E}\right)\dot{\Pi}^E - \left(\frac{\Pi}{C+\Pi}\right)\dot{\Pi}\right] - \left[\left(\frac{\Pi}{C+\Pi}\right)\dot{Q} - \left(\frac{\Pi^E}{C^E+\Pi^E}\right)\dot{Q}^E\right]$$

This then yields the familiar CPI-X formula (with the X-factor re-defined appropriately):

$$\dot{P} = \dot{P}^E - X_1^b$$

Now, equation five is the appropriate general form of Bernstein and Sappington's methodology, as it highlights precisely how changes in relative prices affect the price rise which should occur for the outputs of the regulated firm. However, it may not be necessary to apply such a complex equation. If we may assume that the rest of the economy is in a situation of long-run, competitive equilibrium, with zero economic profits, and a regulator wishes to ensure that the regulated firm is in the same situation, then we may use a simpler version of equation five:

$$\dot{P} = \dot{P}^E - X_0^b = \dot{P}^E - \left\{\left[\dot{T} - \dot{T}^E\right] + \left[\dot{W}^E - \dot{W}\right]\right\} \quad \textbf{(6)}$$

Where, as noted previously, P represents price, W represents the weighted sum of inputs, T represents total factor productivity and the dots above each variable refer to changes in the relevant variable. It is equation six that we suggest would be most appropriate for use in the rail infrastructure industry, rather than the simpler CPI-X mechanism used at present, as it takes into account the fact that relative prices can change, and does so in a systematic way which is transparent to industry and the wider community. Although the assumption of the rest of the economy being in equilibrium could be challenged, we believe that the extra effort needed to calculate equation five would not be worth the additional refinement which it brings. However, we note that sufficient data do exist (from the ABS and other sources) to facilitate the calculation of equation five should ORAR decide that the additional refinement in results it will bring is worth the additional time and cost of its calculation.

## *4.2 Calculating TFP for an Efficient Benchmark Firm*

The basic equation used to calculate TFP is (see Section 3.1.2):

$$TFP = \Sigma r_i \dot{y}_i - \Sigma s_i \dot{x}_i$$

Brunker (1992) adjusts this methodology by using shadow input prices, rather than actual prices, and applies his adjusted methodology to measure rail industry productivity in Australia during the 1980s. His methodology provides a useful basis for calculating TFP for the efficient benchmark firm in rail infrastructure regulation in WA.

Shadow prices reflect the economic value of inputs in production, rather than their market price (which only equals the economic value in a fully-informed, perfectly competitive market). In the case of the Australian rail industry as studied by Brunker, due to overstaffing and inefficient capital use, the shadow price of these factors was less than their actual price as reflected in the accounts of the railroad companies. Brunker strips away the inefficiencies by examining how the rail companies would have maximised their productivity through a standard Lagrangian constrained maximisation approach, if they had been constrained by a function which set their inefficient usage of inputs to zero.

Applying Brunker's basic methodology to the WA rail infrastructure industry would, in a sense, be simpler than its use in Brunker's own work, as he considered multiple outputs, including one incorporating Community Service Obligations, whilst only one output exists in respect to the WA rail infrastructure industry. We also suggest that, whilst Brunker's methodology would represent a suitable starting point of analysis, some refinements would be necessary to ensure accuracy of results. This would require a more detailed review of the TFP literature than was within the scope of this report. Bitzan (2000) provides a summary of productivity studies in the US rail industry which would make a good starting point for further review.

## 4.3 Issues in Implementation

There are perhaps two key issues associated with implementing the above methodology.

### 4.3.1 Existence of Relevant Data

IRIC has conducted a preliminary scan of available data sources. Brunker (1992) utilised the annual reports of Australian rail companies in his study, and we would suggest a similar approach today. Although we have not checked all annual reports, those we have seen do separate above and below rail costs.

US and European rail data are collected by specialist agencies (as well as being available in the annual reports of rail companies). Substantial data appears to be available, particularly in the US. However, in both cases, data must be purchased. Canadian data are available for free from the Railway Association of Canada, but does not appear to be quite as detailed as those available from the US or Europe.

In all cases, we would suggest that some care needs to be taken when interpreting data, to ensure that the influence of any exogenous shocks to the rail system of a relevant country have been taken into account. For example, following the passage of the *Staggers Act* in the US in 1980, its hitherto moribund rail industry improved productivity rapidly, before settling down to more modest increases during the nineties. The passage of Directive 91/440 in the EU, which called upon member states to separate ownership of track and rolling stock and allow would-be carriers of international freight to have access to national track, may have had similar effects. Failure to consider a shock like the *Staggers Act* when looking for comparators could result in an X-factor that is too high.

We would suggest that, although it appears that sufficient data exist for a skilled economist to calculate appropriate TFP indices for an efficient benchmark rail firm, the process could be greatly expedited by the use of a specialist engineer, who would be more familiar with the engineering aspects of the rail industry. In terms of Brunker's methodology, the engineer would assist in developing the constraint function in the Lagrangian maximisation problem.[10]

[10] The Lagrangian maximisation approach is a standard mathematical approach used in constrained maximisation problems, and is widely used in economics.

### 4.3.2 What is the Output of a Rail Track?

Perhaps the most important issue to be resolved is to answer the question of what, precisely, constitutes the output of a rail infrastructure firm, and how is it best quantified. ORAR does not specify the output of a rail infrastructure firm at present, as it caps revenues, not prices. Bitzan (2000), examining the literature on the derivation of cost functions in the US discusses the difficulties surrounding the derivation of an appropriate output measure for rail companies (not rail infrastructure companies) and, more importantly, the manner in which different output measures often lead to very different conclusions. It would be somewhat unhelpful if the findings of a long and involved TFP-based study were rendered irrelevant because output was not properly specified at the outset. We have undertaken some very brief discussions within IRIC, to begin thinking about this issue, but have thus far not progressed sufficiently to answer the question definitively. We suggest that this question needs to be addressed first, before any further research is undertaken. Particular attention should be placed on the consequences of different definitions.

# 5 Conclusions and Recommendations

This brief review of extant price adjustment mechanisms has found that:

- Price adjustment methodologies and capital base valuation methodologies are intertwined, and should not be considered in isolation. For ORAR, the practical consequence of this is that its GRV methodology necessitates the inclusion of only the dynamic-change component of productivity in the X-factor.
- TFP analysis of the efficient benchmark firm (calculated via engineering-economic analysis) appears to be the most useful methodology for the calculation of the X-factor, and Brunker (1992) provides a useful framework within which to operate.
- Changes in relative prices can be important and are not adequately addressed in most methodologies used by regulators today. Bernstein and Sappington (1999) present a methodology which does allow for changes in relative price to be accounted for, and which appears readily implementable in the context of the WA rail infrastructure industry.

Before proceeding further, however, we would suggest two caveats. The first is the need to consider in more detail the nature of the outputs of a rail infrastructure firm. The second is the need to consider the relative costs and benefits of instituting methodologies more complex and precise than that currently used by ORAR to determine the X-factor. Although we did not find any direct references to the calculation of TFP for rail infrastructure,[11] we found no studies which would suggest it is high. Ellig (2002) for the rail industry as a whole in the US from 1990-96 imputes an X-factor averaging about 3.5 percent per annum. Brunker (1992), finds best practice TFP gains of between 3.4 and 4.9 percent per annum for the industry as a whole, during a period of substantial industrial reform in Australia. We would not be surprised if the relevant productivity figures for rail infrastructure were substantially less than half of the figures above. Moreover Davis' comments on the use of 'economic depreciation' and its similarities to the regular re-optimisation of the asset base by ORAR will also influence any cost benefit analysis of different strategies by ORAR. The key question for ORAR to consider is whether the benefits of extra precision in estimating the X-factor outweigh the costs associated with making such more precise estimations.

[11] As this was not part of the brief, our literature search was by no means extensive on this matter.

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