# The long-run level of X in RPI-X regulation: Bernstein and Sappington revisited

# (WORKING PAPER)

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**Abstract** Electricity regulation in the UK is twenty years old, and RPI-X regulation is twenty-five years old. In this paper, we consider the long-run properties of RPI-X price-capping regulation. We argue that the Bernstein and Sappington (1999) mechanism, which has had a major impact on regulatory behaviour, implicitly assumes short-run behaviour by regulators, and consequently leaves a long-run disequilibrium position unresolved. We demonstrate that strong assumptions are required if the optimal X in RPI-X is not zero in the long run. Finally we argue that the explanation for the repeated use of positive X-factors stems from the Crew and Kleindorfer problem of failure of regulatory commitment and we offer an explanation for this in terms of a dynamic model of regulatory response to populist pressure.

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## RPI-X incentive regulation

Electricity regulation in the UK is twenty years old, RPI-X regulation is twenty-five years old, and there are calls for a retrospective cost benefit analysis and a review of the options for the future [Ofgem (2008)]. In this paper, we raise the issue of the long-run properties of RPI-X price-capping regulation.

Although the original intention was that RPI-X price capping would fade away when it had outlived its usefulness [Beesley and Littlechild (1988)], the continued existence of natural monopoly networks implies that some form of regulation is required for the foreseeable future. Consequently, it is timely to consider the long run properties of price cap regulation, and in particular to revisit the X-setting mechanism suggested by Bernstein and Sappington (1999), which has had a major impact on regulatory behaviour. In practice, regulators have adopted the habit of setting the X factor at a positive number at each price control review, and this is characteristic of the USA and elsewhere in Europe, as well as in the UK [Joskow (2005)]. The general but implicit assumption seems to have been that incentive based regulatory contracts would always stimulate out-performance in a world of asymmetric information, and consequently regulators anticipate that inefficiency and slack will be revealed, and that therefore they should seek a forward-looking X factor in order to return to customers, in advance, the efficiency gains which are the results of the incentive mechanism[1]. In general such inefficiency can reflect a potential for both *catching up* with the frontier and *frontier shift.*

In this paper, we devote most of our attention to the frontier shift problem[2] since this is more directly relevant to the long run properties of the regulatory mechanism. We argue that the Bernstein and Sappington mechanism implicitly assumes short-run behaviour by regulators, and consequently leaves a long-run disequilibrium position unresolved. This might seem to be paradoxical since the Bernstein and Sappington results are derived in a well articulated general equilibrium model of regulated and competitive sectors in the economy. However, a core result of the analysis is that the

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1 The vehicle for implementing this claw-back can be either or both of the X-factor and the P-nought factor, see below.

2 The compendium of papers edited by Coelli and Lawrence (2006) examines the existence and measurement of the catching-up effect in theory and practice

equilibrium rate of price change in the regulated sector differs systematically from the equilibrium rate of price change in the competitive sector. In a static model of a one-off episode of privatization and incentive based regulatory review the result is entirely reasonable. However, regulators have in practice interpreted this as a steady state result which does not seem to have been the authors' interpretation. It is regulatory practice that has driven the arguments set out in this paper not the theoretical model suggested in Bernstein and Sappington (1999). It is apparent from the history of regulatory reviews of investor-owned utilities in Europe, and possibly to some extent in the USA, that regulators have in many cases regarded it as a public duty to impose a positive X-factor on regulated businesses many years after the initial privatization or deregulation. This has ongoing and important re-distributive implications, because it leads to an expectation that at every price control review there will be a re-distribution of network industry rents in the form of a positive X-factor for the long term future.

We ask what has been the re-distributive purpose of regulation in the UK and elsewhere, and we explain why regulators are in danger of confusing efficiency catch-up with the frontier shift which lies at the heart of the Bernstein and Sappington mechanism. We pose the fundamental question: based on efficiency considerations alone, why should the X in RPI-X be different from zero in the long run, and argue that most of the drivers of a price differential between the regulated business and the rest of the economy are essentially short term effects (although these effects may last for a number of years). We therefore explore the proposition that the profile of the X factor over time reflects the point made by Crew and Parker (2006) and Crew and Kleindorfer (2002, 2006) that a major driver in the economics of regulation has been the issue of rent seeking and rent re-distribution. We close the paper by suggesting that this could be explained by the regulator's wariness about populist responses to regulatory outcomes that do not capture firms' rents [as cited by Crandall and Winston (1994)] , and we develop a framework for evaluating the impact of populist pressure on the profile of the X factor and the power of the incentive regime.

## Stylised Model of RPI-X Price Setting

In practice, the application of RPI-X regulation in the UK and elsewhere is a complex process involving efficiency assessments of operating expenditure (and in some jurisdictions the total cost of operations), profitability assessments, and scrutiny of forward-looking capital and operating expenditure plans, which may involve forward-looking productivity estimation. A corporate finance model is frequently adopted for the purposes of calculating the price control parameters.

$$PV[P_0(1+RPI-X)Q] = PV[OPEX + D + (wacc)RAB]$$

Where the ($P_0$) is the initial price, which it is often convenient to think of as capturing the excess returns of the past period and returning them to customers, whilst the X factor captures the forward looking expectations of productivity growth. In practice, for any given X factor, the initial price correction can be solved as a present value (PV) calculation conditional on a given set of demand forecasts (Q). The regulatory asset base ($RAB_t$) is determined by adding the capital expenditure flow (CAPEX) and subtracting the depreciation flow (D) during the period to adjust the stock value. The regulator calculates the companies' weighted average cost of capital (*wacc*) and the expected return on capital allowed in the cost projections is $(wacc \times RAB)$. OPEX refers to the company's operating expenditures.

Our examination of the meaning of the X factor in this paper can apply equally to the X factor applied to the whole business, or to the targets imposed on subsets of the businesses' costs, for example, operating expenditure.

## What does the X factor represent?

Burns and Weyman-Jones (1994) initially addressed this issue and showed that, in a partial equilibrium setting, the X factor is given by

$$X = RPI - \Delta \log w^R + \Delta TFP^R - \Delta \log \mu^R$$

The regulated utility sector is denoted by the superscript *R*, and w is the vector of input prices, TFP is the rate of growth in total factor productivity defined across all the relevant outputs and inputs, and $\mu$ is the rate of profit, i.e. the mark-up of revenue over cost. If this is assumed not to change (in expectation) then $\Delta log\ \mu^{R}$ is zero. Bernstein and Sappington (1999) developed a wider general equilibrium framework by introducing both a competitive, unregulated sector, and a regulated industry. In the competitive sector of the economy, denoted by the superscript *G*, assuming that all input prices have been properly accounted for including the return on capital for shareholders, profit will be at the zero level in long run equilibrium. Then:

$$\pi^{G} \equiv p^{G} y^{G} - w^{G} x^{G} = 0 \Rightarrow p^{G} y^{G} / w^{G} x^{G} = \left[1 + \left(\pi^{G} / w^{G} x^{G}\right)\right] = \mu^{G} = 1$$

where p, y, w and x represent prices, outputs, input prices and inputs respectively. This provides in turn the result:

$$\Delta log\ p^{G} - \Delta log\ w^{G} + \Delta log\ y^{G} - \Delta log\ x^{G} = \Delta log\ p^{G} - \Delta log\ w^{G} + \Delta TFP^{G} = 0$$

However, unless the regulated sector is very large relative to the whole economy, it will be the case that the rate of output price change in the competitive, unregulated sector will define, or be very close to, the RPI, which is the general rate of output price inflation: $\Delta log\ p^{G} \equiv RPI$ .

The results for both sectors can now be shown together to contrast and compare, as well as the general equilibrium result from Bernstein and Sappington that combines the two:

Regulated sector: $X = RPI - \Delta \log w^{R} + \Delta TFP^{R} - \Delta \log \mu^{R}$ [1]

Competitive sector: $0 = RPI - \Delta\ log\ w^{G} + \Delta TFP^{G}$ [2]

$X = (\Delta \log w^{G} - \Delta TFP^{G}) - (\Delta \log w^{R} - \Delta TFP^{R}) - \Delta \log \mu^{R}$ [3]

From [3] it is clear that the forward-looking X factor reflects the expectations of the ratio of the rate of change of input prices relative to productivity for the regulated business relative to the same ratio in the rest of the economy, assuming $\Delta log\ \mu^{R}$ is zero. It is also clear that for any X greater than 0, a stronger re-distributive requirement is imposed on the regulated sector than on the competitive sector (where X by definition is zero).

An X of greater than zero is in itself is an unusual result for long run equilibrium. Equations [1], [2] and [3] predict a systematic difference between the rate of price evolution between the whole economy and one sector of it. If this result was in fact a long run equilibrium outcome, it would imply that the regulated sector was always on a different steady state path from the competitive remainder of the economy. We now explore why this might be the case.

## Why should X be different from zero?

In order to justify systematically different rates of output price inflation between the regulated and the competitive sectors, it would be necessary to explain why systematic differences in the productivity rates of regulated businesses and the rest of the economy that were not captured by similar systematic differences in input prices. Or, to put it another way, if X is positive, why are the owners of the inputs in regulated businesses apparently systematically unable to obtain the same rewards from greater productivity performance than they are able to do in the rest of the economy, as the equations below illustrate from a simple re-arrangement of [1] and [2]:

$$\Delta \log w^R - RPI = \Delta TFP^R - X$$

$$\Delta \log w^G - RPI = \Delta TFP^G$$

There are a number of reasons why the X factor could either be positive or negative.

a) Uncontrollable input price inflation (relative to the input's productivity) that is both different from the rest of the economy and which relates to an input to which the regulated business is more exposed than businesses in the rest of the economy
b) scale effects that permit greater productivity in network businesses than in constant returns-to-scale businesses in the rest of the economy

c) agency hidden information: regulated utilities have monopoly rents (including informational rent) which must be captured and continually re-captured for the consumer (in advance) by providing the businesses with profit incentives to reveal that information

d) agency hidden action: without competition, regulated companies will have costs that exceed the efficient frontier level and need an incentive to reduce these costs

e) the existence of measured slack in the activity of the regulated firm; this is the inefficiency that is treated as a potential source of catch-up cost savings, and that can be assumed to tend to zero if the regulatory mechanism is effective in providing a profit incentive to the firm which it can retain. This factor signals to owners of the firm that their incentives to managers are deficient.

The first two of these are not the principal subject of the paper but can be dealt with fairly succinctly. As far as differential input price inflation (relative to productivity) is concerned, regulated businesses are typically more exposed than firms in the rest of the economy to particular input price shocks that are both largely uncontrollable and unrelated to any change in productivity that the business can achieve in using the input. The use of copper by electricity and telecommunications businesses is a good example. These cases do not justify a systematic difference in the price profile of regulated businesses and the rest of the economy, but they may require an indexation factor within the RPI-X formula that would enable shocks in the prices of these inputs to be accommodated as they occur. As far as scale is concerned, networks characterised by economies of scale should be able to achieve a faster rate of cost reduction than a CRS business for the same levels of output growth. It is an empirical matter to determine the significance of the scale effect, although we note that the evidence on the existence of scale effects in mature network businesses is mixed. Further, for output growth of say, 2% p.a., it would require very large scale effects to drive a differential X factor effect of more than 0.5% p.a.

The last three factors provide a compelling short run explanation for the existence of positive X factors, but in the longer term, as the informational rent dissipates and the pre-reform inefficiency is removed, these motivations for a positive X factor disappear. In fact, the risk of persisting with a positive X factor for longer is that the regulator is in danger of violating the input owner's participation constraint, forcing labour and capital out of the regulated sector and into the rest of the economy where rewards relative to productivity are greater.

The policy conclusion therefore is that the forward-looking productivity factor, X, is positive to capture agency rents when the industry is privatised or restructured, but when this has been achieved, X should only be positive in order to capture verifiable scale effects and reasonable expectations of divergences between factor price inflation and productivity in regulated businesses that do not apply to a materially similar extent in the rest of the economy (unless these are handled through separate indexation arrangements).

Given this conclusion, the long-run basis for expecting the rate of cost reduction in the regulated sector to differ systematically from the rate of cost reduction due to generalized total factor productivity growth is weak, unless incentive-based regulation is failing to deliver its long-run efficiency objective. This raises the fundamental question of whether regulation is working effectively. In the UK, Ofgem (2008) is broadly optimistic and positive about the successes of price cap regulation to date: "by almost any measure the incentive- and comparison-based price controls have been hugely successful" [Ofgem (2008, p. 11)], and as a consequence, it is wrestling with the natural consequence of that success, namely that the X factor will tend to zero in future.

In a US context, Crew and Parker (2006) and Crew and Kleindorfer (2006) are more sceptical. They contrast the old regime of rate of return regulation in the US with the price cap regulation that replaced it, including the whole range of principal-agent analyses [such as Laffont and Tirole (1993)]. The principal-agent models, they argue, cannot be applied in practical reality, and the price cap regulation has failed because it could not address the problem of regulatory commitment. To ensure success, regulated firms must be allowed to keep the incentive rewards they have earned, but no regulator can sustain public support while leaving economic rents on the table. In the US, Crew and Parker (2006) and Crew and Kleindorfer (2006) see the use of performance based regulation as a hybrid that has emerged from the failure of price-cap regulation to effectively remove the X-inefficiency that was attributed to rate of return regulation. It is a hybrid that emphasises profit sharing and sliding scale regulation. This identifies the issue at the heart of the problem: rent-preservation by the regulated firm and rent-seeking by the regulator on behalf of consumers may be so resource costly that the rents are dissipated. In large part, this problem relates to the effectiveness of the regulator in identifying the ability of the firm to catch-up to the frontier, and setting prices accordingly. In that context, it can be argued that the use of effective benchmarking to determine X in the RPI-X mechanism may overcome this dilemma where it is perceived that rents continue to sit within regulated businesses, and indeed this is increasingly common practice in Europe.

However, the broader issue of commitment and credibility may also have an important part to play in the setting of the long run, frontier shift level of X. As we now move on to discuss, the problem of commitment in regulation can lead to regulatory action that could either lead to the X factor remaining zero for longer than is objectively necessary, or to the creation of a cycle in which not only the level of the X factor, but also the incentive power of the regime changes over time.

## Dynamics and Commitment

We begin by noting that even if there is no long-run basis for a permanent transfer of monopoly rent to consumers, this does not mean that RPI-X regulation has necessarily outlived its usefulness. This is because it is first and foremost an incentive mechanism that has a continually disciplining effect on monopoly providers' behaviour where slack in resource allocation is believed to exist or where it could exist in future if incentives are weakened. An incentive mechanism is still needed even when the X-factor's scope for capturing rent has been reduced to zero, reflecting the importance of the existence rather than the level of the regulatory mechanism [Shleifer (1985)]. Without such an incentive contract, then these rents would build up again requiring the re-introduction of incentive based mechanisms to remove them at some point in the future.

This raises the issue of dynamics. We have suggested that there is period of positive X-factors immediately following privatization, but tending toward zero X-factor in the long run as incentive regulation works itself out, except where slack is persistent.

However, this conclusion remains embedded in an essentially static world. It is conceivable that a dynamic process emerges, with initially a large impact on efficiency and resource allocation with a high X-factor followed by a diminishing role for the X-factor as reasons to expect differences in cost performance between regulated and competitive firms are eroded. However, if a low X-factor is coupled with a low-powered regime then inefficiency could re-emerge, and the profile of high X-factor price capping may re-appear. A useful framework in which to examine such a dynamic evolution is the real options model of regulatory regime shift, see for example Burns, Turvey and Weyman-Jones (1998).

At the heart of the problem is the issue of regulatory commitment. Each regulator has its own public constituency most closely represented by the public body that appoints the regulator but which is ultimately represented by the public at large. Each regulator will be aware of an uncertain but potentially difficult populist response to regulatory decisions that impact of the profitability of the regulated company. Consequently, over time the regulator is typically compelled to consider a repeated set of interactions with the regulated firm which will on each occasion lead to an uncertain but possibly populist response that the profit confiscation should have been tougher. This public pressure to recapture monopoly profits can be interpreted as a populist model of regulation along the lines suggested by Winston and Crandall (1994, p.2, n. 3):

> "By populist, we mean that the objectives appear to be consistent with an attempt to maximise direct consumer welfare without regard to the indirect effects on welfare that arise from raising business costs and, therefore, eventually the prices of products."

In support of this proposition, Pollitt (2008) emphasises that in practice regulators have been motivated to concentrate on the issue of capturing economic rent and transferring it to consumers. He argues that while efficiency benchmarking may become less important in regulation, the focus on rent capture will remain as the key to what regulators do in practice.

With this in mind, consider a dynamic regulatory game in which the regulator has a range of real options to consider. As a simple example, suppose the choice is:

- stay with a high powered incentive price cap, but allow for the possibility that X = 0 in long run equilibrium
- set X = 0, but weaken the incentive power of the regime
- maintain rent capture through a positive X-factor, X > 0 even if this is not the long run equilibrium

The real option cost (negative real option value) in each case reflects the fact that the uncertainty of the long term efficiency gain is conditional on the stochastic process governing the probability of a populist response to the regulator's decision. A negative populist response to a change in regulatory policy to X = 0, could reflect the costs of loss of credibility of the regulator in the public's eye. The stochastic process governing the evolution of the distribution function of the uncertain populist response is likely to be conditional on the current state of the regulatory mechanism, i.e. cost-plus or high powered regulation. The loss of credibility associated with setting an X factor that is, with the benefit of hindsight, too low, will be greater in a higher powered regime than in a lower-powered regime.

In such circumstances, the regulator will have a repeated incentive to delay a policy change to the long run equilibrium value of X = 0, in order to gain more information about the nature of the uncertain populist response. Maintaining a positive X-factor, even when that is not a long run equilibrium has a real option value for the regulator by allowing him to evade the cost of an unwelcome populist response, despite the welfare loss associated with the impact of the inefficient outcome. In the Bernstein-Sappington mechanism, this emerges as a series of dynamic regulatory reviews with a repeated finding of a positive X-factor, to demonstrate that the regulator has found some rent to transfer to consumers in order to assuage likely populist pressure.

On the other hand if a regulator has chosen the X-factor to be equal to zero, then in order to minimise the risk of loss of credibility, the regulator may shift towards a lower-powered, cost-plus regime so that profits are not revealed to be too high. Such a settlement would be likely to lead to a build up of inefficiency over time, which would require a change of regulatory regime back to high-powered incentive regulation with a positive X-factor. However, there remains a real option value to staying with low powered cost of service since high-powered regulation is known to generate high firm profits and therefore an unwelcome populist response. This inertia holds for as long as populist discontent with the high profits that could emerge from high-powered regulation outweighs the discontent with low levels of inefficiency and service associated with low powered regimes. In this respect it is worth noting that fundamental problems with the nationalised industry model in the UK were identified as early as the 1967 White Paper, but it was not until the mid 1980s that these were addressed through liberalisation and incentive-based policy reforms.

Consequently, an inertia in changing regulatory policy emerges in this real options analysis. The result is twofold: i) a long run equilibrium value of zero for the X-factor, if it appears to be very unpopular, will generate a positive real option value to the decision to stay with a positive X-factor; or (ii) if the regulator does choose to adopt an X of zero, it will weaken the power of the incentive regime in order that profits are not revealed to be too high.

Both cases carry with them particular public policy risks, but arguably the greater is the second course of action, since once low-powered regimes are embedded, they remain in place for a lengthy period, with the associated efficiency detriment.

## Conclusions

In this paper, we have argued that at a time when regulatory mechanisms are under serious review, it is useful to consider again the long run properties of the X factor in the RPI-X regulatory framework. We have shown that over time the X factor should tend towards zero as the pre-reform inefficiencies are stripped out of the businesses – a process which may take a number of years of management action. In other words, in the long run, X should only be positive in order to capture scale effects and reasonable expectations of divergences between factor price inflation and productivity in regulated businesses that do not apply to a materially similar extent in the rest of the economy.

In practice, however, a positive X factor may be sustained for longer than is optimal in order that the regulator can extract rent from the regulated businesses, in response to populist pressure. If this is persisted with for too long, it may lead to missed targets and associated financial losses and possible service degradation. Alternatively, the regulator may respond to the populist pressure by setting a low or zero X factor, but accompanied by a shift to a low-powered regime to prevent the realisation of excess profits. This begins a build-up of X-inefficiency that may last many years before populist pressure against inefficiency is sufficient to force a policy switch towards high-powered regulation.

However, if these pressures are absent, then a regulator may be able to opt for the more efficient outcome by simultaneously set the X factor closer to the objective long run equilibrium value, and also retaining the discipline on the business of a high-powered incentive contract.

## References


Bauer, Paul W. (1990) Decomposing TFP Growth in the Presence of Cost Inefficiency, Nonconstant Returns to Scale, and Technological Progress, *Journal of Productivity Analysis*, 1, 287-299

Beesley and Littlechild (1988) The Regulation of Privatized Monopolies in the United Kingdom, *RAND Journal of Economics*, 20, 454-72

Bernstein, J., and Sappington, D. (1999) “Setting the X factor in price cap regulation plans”, *Journal of Regulatory Economics*, vol. 16, pp. 5-25

Bundesnetzagentur (2006) *Incentive Regulation in the German Electricity and Gas Sector – efficiency and reliability to set the yardstick*, International Scientific Conference of the Bundesnetzagentur (Federal Network Agency), Bonn, Bad Godesberg, April 25-6, 2006

Burns, P, R. Turvey, and T. Weyman-Jones, The Behaviour of the Firm under Alternative Regulatory Constraints, *Scottish Journal of Political Economy*, May 1998

Burns, P. and T. Weyman-Jones (1994) The Performance of the Electricity Distribution Business – England and Wales, 1971-1993 *Discussion Paper 8*, Centre for the Study of Regulated Industries, London, Chartered Institute of Public Finance and Accountancy

Coelli, Tim and Denis Lawrence (eds) *Performance Measurement and Regulation of Network Industries*, Cheltenham, Edward Elgar

Crew, Michael and David Parker, (2006) Development in the Theory and Practice of Regulatory Economics, in Michael Crew and David Parker (eds) *International Handbook on Economic Regulation*, Cheltenham, Edward Elgar

Crew, Michael, and Paul Kleindorfer (2002) Regulatory Economics: twenty years of progress, *Journal of Regulatory Economics*, 21, 1, 5-22

Crew, Michael and Paul Kleindorfer, (2006) Regulation, Pricing and Social Welfare, in Michael Crew and David Parker (eds) *International Handbook on Economic Regulation*, Cheltenham, Edward Elgar

Joskow, Paul (2005) Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks, *National Bureau of Economic Research Conference on Economic Regulation*, Washington

Laffont, Jean-Jacques and Jean Tirole (1993) *A Theory of Incentives in Procurement and Regulation*, Cambridge, Mass., MIT Press

Lovell, C.A. Knox (2003) The Decompostion of Malmquist Productivity Indexes, *Journal of Productivity Analysis*, 20, 437-58

Ofgem (2008) *Ofgem’s RPI at 20 Project*, speech by the Chief Executive Alastair Buchanan, London March 6, 2008

Orea, Luis (2002) A Generalised Parametric Malmquist Productivity Index, *Journal of Productivity Analysis*, 2002, 5-22

Pollitt, Michael (2008), Efficiency Analysis for Regulatory Price Reviews: Why Do Regulators Do What They Do? *Fifth North American Productivity Workshop, NAPW V*, Stern School of Business New York University, June26, 2008

Shleifer, Andrei (1985) A Theory of Yardstick Competition, *Rand Journal of Economics*, 16, 3, (Autumn) 319-327

Winston, Clifford and Robert W, Crandall (1994) ‘Explaining Regulatory Policy’ *Brookings Papers: microeconomics, 1994*, pp. 1-49