Risk, Volatility and Smoothing:

Regulatory Options for Controlling Prices

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November 1999

This paper is based on work undertaken in 1998 by Ian Alexander and Rebecca Burdon (both then at London Economics) for the EBRD.

The views expressed in this paper represent the views of the authors and should not be interpreted as the views of their respective organisations. The authors would like to thank Antonio Estache (World Bank Institute) and Rob Francis and Adele Oliveri (Frontier Economics) for comments received. All errors and omissions are the sole responsibility of the authors.

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1 Introduction

Choosing a price regime for a regulated business raises several very important concerns. To date, much of the attention has focused on the ability of different types of regime to deliver incentives for efficiency savings. Work in the UK, Australia and Argentina has developed the incentive based (RPI–X or CPI–X) types of price regime to overcome the perceived lack of incentive power in the traditional US rate-of-return approach. There are, however, a range of additional detailed implementation issues that should be borne in mind when choosing which regime is best able to meet the general objectives behind the choice of a regulatory regime. These concerns include:

- the incentive that any regime creates for companies to play 'regulatory' games;
- the risks borne by a company under a regime and how these relate to the cost structure of the company and whether this creates any perverse incentives for the company; and
- how the allocation of risks impact on price volatility and what this implies for both the company and its consumers.

This paper explores the impact of different price regulation mechanisms, especially incentive based ones on:

- price and revenue stability;
- the allocation of risk; and
- the incentives created for operators, including regulatory gaming.

It is often asserted that a hybrid price control – bringing together elements of a price-cap and a revenue-cap – is a better solution that a regime based on one of the pure models. This assertion is explored in this paper.

Further, options for mitigating the price volatility that some types of incentive based regimes create and the consequent implications of the mitigation schemes for risk allocation and incentives are considered.

It is impossible to consider a regulatory regime without establishing the overall objective by which to assess a regime. Standard objectives for regulation that are embodied in acts around the world include:

- the promotion of competition;
- ensuring the long-term viability of an efficient industry; and

- the protection of consumers.

This paper focuses on aspects of the latter two objectives. These are:

- the ability to create stable revenue flows for an efficiently operated company and what that implies for the prices that customers face; and

- the effectiveness of a regulatory regime in terms of creating simple clear incentives for a company to cut costs rather than creating incentives for companies to play regulatory games.

This latter point focuses on another objective for regulation. This is the establishment of simple and effective regulatory regimes rather than having to create a regulatory edifice with numerous additional rules to counter the perverse incentives created by the initial regime. If this happens, regulation becomes bureaucratic and intrusive, neither of which are desirable outcomes.

Consequently, this paper establishes a framework by which the risk allocation can be established for any regime which then allows us to establish how well these specific aspects of the objectives for regulation can be met. The framework is based on one developed in an earlier World Bank Policy Research Working Paper (explained in detail in annex 1).[1]

The framework, can be stated simply as two questions:

1. "In what ways does a regulatory regime open a company to risk?" The options include divergences in:

    - fixed costs from those forecast;

    - variable costs from those forecast; and

    - the quantity sold than that forecast.

2. "Does the regulatory regime mirror the cost structure of a company? If it does not, what incentives does that create for the company?" When addressing this question it is vital that the various 'classes' of risk are considered – these are discussed in annex 1. These risks are spread between the operator, consumers and possibly the government. One aspect of risk that requires specific attention is that associated with volatility in prices and profits – important to consumers and operators respectively.

[1] Regulatory Structure and Risk and Infrastructure Firms: An International Comparison, Alexander, Mayer and Weeds, Policy Research Working Paper Number 1698, World Bank, December 1996.

The remainder of this paper is concerned with assessing various regulatory options against this framework. The work underlying this paper was originally undertaken with reference to a specific water and sewerage project. Elements of the work still reflect this although the paper has been significantly recast to make it more user friendly and of broader relevance. Aspects of this work have been reflected in the forthcoming Sofia water and sewerage concession.

2 Pure systems of price control

This section considers the basic forms of price regulation. It considers:

- the form of the regime in relation to the price, cost and revenue elements;
- examples of the type of system used;
- an evaluation of the incentives created by the regime; and
- any options for regulatory gaming that arise.

2.1 Pure price cap

With a price-cap regime, estimates of the costs and demand for the product are established. This allows a forward-looking price per unit to be set, which is consistent with the estimated revenue requirements of the business.

The future prices are set with an updating factor based on an index of inflation (for example in the UK, RPI is used), less an adjustment factor, which is based on expected efficiency gains (the X-factor). The formula is normally referred to as RPI–X since the prices are held constant in real terms, except for this efficiency adjustment. An example of a pure price-cap is provided in Box 1.

Under this approach, the forecast value of profit can be compared to the actual out turn profits. Algebraically regulated prices are set by:

$$\overline{\mathrm{P}} = \frac{\left[\left(\widetilde{\mathrm{F}}\mathrm{C} \times \widetilde{\mathrm{Q}}\right) + \left(\widetilde{\mathrm{V}}\mathrm{C} \times \widetilde{\mathrm{Q}}\right)\right] + \widetilde{\mathrm{P}}\mathrm{rofit}}{\widetilde{\mathrm{Q}}}$$

Rearranging, forecast profits are:[2]

$$\widetilde{\mathrm{P}}\mathrm{rofit} = \left(\overline{\mathrm{P}} \times \widetilde{\mathrm{Q}}\right) - \left[\left(\widetilde{\mathrm{F}}\mathrm{C} \times \widetilde{\mathrm{Q}}\right) + \left(\widetilde{\mathrm{V}}\mathrm{C} \times \widetilde{\mathrm{Q}}\right)\right]$$

Where:

P is the price per unit

Q is the quantity

[2] Forecast profits are in turn based on an evaluation of the appropriate rate of return and the regulatory asset base of the operator.

FC is fixed cost per unit sold

VC is variable cost per unit sold

~ is used to denote a forecast and – denotes a regulatory determined variable.

Out-turn profits are determined by:

$$\text{Profit} = \left(\overline{P} \times Q\right) - \left[\left(FC \times Q\right) + \left(VC \times Q\right)\right]$$

Quite clearly, since the regulated price is fixed, out-turn profits will differ from forecast ones if any of the following occurs:

$Q \neq \tilde{Q}$: a difference in units sold

$FC \neq \widetilde{FC}$: a difference in fixed costs

$VC \neq \widetilde{VC}$: a difference in variable costs

Consequently there are a number of factors that can lead to abnormal profits (either positive or negative) being made.

2.1.1 Risk allocation and incentive effects

The way in which risks are allocated and incentives created depends, in part, on the cost structure of the operation being undertaken. To begin with, this part of the paper will assume that the company that is being regulated has no fixed costs but rather has an entirely variable cost based cost structure.

Risk allocation

A pure price cap ensures a stable price path, but means that the revenue stream from the company's regulated businesses may vary as a result of demand being higher or lower than forecast. This volatility will be reflected in the profit stream. Thus under a pure price cap, the company bears the risk (both upside and downside) of unexpected changes in demand. Further, the impact of any changes in costs is incurred entirely by the firm.

In the case of the example given in Box 1, that of the Regional Electricity Companies (RECs) the revenue stream between 1990-1994 was much higher than forecast leading to higher than forecast profits. Most companies also had a 'K_{dt} stock' (a stock of unused price increases) available to them, since they never charged full M_{dt} - this was used to partly offset the P_o cut initiated at the 1994 price review.

The higher risk borne by companies under a price cap regime results in them facing a higher cost of capital than if they were regulated under an alternative mechanism such as a revenue cap.[3]

Incentives

Key outcomes of a price cap regime are the strong incentives it places on companies to maximise efficiency gains. This feature is common to other RPI – X regimes where there is a sufficiently long period between price reviews.

Box 1: The Regional Electricity Companies (RECs), 1990-94

Following privatisation in 1990, the RECs distribution businesses were regulated using a pure price cap—there was a strong perception of inefficiency in the industry and consequently a desire to introduce greater pressure for efficiency savings. This pure price-cap was discontinued in the 1994 price review and a hybrid system adopted.

The price cap formula used by the Office of Electricity Regulation (Offer) to regulate the prices charged by the RECs was:

$$M_{dt} = \left[1 + \frac{RPI_t + X_d}{100}\right] \times P_{(dt-1)} \times A_t - K_{dt}$$

Where:

M_{dt}	is the maximum average charge per unit distributed.
X_d	is the annual efficiency saving for the distribution business.
A_t	represents the distribution losses. This term is included to give companies an incentive to reduce distribution losses.
P_{dt-1}	is the amount per unit distributed in the previous year (i.e. year $t-1$). This is made up of a weighted basket of four prices for different distribution categories – three low voltage and one high voltage. The formula is: $$P_{(dt-1)} = \sum \left[P_{(dit-1)} \times W_{dit}\right]$$
W_{dit}	is the weighting for each distribution category. This is calculated as $W_{dit} = D_{it}/D_t$. Therefore the weights are determined by the actual of each category distributed in the year to which the price control relates. They are effectively forward looking weights that can be influenced by the companies' behaviour.
K_{dt}	is the correction factor per unit to be applied to the average charge per unit distributed in year t. This is specified as: $$K_{dt} = \left[\frac{R_{dt-1} - (D_{t-1} \times M_{dt-1})}{D_t}\right] \times \left(1 + \frac{I_t}{100}\right)$$

Where

R_{dt-1}	is the distribution revenue
D_{t-1}	is the regulated quantity distributed
I_t	is the interest rate.

The interest element is included in the correction factor to prevent the company or the customers from benefiting from regulatory gaming. When K_{dt} is positive the company has received more than the regulated maximum revenue, hence the correction factor is negative in

[3] Regulatory Structure and Risk and Infrastructure Firms: An International Comparison, Alexander, Mayer and Weeds, Policy Research Working Paper Number 1698, World Bank, December 1996.

the main formula. If the company has under- recovered, K_{dt} is negative and so the impact on the main formula is positive.

In the REC's price control formula, the correction factor is designed to correct for any deviation from the maximum average unit price set for year t-1, **rather** than correct for a deviation in units. This is to take into account the likelihood that actual customer numbers in different customer categories may differ from forecast numbers and, as a result the actual average tariff may exceed the forecast maximum. Correction factors are applied to account for differences between forecast and out turn variables. The aim of the correction factor is to ensure that customers pay and the business receives the 'correct' regulatory amount. The design of the correction factor will determine the incentives on businesses (or customers) to engage in regulatory gaming. It is symmetric, so that if a firm charges less than the maximum average tariff in any one year it can charge more in the following year. No correction is made for units distributed varying from forecast units—this is a key difference between the price cap and the revenue cap.

Whether there is an incentive relating to the number of units sold depends on the actual cost structure as opposed to that being assumed by the regulatory regime.

Table 2-1: Incentives relating to forecast units under a price-cap

Cost structure	*Incentives*
Pure variable cost based structure	No incentive to mis-forecast units either above or below true expectations.
Mixture of fixed and variable costs	Incentive to mis-forecast units below the true expected value.
Purely fixed cost structure	Strong incentive to mis-forecast units below the true expected value.

Since utility company cost structures are heavily biased towards fixed costs, it is likely that the incentive for under-forecasting unit demand—or more charitably, placing a great emphasis on encouraging demand growth—will be high. This is particular to a price cap. *As long as the price cap is set so that marginal revenue is greater than marginal cost, the firm will always have an incentive to sell more units*. This may be appropriate if there is long term excess capacity, but may not be the best approach if resource conservation and demand management are important objectives. In addition, there may be environmental reasons for not wanting to place strong incentives on the company to maximise the number of units distributed.

Incentives for Regulatory Gaming

As shown at the start of this section, out-turn profits may deviate from forecast profits if:

- costs are lower or higher than assumed; and

- if the number of units sold is higher or lower than assumed.

Regulatory gaming is therefore likely to occur in the estimation of both costs and demand. Estimation of costs is a problem common to all price regulation mechanisms based on RPI-X.

Estimation of demand, however, is only an issue under mechanisms that include a price cap component and the actual cost structure differs from the implied regulatory cost structure that is based on 100% variable costs.

Under a price cap regime, so long as the regulated price exceeds marginal costs, the company has strong incentives to bias down its demand forecasts, and then act to maximise actual demand.

2.2 Price cap with triggers for review

A price cap with triggers for review is similar to the price cap described above, except that when certain specified variables move outside a certain range, it triggers a price review.

For example, a trigger could be specified such that if demand increases (or decreases) by more than 20% above (or below) the forecast level, then a price review occurs. The other variable most commonly included as a trigger for a price review is per unit costs.

Therefore out turn profits are still determined by:

$$\text{Profit} = \left(\overline{P} \times Q\right) - \left[\left(FC \times Q\right) + \left(VC \times Q\right)\right]$$

and will deviate from forecast levels where ever:

$Q \neq \tilde{Q}$: a difference in units sold

$FC \neq \widetilde{FC}$: a difference in fixed costs

$VC \neq \widetilde{VC}$: a difference in variable costs

However, the trigger imposes an upper bound on the degree by which out-turn profits can differ from forecast profits, giving the regulator an automatic right to intervene when that bound is breached.

Box 2: Examples of Price-caps with triggers

Price caps with review triggers have been relatively widely used in concession agreements. For example triggers for review have been used in various forms in water sector leases and concessions in:

- **Guinea**. At the time that the 10 year lease was let in 1988, tariffs were well below average cost. The tariff adjustment mechanism included in the lease specified a steady rate of increase in tariffs sufficient to ensure they covered marginal cost and allowed subsidies to be phased out by 1995. The tariff is made up of two parts (*tariff exploitant* covers the operating companies expenses and *redevance* which covers the asset companies operations investment expenses and related debt service). The lease specifies that the *tariff exploitant* can be modified based on pre agreed economic criteria; and

- **Buenos Aires, Argentina**. The concession differentiates between 'ordinary' and 'extraordinary' revisions. The average water rates are strictly controlled under the criteria for ordinary revisions—for the first five years the only ordinary revisions permitted are reductions in tariffs, and after this tariffs can only be raised if there is a change in investment goals. Extraordinary revisions can occur 'when the cost index changes by more than 7 or if there are changes in regulations or fundamental conditions in the concession'.

Sources: Guinea - Implementation Completion Report: Republic of Guinea Second Water Supply Project World Bank. Report No. 17553, March 1998; and Argentina - Chapter 8 Worldwide Water Privatisation: managing risks and sanitation. David Haarmeyer and Ashoka Mody. Financial Times Energy 1998. Note it is not clear from the source document whether this is a change of 7% or 7 points in the cost index.

2.2.1 Risk allocation and incentive effects

Risk allocation

A price cap with triggers for review is often included in agreements in developing countries because of a lack of information about demand and cost conditions in the early stages of the concession. It reduces the risks both to the regulator and the firm that the forecast demand or costs will in fact differ significantly from actual values.

If the trigger is symmetric so that both excess profits and losses can prompt a review then the allocation of risk is much the same as under a pure price cap except when the triggers are approached. However, the trigger should reduce the magnitude of the risk, and may lower the costs of capital to the firm. Whether the impact is significant will depend on:

- the divergence from forecast values required to trigger a price review; and
- the perception of the risk associated with a price review.

If an asymmetric trigger is included so that only losses cause a price review, this clearly should reduce risks to the firm, lower their cost of capital, and increase their attractiveness to investors.

In the water industry in England and Wales, triggers were included at privatisation. These were referred to as 'ship wreck' clauses. [4] While many

[4] These allow for a change in the adjustment factor if any circumstance arises which has a substantial adverse or favourable effect on the Appointment Business. Substantial effect is defined as one where the NPV of cash flows are ± 20% as a result of the change in view.

companies have subsequently 'bought' out these clauses they have been retained by some companies. In addition, the regulator has stated that in exceptional cases, Ofwat will consider a proposal made by a company for modification to a licence "in order to deal with financial problems of sufficient gravity".[5]

Overall it is not clear whether regulatory risk faced by the companies is increased or decreased by the existence of triggers in the price control formula. This depends on the confidence that the company has in the way in which the regulator will act and the regulator's ability to handle the price review that occurs. Further, the scope of the review could be of crucial importance. If the regulator is only required to consider the issue that has caused the review to be triggered then the company may have significant confidence in the outcome of the review. If the regulator is allowed to address all issues that it believes important, then the company may have much less confidence in the system.

Regulatory risk depends in part on the triggers but primarily on the separate issue of the degree of discretion given to the regulator to call a price review during a price control period. For example, in electricity in Northern Ireland the regulator can call for a review at any point. In the water sector the price control period is ten years, but both the companies and the regulatory can request a review after five years. Clearly the greater the regulators discretion the higher the risk to the regulated companies, but the lower the political risk.

Incentive effects

The incentive effects are also much the same as under the price cap regime. The strong incentives to maximise efficiency gains, and increase the number of units sold remain provided that the cost structure includes a mixture of fixed and variable costs. However these incentives will be bounded by the triggers.

Regulatory gaming

The inclusion of review triggers is likely to affect the regulatory gaming that will occur. If the firm believes it may approach an upper bound it will engage in regulatory gaming to stay below the bound. For example cost savings may be deferred or smoothed.[6]

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5 Section 13 of The Water Industry Act 1991. Reference from the MMC Report on the Determination of Adjustment Factors and Infrastructure Charges for South West Water Services Limited, page 76.

6 This type of gaming is not dissimilar to that witnessed in the UK by regulated companies prior to a price review. Savings may be down-played, or postponed, so that a 'better' regulatory outcome for the company is achieved and then the benefits of the savings are reaped.

It is not immediately clear how the firm will respond if variables shift such that it is approaching a lower bound. For example, if costs increase substantially but by just less than is necessary to prompt a review, the firm may have an incentive not to maximise efficiency if by doing so it can allow costs to increase sufficiently to trigger a review that may allow it to increase tariffs. Depending on the firm's ownership structure, this may be offset in part by pressures to maximise profits.

In each case, however, the key variable is how the company and its owners expect the regulatory body to react at a price review brought about by the triggers being breached. When it is a down side risk the requirement to improve its ability to finance its functions is likely to dominate—as noted in the Introduction, this is often a stated objective for the regulatory system. This can be controlled by allowing the regulator only to consider the factor that caused the trigger to be breached. However, fettering the discretion of the regulator may also cause problems.[7]

2.3 Revenue cap

A revenue-cap is designed to provide a fixed amount of revenue for the company, irrespective of actual output or demand and is frequently used within an RPI-X framework. This is achieved by estimating the allowed revenue and then dividing it by the forecast number of units. In this respect it is exactly the same as a price-cap with the same forecast price per unit. Revenue caps, however, differ from price-caps inasmuch as the correction factor included with the revenue-cap means that if the actual number of units sold differs from the forecast number of units, this will be corrected for in the following year to ensure that only the allowed revenue was collected.

For example, with a water company, if total revenue required by the company is set at £500m and forecast sales are 1,000m cubic meters of water sold, then the average price per cubic meter is £0.5. If the actual cubic meters of water sold are higher than forecast (say, 1,200m instead of 1,000m), then the revenue earned by the company is higher (by £100m) than forecast. A revenue-cap would then adjust the next year's price so that the £100m was returned to the customers through prices lower than would have been necessary if the higher sales had not occurred. Similarly, in the case where sales are 800m cubic metres rather than 1,000m, revenue would need to be higher by £100m in the following year to make up for the short-fall.

This can be shown algebraically. Again, forecast profits are determined by:

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7 The sort of problems that may arise include those associated with regulators becoming much more conservative since individual decisions will be made without reference to their impact on other aspects of the regulated activity and potentially without regard to their future effect.

$$\tilde{P}\text{rofit} = \left(\overline{P} \times \tilde{Q}\right) - \left[\left(\tilde{F}C \times \tilde{Q}\right) + \left(\tilde{V}C \times \tilde{Q}\right)\right]$$

Out-turn, or actual, profits are determined by:

$$\text{Profit} = \left(\overline{P} \times Q\right) - \left[\left(FC \times Q\right) + \left(VC \times Q\right)\right]$$

But, the correction mechanism means that the company is only allowed to keep profits of:

$$\text{Profit} = \left(\overline{P} \times \tilde{Q}\right) - \left[\left(FC \times \tilde{Q}\right) + \left(VC \times \tilde{Q}\right)\right]$$

Quite clearly, out-turn profits that can be kept will differ from forecast ones only if one or more of the following occurs:

$FC \neq \tilde{F}C$: a difference in fixed costs

$VC \neq \tilde{V}C$: a difference in variable costs

So, the ability to make additional profits through mis-forecasting the level of sales is removed.

Revenue caps are most appropriate in industries where:

- demand is stable and consequently can be forecast with a high degree of certainty. This reduces the risks of high levels of price volatility; and

- fixed costs are very high as a proportion of total costs. Where this is the case the firm has less incentive to adjust forecast output downwards in order to maximise profits.

Box 3: Example of a Revenue-cap - National Grid Company (NGC)

The NGC's transmission business has been subject to a pure revenue control since it was vested in 1990 and privatised as a part of the RECs (each REC owned equity in the NGC).

The first price control, established in 1990, set a maximum rate of increase in NGC's regulated transmission revenue per kilowatt equal to inflation (RPI-0). The second price review, which took effect three years later, tightened this control to (RPI-3).

The regulatory formula is:

$$M_t = \left[1 + \frac{RPI_t - X_g}{100}\right] \times P_{t-1} \times G_t - K_t$$

Where:

M_t is the maximum average charge per kilowatt in year t.

X_g is the annual efficiency factor.

P_{t-1} is the price in the previous period calculated as:

$$P_{t-1} = P_{t-2} \times \left[1 + \frac{\left(RPI_{t-1} - X_g\right)}{100}\right]$$

G_t is a weighting factor related to the previous system maximum average cold spell demands, and defined as:

$$G_t = \frac{Q_t + Q_{t-1} + Q_{t-2} + Q_{t-3} + Q_{t-4}}{5Q_t}$$

Where Q_t is the system maximum demand. The number of kilowatts (Q_t) used in the formula is set in advance by Offer. This effectively sets the NGC's maximum regulated transmission revenue in each year.

K_t is a correction factor that adjusts for under or over recovery of revenue in the previous year. This is calculated as:

$$K_t = \frac{Q_{t-1} \times \left(C_{t-1} - M_{t-1}\right) \times \left(1 + \frac{I_t}{100}\right)}{Q_t}$$

Note: Although the Transmission licence provides this formula, it would be easier to interpret if it was restated as:

$$K_t = \frac{Q_{t-1} \times \left(\tilde{M}_{t-1} - M_{t-1}\right) \times \left(1 + \frac{I_t}{100}\right)}{\tilde{Q}_t}$$

Where

C_{t-1} is the average charge per kW, effectively the forecast value of M_{t-1}.

As noted above, the principal difference between the price cap formula and the revenue cap is that in the revenue cap the correction factor adjusts for under or over recovery of revenue. This occurs because whenever actual demand is greater than the forecast quantity i.e. $Q_{t-1} > \tilde{Q}_{t-1}$, then earned revenue will be greater than that allowed under the regulatory system. Consequently, K_t will be positive.[8] So the effect of K in the overall formula will be to reduce the maximum average charge in the following year i.e. adjust revenue down to compensate for over-recovery in the previous year.

Conversely, where the actual quantity demanded is less than the forecast quantity, the effect of K will be to adjust the maximum average charge up in the next year to compensate for the under-recovery of revenue.

[8] This can be seen since out- turn revenue will be determined by the price charged (C_{t-1}) and the actual system maximum demand (Q_{t-1}). However, since the system maximum demand is higher than that forecast, this means that $C_{t-1} > M_{t-1}$.

2.3.1 Risk allocation and incentive effects

Risk allocation

Under a revenue cap a greater proportion of risks are borne primarily by consumers than under a price cap. For example, the NGC is guaranteed a revenue stream, and prices can fluctuate year by year in order to ensure that revenue stream is generated. Thus, while prices may be more volatile under a revenue cap, profitability will be more stable relative to a price cap.

This reduced risk lowers the cost of capital to the firm, relative to that under a price cap, but it is still higher than under a rate of return approach.

Incentive effects

Under a revenue cap, the incentives to maximise productivity and efficiency gains are maintained, but the firm has no incentive to increase output. This is because the marginal revenue will be zero, but the marginal cost may be positive.

Revenue caps, therefore, induce firms to discourage rather than encourage consumption. As such it creates a different set of incentives to those found under the price-cap type regimes. Table 2-2 illustrates the way that incentives may exist for over-estimating the level of demand, although whether this creates any advantage for the company depends on whether the correction factor is able to reclaim investment related costs that were associated with the over-forecast of demand. If the investment funds are not spent, owing to the forecast demand not occurring, then the company may be able to make additional profits through mis-forecasting the level of demand. This story is, however, far less clear cut than the incentive story associated with the price-cap regimes discussed earlier in this Section.[9]

Table 2-2: Incentives for demand gaming under a revenue-cap

Cost structure	*Incentives*
Entirely variable cost	An incentive exists to over-estimate future demand. Although costs associated with the additional units will be reclaimed through the correction factor, it is unlikely that additional investment predicated on the basis of higher

[9] The issue of whether investment funds should be returned if projects are cancelled or delayed is one that the MMC had to address in respect of the 1997 NIE referral. It determined, and was subsequently accepted by OFREG, that in cases where improved demand management, equipment utilization or alternative solutions had been adopted, the company should be allowed to keep the revenues associated with the investment. The implication of this, however, is a more intrusive analysis of investment activities by the regulator and a consequent further move away from the ideal **output** related regulatory regime.

	demand will be fully reclaimed.
Mixture of fixed and variable costs	An incentive exists to over-estimate future demand. Although costs associated with the additional units will be reclaimed through the correction factor, it is unlikely that additional investment predicated on the basis of higher demand will be fully reclaimed.
Entirely fixed cost	No incentive to over or under-estimate future demand.

The choice of a revenue-cap may be appropriate if demand management is a key objective. If increasing the demand of existing consumers or expanding service coverage are important aims then a revenue cap is unlikely to be the preferred option. The lack of strong incentives to increase customer numbers can, however, be offset through including specific expansion targets in the contract. It may be more difficult (and less desirable) to specify targets for maintaining or increasing demand of existing customers.

Regulatory gaming

A revenue cap creates two strong incentives for firms relating to capital expenditure. These are:

- to over estimate their capital expenditure over the price control period; and
- to delay, at least within the life of the price control period and more probably between price control periods, the undertaking of the investment.

This latter points is particularly related to capital expenditure aimed at improvements in quality or service extensions.[10] This is because unit demand does not determine total revenue (because prices will respond to changes in demand in order to maintain revenue).

A revenue cap also removes the strong incentives for companies to game over the forecast number of units they will sell—although depending on the precise treatment of capital expenditure within the regulatory regime and the mixture of fixed and variable costs, there may be an incentive for the companies to over-estimate future demand. Under a price-cap there is an incentive for the company to provide unrealistically low forecast numbers of units so that it is then able to make additional profits by selling more units.

[10] Clearly an incentive can be created through including specific requirements to improve quality or extend service, and imposing penalties in the event that the requirements are not fulfilled.

The reduced gaming over demand forecasts under a revenue cap is often a key determinant of choosing this mechanism over a standard price-cap.

3 Hybrid (price and revenue) cap

As seen in the previous Section, the 'pure' price-control approaches create incentives for gaming and risks owing to a divergence between the assumed regulatory cost model and the actual cost structure of an operator. Hybrid systems are based on trying to make the regulatory regime mimic the mix of fixed and variable costs in a company. The theory is that:

- the fixed variant is regulated through a revenue-cap; and
- variable costs are regulated through a price-cap.

This is intended to maximise the incentives for the company to increase efficiency, while ensuring that perverse incentives are minimised by making the mix of regulation reflect the true cost structure.

However, a series of issues that need to be addressed arise. These include:

- the basic approach is no different to that of the price-cap and revenue-cap and so suffers from the same problems, especially with respect to the ability to forecast key cost drivers and the consequent regulatory games. Therefore, the political need for correction factors still exists;
- the mix of fixed and variable costs is always changing and so it will never be possible to exactly mimic the mix through the hybrid—how good an approximation can be achieved is debatable, especially when the life of the price control is quite long, say five or more years; and
- establishing exactly which costs are fixed and which are variable does, to an extent, depend on a subjective decision as to the nature of costs, the length of the price control and the degree of control that companies can exercise.

Hybrid systems can, however, better mimic a company's cost base and can provide improved incentives for it to behave in a way that maximises welfare (relative to alternative regulatory formulas).

3.1 Examples

Hybrid caps have mostly been used in the electricity sector. Examples include:

- most power purchase agreements (PPAs) are effectively hybrid pricing systems since they have a fixed component, primarily based on the cost of financing a generating station, and a variable element based on the costs associated with the actual operation of the plant;

- England, Wales and Scotland electricity distribution businesses where a hybrid has been used since 1994; and

- in Northern Ireland Electricity (NIE) transmission and distribution (T&D) businesses, since it was established in the early 1990s.

As far we know no explicit hybrid cap has been applied to a water and sewerage company although some close examples exist – noted in Section 6. In England and Wales, however the way that the regulated quantities are specified in the revenue cap means that it implicitly has some features of a hybrid formula.

Box 4 describes the price control system applied to the transmission and distribution businesses of NIE while annex 2 provides details of other examples.

3.2 Risk allocation and incentive effects

Risk Allocation

Under a hybrid control there is greater risk sharing between the company and consumers than under either a revenue cap or a price cap. The inclusion of:

- a fixed component in the formula reduces the sensitivity of revenue to changes in the volume of units distributed, thereby lessening the volatility in profits relative to a price cap; and

- a variable component reduces the level of price fluctuations compared to a revenue cap, thereby lessening risks to consumers.

The dampening of both profit and price volatility reduces the political risks that can be associated with high fluctuations in either variable.

Incentive Effects

A hybrid formula maintains incentives to maximise gains in efficiency that are present under both the revenue cap and price cap. The incentives faced by companies regarding levels of output and quality are, however, less clear under a hybrid than under pure systems. The specification of the hybrid will affect the regulatory gaming that occurs. In particular the split of fixed and variable costs in the hybrid will determine what incentives the company faces with respect to regulatory gaming. If the proportion of fixed costs is under estimated in the regulatory formula it creates an incentive to bid down forecast demand and to increase actual demand. This arises because it allows the company to earn marginal variable revenue greater than marginal variable costs on each additional unit distributed. The degree of divergence between the assumed cost structure in the regulatory regime and the actual cost structure will determine the degree of incentive created for gaming the level of demand. Table 3-1 summarises the options for gaming.

Box 4: Northern Ireland Electricity (NIE) T&D businesses

Since it was established in 1992 the maximum revenue the NIE can earn from its regulated T&D businesses has been determined by the formula:

$$M_{Dt} = (h \times F_{Dt}) + [(1-h) \times V_{Dt} \times Q_{Dt}] - T_t + K_{Dt}$$

Where:

M_{Dt} is the maximum regulated T&D revenue (in £ million)

F_{Dt} is a fixed component (in £ million) calculated as:

$$F_{Dt} = F_{Dt-1} \times \left[1 + \frac{(RPI_t - X_{Ft})}{100}\right]$$

The revenue cap aspect of the formula is embodied in the (F_{Dt}) term. It fixes allowed revenue irrespective of the quantity of units transmitted and distributed. This was initially set as a total monetary amount, but it was changed in the second price review period to an amount per customer. This was purely a presentational change because the number of customers used in the formula is set in advance.

V_{Dt} is a variable component (stated in p/kWh). It is calculated as:

$$V_{Dt} = V_{Dt-1} \times (1 + \frac{(RPI_t - X_{Vt})}{100})$$

The V_{Dt} term represents the price cap component of the formula which sets the maximum allowable charge per unit sold. It is an average charge per unit sold (rather than a tariff basket for example).

h is a weighting factor which determines the proportionate weight of the revenue (h) and price cap (1-h) elements in the overall formula. At present h = 0.75.

Q_{Dt} is the regulated quantity transmitted and distributed (in kWh).

T_t is the adjustment factor for T&D electrical losses. The inclusion of this term means that the permitted maximum revenue changes if electricity losses are above or below a specified value. It is included in order to give an incentive to reduce electricity losses.

K_{Dt} is the correction factor, which recovers (or penalises) for revenue foregone or gained over and above the maximum regulated revenue in the previous year. This is specified as:

$$K_{Dt} = (M_{Dt-1} - R_{Dt-1}) \times \left[1 + \frac{I_t}{100}\right]$$

Where R_{Dt-1} is the actual revenue from the regulated T&D businesses.

The weights (h and (1-h)) attached to the revenue and price cap components respectively approximate the proportion of fixed and variable costs in the T&D business's total costs. A weighting of 75:25 fixed to variable has been adopted. It can be very difficult to ascertain the 'correct' proportion of fixed and variable costs in a business. For example, in the case of NIE's T&D business in the 1992 review, estimates varied enormously. As discussed later, the weighting of fixed and variable costs affects companies' incentives in regulatory gaming.

In the first price control period (1 April 1992- 31 March 1997) the X factor (the allowed annual change above or below inflation) relating to the fixed component (FDt) was set at -3.5, so that the base allowed annual change was (RPI+3.5). Over that period, the permitted annual change in the variable component (V_{Dt}) was 1 percentage point above RPI, (i.e. RPI+I). In the second price control period (beginning 1997/8), Ofreg decreased revenue allowed by the price control formula by 25% in the first year and then set the same X factor of 2 for both fixed and variable components so that the base allowed annual increase was (RPI-2).

It is probably more simple, from a public presentation perspective, to have a single X value for any company. However, using different X values for fixed and variable costs may provide the regulator with more transparent tools for:

- taking into account the effect of economies of scale on average fixed costs; and
- increasing pressure for efficiency gains in either fixed or variable costs.

It might be taken as an indication of the success of the NIE hybrid that there was very minimal change to the formula at the 1996 price review. This is in contrast to the RECs' formula, described in annex 2, which was comprehensively revised from a price cap to a hybrid.

Table 3-1: Incentives under a revenue-cap

Cost structure	*Incentives*
Entirely variable cost based	Incentive is to bid up the forecast demand since the fixed regulatory element will provide a guaranteed return to the company.
Mixed variable and fixed cost, where proportion of actual fixed costs is less than that assumed in the price control	Incentive is to bid up forecast since the loss arising from actual demand being lower than forecast is less than the true cost of lower production.
Mixed variable and fixed cost, where proportion of actual fixed costs is equal to that assumed in the price control	No incentive to over or under-estimate the forecast demand.
Mixed variable and fixed cost, where proportion of actual fixed costs is greater than that assumed in the price control	Incentive is to bid down the forecast since the gain arising from actual demand being higher than forecast is greater than the true cost of higher production.
Entirely fixed cost	Incentive is to bid down the forecast since the gain arising from actual demand being higher than forecast is greater than the true cost of higher production.

A further area where a hybrid may offer a preferable outcome to that found under either a price-cap or revenue-cap is through the fact that greater cash-flow certainty can be created. If the marginal cost of production is correctly captured through the price-cap element of the hybrid, then the cost structure is perfectly mirrored and the company's cash-flow should be covered with more certainty through the regulatory system.

The proportion of fixed and variable costs will also affect the incentives on companies to game the regulator on investment in quality improvements. If however, the regulator can capture investment in quality improvements in fixed components a hybrid can be a useful tool for removing companies' incentives to over invest, while at the same time encouraging quality improvements.

Uncertainty over the gaming incentives on firms under a hybrid may increase the complexity for the regulator relative to a pure price or revenue cap. Adoption of a simple formula should help to minimise any additional complexity associated with a hybrid.

4 Comparison of alternative price regulation mechanisms

So far, this paper has considered a framework within which alternative regulatory regimes can be assessed. Clear conclusions arising from the consideration of a range of alternative regimes are:

- all regimes have aspects of regulatory gaming associated with them and consequently the choice of regime should partly depend on the regulatory authority's ability to handle the gaming; and

- the allocation of risk and volatility differs between regimes. Part of the choice mechanism should be a decision as to who is best placed to handle that risk, and whether alternative additional mechanisms exist to help dampen the volatility without creating additional problems.

Table 4-1 summarises the regimes considered.

Although the conclusions appear straight-froward, it is vital that regulators and companies have access to a clear and simple framework that allows them to assess the overall impact of a choice of a specific type of regulatory regime. As was noted in the Introduction, the choice of regulatory regime is often predicated on a broad government or regulatory objective, such as creating a system that encourages companies to become more efficient. But as this paper has shown, within the spectrum of regulatory regimes there are important implications for:

- the operation of regulation;

- the incentives for companies, including incentives to game;

- the allocation of risk; and

- consequently the volatility of prices.

The framework developed within this paper has shown that when deciding on the choice of regime a range of factors should be borne in mind since they have a major impact on the points noted above. Primary factors include:

- the actual cost structure, in terms of fixed and variable costs, as opposed to that assumed in the regulatory regime; and

- the relationship between the actual marginal cost of production and that allowed in the regime.

The remainder of this paper is concerned with a consideration, through some simple numerical modelling, of the volatility each type of system produces and options for mitigating that volatility.

Table 4-1 : Summary impact of alternative price regulation mechanisms

	Approach			
	Price Cap	***Price Cap with review triggers***	***Revenue Cap***	***Hybrid***
Volatility				
Price	X	X	√√	√
Revenue	√√	√√	X	√
Profits	√√	√√	√	√
Incentives	Cut costs to maximise profits, and maximise sales provided MR>MC.	Cut costs to maximise profits, and maximise sales provided MR>MC, but only within the bounds set by the triggers	Cut costs as route to maximise profits	Cut costs to maximise profits and maximise sales provided MR>MC
Regulatory Game: costs	Incentive on company to forecast high costs ie gaming on the MC of output so as to ensure that MR>MC.	Incentive on company to forecast high costs ie gaming on the MC of output so as to ensure that MR>MC.	Incentive to forecast high cost, and high capital expenditure.	Incentive to game on the MC of output so as to ensure that MR>MC.
Actual cost structure is 100% variable	No incentive to game on forecast demand.	No incentive to game on forecast demand.	Strong incentive to over-estimate forecast demand.	Strong-incentive to over-estimate forecast demand.
Actual cost structure is a mixture of fixed and variable	Incentive to under-estimate forecast demand.	Incentive to under-estimate forecast demand.	Incentive to over-estimate forecast demand.	Incentive depends on the relationship between the actual fixed and variable costs and those assumed in the regulatory regime. A range from an incentive to over-estimate demand, to no incentive and then finally an incentive to under-estimate

				demand can be found.
Actual cost structure is 100% fixed	Strong incentive to under-estimate forecast demand.	Strong incentive to under-estimate forecast demand.	No incentive to game on forecast demand.	Strong incentive to under-estimate forecast demand.
Examples	England and Wales Regional Electricity Companies distribution businesses (1990-1994)	Buenos Aires Water and Sewerage Concession Guinea Water and Sewerage Sector Lease England and Wales Water and Sewerage Companies – 'shipwreck' clauses	England and Wales National Grid Company	Northern Ireland Electricity transmission and distribution businesses. England and Wales Regional Electricity Companies distribution businesses post 1994

Key:

In the volatility consideration, the impact that is considered is the impact of a change in one of the cost drivers or demand. Three levels of impact have been considered:

X No volatility in this element.

√ Some volatility in this element.

√√ Potentially strong volatility in this element.

5 Volatility

This Section is concerned with the development of a simple model to assess the possible volatility of prices under alternative regulatory systems and demand shock scenarios.

5.1 Sources of volatility

Earlier sections of this paper showed that there are three main sources of volatility for a company. These are when:

$Q \neq \tilde{Q}$, i.e. actual demand is different to forecast demand;

$F \neq \tilde{F}$, i.e. actual fixed costs are different to forecast fixed costs; and

$V \neq \tilde{V}$, i.e. actual variable costs are different to forecast variable costs.

Of these three sources of volatility, only the demand aspect impacts on the price in a revenue-cap or hybrid system. This is because during the price control period the two cost issues only impact on the company's profitability and not on the price charged. [11] The types of system that will be considered are set out below while the types of scenario that could affect demand are shown later.

5.2 The alternative regulatory systems

Although the desire is to consider the impact of changing demand on alternative variants of the hybrid regime, it is important to have a benchmark against which these alternative can be measured. To provide this benchmark the revenue-cap will be considered—a price-cap leads to no volatility in the out-turn price level since the company is exposed to all types of risk.

The main focus of this and the following Sections are prices and consequently the revenue formulae developed earlier in this paper are restated as price formulae – achieved by dividing through by the forecast number of units.

5.2.1 Revenue-cap

From Section 2, a revenue-cap price control can be defined as:

$$\overline{P}_t = \tilde{F}C_t + \tilde{V}C_t - K_t$$

[11] The price control period is defined as the length of time between two price reviews. So, if reviews happen once every five years, the price control period is five years.

The correction factor, however, only captures differences in out-turn quantity; differences in either of the cost components are not corrected for. K can be defined as:

$$K_t = \frac{\left(\overline{P}_{t-1} \times Q_{t-1}\right) - \left(\overline{P}_{t-1} \times \tilde{Q}_{t-1}\right)}{\tilde{Q}_t}$$

This can be restated as:

$$K_t = \frac{\overline{P}_{t-1} \times \left(Q_{t-1} - \tilde{Q}_{t-1}\right)}{\tilde{Q}_t}$$

This effectively means that the price is adjusted by the total over- or under-recovery of forecast costs arising from the divergence in demand, divided by the forecast number of units for this period.

5.2.2 Hybrids

Like the revenue-cap a hybrid system ensures that a company is not penalised, or allowed windfall profits, when quantity diverges from that forecast. However, unlike the revenue-cap, an adjustment is only made for the proportion of fixed costs that was over- or under-recovered. Variable costs, it is assumed in this model, are not affected by the change in demand since the company will not incur costs, or will recover them through the price, if out-turn demand is lower or higher than forecast, respectively. So, the price can be defined as:

$$\overline{P}_t = \tilde{F}C_t + \tilde{V}C_t - hK_t$$

The correction factor should just relate to the impact on fixed costs. However, for simplicity, K is again defined as:

$$K_t = \frac{\left(\overline{P}_{t-1} \times Q_{t-1}\right) - \left(\overline{P}_{t-1} \times \tilde{Q}_{t-1}\right)}{\tilde{Q}_t}$$

Then, to ensure that just fixed costs are captured under the correction factor, h is defined as the assumed regulatory proportion of fixed costs. For example, if h=0.4 then it is assumed that 40% of costs are treated as fixed and consequently protected under the correction factor.

A key aspect that should be addressed are the possible variants of this model that should be considered in the scenarios. A simplifying assumption has been made such that VC is a constant per unit amount. Few hybrid systems appear to exist in the world in the water industry. However, in one of the three that we have been able to identify as coming close to a hybrid, Canada, the variable per unit charge differs according to which band the consumer is in.[12] The other two countries are England and Wales and New Zealand (where four of the 15 water agencies reviewed in the World Bank study, see footnote 2, reported using a fixed and volumetric charge).

5.2.3 Hybrid variants

Fixed costs should dominate the cost structure of an infrastructure or utility service provision company if the assets are valued on a current cost basis. However, few countries charge for assets on the basis of current cost values since traditionally prices have been subsidised by the State. This means that, according to the valuation technique adopted, the proportion of fixed to variable costs could lie anywhere in quite a broad range. Consequently, a range of alternative hybrid models are considered.

The following table sets out alternative mixes of fixed and variable cost assumptions that the scenarios will consider.

Table 5-1: Alternative hybrid formulae

Variant	*Fixed costs %*	*Comment*
Hybrid 40	40	The valuation of the assets is low leading to variable costs dominating fixed costs.
Hybrid 60	60	Fixed costs are higher than variable costs, but the difference is not great, suggesting that assets are valued relatively low.
Hybrid 90	90	Fixed costs dominate variable costs, suggesting that assets are valued closer to their true value than in the other cases.

5.3 Scenarios

Now that the four regulatory regimes that are to be considered have been determined it is possible to consider the actual scenarios that will be modelled. The scenarios we will consider include:

- a one-off reduction in demand. Reductions of 1%, 5% and 10% will be modelled;
- a once-and-for all reduction in demand taking place in the first year and lasting for the whole of the remainder of the price control. Reductions of 1%, 5% and 10% will be modelled; and

12 This is based on the evidence provided in Table 6.3 Unit prices and marginal prices for municipal water service by province 1991, on Page 43 of *Water Pricing Experiences: An International Perspective*, the World Bank, 1997.

- a two-year 20% per annum reduction in demand in each year, starting in the second year of the price control. This case is loosely modelled on the impact of natural/environmental causes, such as El Nino.

In all cases the original price profile against which this will be modelled will be the same for all the regulatory regimes. It will only be the divergences that differ. In each case the mixture of fixed and variable costs is assumed to be correct and that actual costs equal forecast costs. Clearly, each of those factors would affect the profitability of the concessionaire but would not impact on the price volatility.

5.4 The model

As mentioned earlier, a simple highly stylised model has been adopted for this work. The model assumes that:

- forecast demand is constant at 100 units;
- forecast costs are constant at £100;
- the forecast price level is £1 per unit; and
- there is no inflation and interest rates are zero.

The last assumption means that no adjustment has to be made to the correction factor to ensure that changes in revenue flows are net present value neutral. These assumptions allow very stylised conclusions to be drawn.

5.5 Results

Results for each of the scenarios are provided in annex 3 of this paper. The overall results are briefly summarised below.

Price volatility. As would be expected, the revenue-cap creates the greatest volatility in the price level while hybrid based systems display dampened versions of this. The degree of dampening depends on the value that h takes. The closer that h is to 1, the closer the degree of volatility under the hybrid system to that under the revenue-cap – in the extreme a revenue-cap is a hybrid with h set equal to 1.

Revenue volatility. A second area of concern, apart from the price issue addressed above, relates to the impact on revenue. If a significant impact on revenue occurs it is likely that this will be reflected in the rates of return earned by the company since utility and infrastructure service provision activities are capital intensive.

Given that the greatest volatility in prices is seen with the revenue-cap it is not surprising that the lowest revenue volatility is associated with this regulatory system—the price volatility exists because of the desire to bring about revenue stability. As h moves away from 1 and closer to 0, the degree of volatility increases. Again, this is not an unexpected result.

6 Options for dealing with volatility

It is clear from the very simple stylised scenarios shown in Section 5 and the detailed results provided in annex 3 that even quite small changes in demand can have a significant impact on the volatility of prices. Because of this, and the desire to provide consumers with relative certainty about the price path, some consideration should be given to the options available for smoothing the price volatility. Two basic approaches are considered as well as one more complex one in this Section of the paper. They have been characterised by the general headings of:

- averaging;
- limits on price increases; and
- a revenue fund.

Before considering those three broad approaches, however, it is worth considering what a smoothing option actually achieves.

As with the modelling in the last Section, simplifying assumptions are made. So, the model is operating in real terms and interest rates are zero, consequently removing the need to ensure revenue streams are kept at a net present value neutral level.

6.1 Volatility, smoothing and risk

As was discussed earlier, the choice between mechanisms is partly predicated on the choice of the allocation of risk between company and consumer. For example, with a revenue-cap the company bears the cost risk while the consumer bears price and quantity risk. A smoothing system is a way of altering this allocation of risk, or at least changing the profile of the risk, and as such should be considered very carefully to ensure that the impact of a smoothing system does not undo the earlier choice of regulatory regime.

It is also important to consider that some types of smoothing system can create a form of regulatory risk. If volatility is smoothed over a period of years and a periodic review system has been adopted to establish price levels, then it is important that the operator has confidence that the smoothing system is 'ring-fenced' from the general review. Otherwise there may be concern that positive benefits from the smoothing system could be captured by the regulator. This is a concern in the Manila water and sewerage concessions where smoothing happens over a potentially extremely long period (the whole remaining life of the concession, which is over 20 years at the moment) but price reviews will start at either year five or ten (the choice of which start date is to be employed for full periodic reviews is at the discretion of the regulatory authority).

6.2 Averaging

The first broad type of smoothing system that should be considered is that offered by averaging. Averaging can be either:

- *ex post* averaging of actual quantity; or
- *ex ante* averaging of impacts over the remaining life of the concession.

6.2.1 *Ex post* averaging

A system based on ex post averaging of quantity supplied could be characterised by a correction factor, K, like that set out below.

$$K_t = \frac{\left(\overline{P}_{t\text{-}1} \times \hat{Q}_{t\text{-}1}\right) - \left(P_{t-1} \times \tilde{Q}_{t\text{-}1}\right)}{\tilde{Q}_t}$$

where:

$$\hat{Q}_{t-1} = \frac{1}{n}\sum_{t-1-n}^{t-1} Q_{t-1-n}$$

So, the average quantity is the sum of out-turn quantity over the last n periods, divided by n. This means that rather than recovering the whole impact immediately, the company recovers over a period of years. In the above correction factor the forecast Q is a single value for (t-1), not an average. The specification of this term should be considered further to assess if this is appropriate. A single value may reduce volatility, however, if there is a trend in demand (upward or downward) it may generate a bias in the correction factor. The choice of n will partly depend on the risk of large demand shocks and the life of a price control. For example, as mentioned above, a company facing a five-year price control could experience significant 'regulatory risk' if it faces an averaging period in excess of five years. Arguably, even a five-year averaging process could cause problems if shocks happen after year one and so companies could require an even shorter averaging period. The choice of n then becomes a trade-off between:

- the degree of price volatility;
- the likelihood of increased company risk being reflected in required rates of return; and

- the expectation of when shocks may occur – for example, forecasting becomes more difficult the further out into the price control period that you go.

Figure 6-2 and Figure 6-2 show the price paths that would occur under the three and five year averaging processes for various price control variants with a scenario of a 5% fall in demand in year one that lasts for the whole of the price control period. It is assumed that demand before the start of the period was constant at 100 units, hence it falls to 95 from year one onwards. This assumption has been included to allow maximum clarity regarding the underlying concept being considered.

Figure 6-1: Impact of 3-year rolling averaging on price volatility

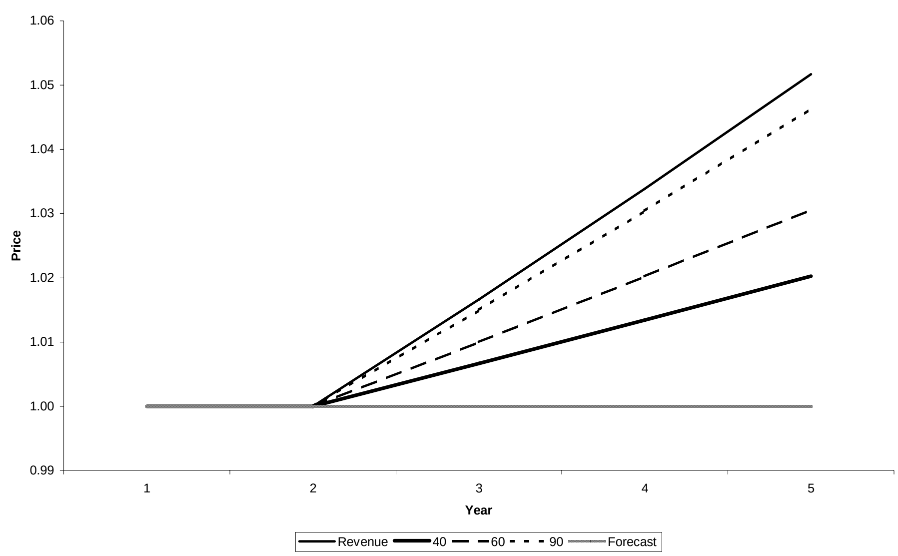
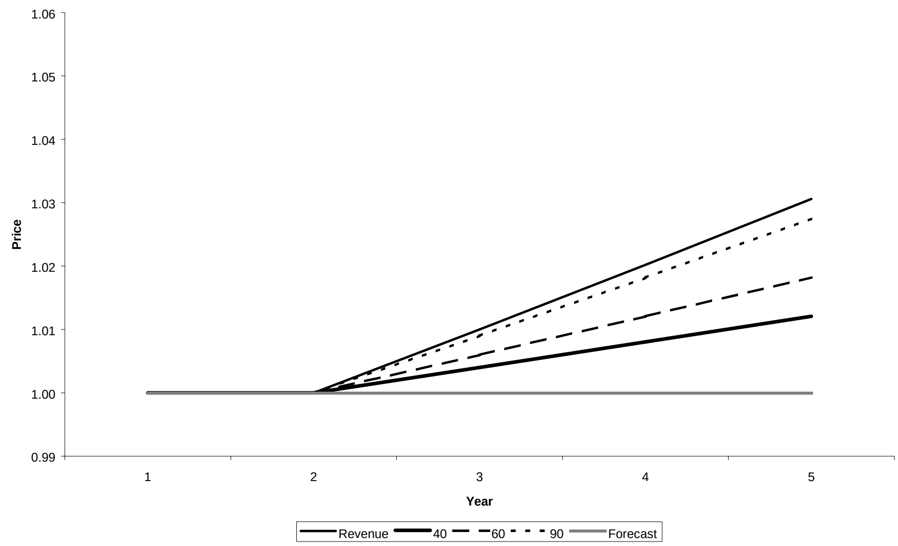


Figure 6-2: Impact of 5-year rolling averaging on price volatility



As can be seen, the averaging processes dampen the quantity figures with the longer averaging period showing a lower impact on the price level, i.e. providing greater dampening of the volatility. More information, for example the impact on revenues etc. is provided in annex 3.

As can be seen from the figures, the impact on the average price of the shock is lowered when compared to the situation of no dampening. Further, the volatility of the prices, as measured by the standard deviation, is lowered – reported in annex 3. The figures show that the risk being re-allocated by the smoothing system can be quite significant. Under a revenue-cap the 5% fall in demand leads to an average annual reduction in revenue of a little over 1% over the five-year price control period.[13] Under the three-year and five-year rolling smoothing systems this drop in average annual revenue increases to over 3% and almost 4% respectively. Hybrid systems, owing to their arrangement, have even greater impacts.

Issues

There are several issues that arise from this basic discussion of an *ex post* averaging system. These include:

- Are any dynamic gaming incentives created through the use of the averaging process? And

- Should averages of both actual and forecast Q be used in the correction factor?

13 This occurs because the correction factor captures last year's divergence, meaning that this shift in demand is reflected in the revenues of the operator during the price control period.

6.2.2 *Ex ante* averaging

An alternative form of averaging that has been undertaken in the Manila water and sewerage concessions is based on smoothing a price increase over the whole remaining life of the concession. This ensures that the volatility created by the price increases is minimised at the beginning of the concession when the most 'learning' about a system is occurring. However, towards the end of a concession there could be significant volatility introduced into the price level by this type of approach.

6.3 Limits

Rather than considering a solution that smoothes the impact of demand changes through averaging the actual changes, it is also possible to consider an approach that imposes externally determined limits. Politicians or the regulatory body may deem a certain level of volatility acceptable but not wish to see prices increase or decrease by more than a certain amount in any one year. Assume that the standard definition of K is employed, i.e.:

$$K_t = \frac{\left(\overline{P}_{t-1} \times Q_{t-1}\right) - \left(\overline{P}_{t-1} \times \tilde{Q}_{t-1}\right)}{\tilde{Q}_t}$$

But, allow the price mechanism to be:

$$\overline{P}_t = \tilde{F}C_t + \tilde{V}C_t - B_t$$

Consider the following definition of B:

If hK < +/-1% then B = hK

If hK > +/- 1% then B = 1%

This places a maximum limit on the volatility of 1% in any one year. If a larger price change is required this is then stored and recovered over time. One of the key issues here is what level of limit is acceptable. Cases of 1% and 3% are considered.

Again, if a scenario based on a 5% negative demand shift in all five years is considered, the results set out in Table 6-1 and Table 6-2 are found.

Table 6-1: Impact of averaging on average annual price

	Average price			*Standard deviation of price*		
	Basic	***1% limit***	***3% limit***	***Basic***	***1% limit***	***3% limit***

Forecast	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
Revenue-cap	1.0416	1.0080	1.0240	0.0233	0.0045	0.0134
Hybrid 40	1.0162	1.0080	1.0162	0.0091	0.0045	0.0091
Hybrid 60	1.0246	1.0080	1.0240	0.0137	0.0045	0.0134
Hybrid 90	1.0373	1.0080	1.0240	0.0208	0.0045	0.0134

Note: a shaded cell implies that the price limit has taken effect.

Table 6-2: Percentage impact of averaging on average annual revenue

Regime	*Basic*	*1% limit*	*3% limit*
Forecast	0.0	0.0	0.0
Revenue-cap	-1.05	-4.24	-2.72
Hybrid 40	-3.46	-4.24	-3.46
Hybrid 60	-2.67	-4.24	-2.72
Hybrid 90	-1.46	-4.24	-2.72

It is clear that the limits as chosen, 1% and 3%, are unable to handle the volatility created by this example and lead to risk being passed on to the company since the price limits mean that some of the needed price change cannot be immediately passed-on to the consumers. Slightly higher limits would capture the Hybrid 60 regime. Annex 3 presents the impact of the 5% in one year scenario and it is clear that this approach is able to handle this with lower volatility. What this suggests is that this approach may be better placed to handle one-off changes rather than continuous ones.

6.3.1 Issues

The discussion of this approach has only started to address some of the issues involved. Although simple in principle, this smoothing system raises some problematic modelling issues. To fully assess the implications of the approach when more realistic scenarios are considered further thought to the modelling of this approach must be given.

Some thought should also be given to the impact of choosing asymmetric limits. For example, what would be the impact of a definition of B which states:

If hK < 1% then B = hK

If hK > 1% then B = 1%

In this case, any decline in prices is automatically passed through, as are price increases provided that they are no more than 1%. If an increase was in excess of 1% then it is curtailed to a maximum of 1% in any one year. What would be the incentive and gaming aspects of this type of rule?

6.4 A revenue fund

A final approach that should be considered is a variant on a relatively well established regulatory regime. In Hong Kong several of the regulated businesses have,[14] at least at some point over the last 20 years, faced a regime that involved profit sharing. However, this profit sharing was not of the form employed by the New York Telephone Company (the classic profit-sharing scheme quoted in Laffont and Tirole) when excess profits were shared with customers through price reductions and 'excess' losses through price increases. Rather, the Hong Kong based system used the concept of a development fund. When profits were above the allowed stated rate of return (the regimes were basically rate of return with no margin around the central rate) profits were transferred to the development fund and when profits were below the allowed rate of return payments out of the development fund were made.

This principle could be carried over to a 'revenue fund'.[15] The system would work as follows:

- in years when demand exceeds that forecast, payments could be made to the revenue fund; and
- in years in which demand is less than forecast, payments would be made from the revenue fund.

This approach has not been modelled since it raises no issues relating to volatility of prices. There are, however, several questions raised relating to the operation of this type of system. These include:

- Would the down-side protection system only operate once payments into the fund had occurred?[16]
- Could a system like this be operated given the ability to impose governance controls on any fund? And
- Could such a system be credible unless there is a regulatory guarantee of being able to recover funds from customers if

[14] This includes electricity, buses, the underground system and telecommunications.

[15] As with most of the other smoothing systems that have been discussed in this Section, we are aware of no actual examples of this.

[16] This is the rule that is operated in Hong Kong.

necessary? This raises issues regarding the flexibility of the regulatory regime.

These questions, especially the last one, make assessing this option in a practical way extremely difficult. There are, however, some aspects of this type of regime that make it interesting. For instance:

- no volatility would be introduced into the price system since customers would not be affected by the demand shocks; and

- provided that the fund could borrow money as necessary, corrections could happen in the year immediately following the demand shock.

6.5 Summary

This Section has developed some basic options for smoothing the impact of volatility brought about by demand shocks. Owing to the paucity of existing systems, much of what has been discussed is still quite theoretical and high level. However, if there is a desire to employ a smoothing system in a regulatory regime it will either be necessary to undertake further detailed modelling work on all the options to determine which is best placed to meet the concerns of the specific system.

It is also necessary to remember that any correction system, whether it includes a smoothing system, will need to take interest into account to ensure that the overall impact is revenue neutral. This will be achieved through specifying the correction factor as:

$$\overline{\mathrm{P}}_t = \tilde{\mathrm{F}}\mathrm{C}_t + \tilde{\mathrm{V}}\mathrm{C}_t - \mathrm{h}\left[\mathrm{K}_t \times (1 + r)\right]$$

Where r is the relevant cost of capital for the operator.

7 Choosing a smoothing option

To be able to choose which of the smoothing options described in Section 6 is best suited to meet a particular regimes problems requires a framework to be established. This framework should consider the key criteria that any smoothing option should embody. Issues set out in this Section start to address a range of key criteria but should be seen as a first attempt to identify the key issues rather than a comprehensive list. Further development of these criteria is required for a full assessment of the options to be possible.

7.1 Impact on company incentives

Any option should be considered in terms of the way it impacts on the incentives of a company. This could happen in a number of ways. These include:

- re-allocation of risks as described in Section 6.1;
- the creation of new regulatory risks; and
- the creation of possible new regulatory games.

7.2 Impact on regulatory gaming

New regulatory games may be created through the establishment of smoothing systems. For example, if an averaging based smoothing system is used then provided the hybrid system places sufficiently great emphasis on the fixed costs, it could be in the company's interest to seek to under-forecast demand. This will ensure that the company loses as little as possible if actual demand proves to be lower than forecast but does still benefit from some of the upside if actual demand proves greater than forecast.

This suggests that a careful consideration of the cost structure and the impact of the smoothing option should be undertaken. Identifying further possible areas for gaming would be important.

7.3 Impact on financial viability and ability to handle shocks

There are effectively two linked criteria here. The impact of any option on a company's financial viability will depend to a significant amount on the ability of the option to handle that type of shock.

For example, it would appear from Section 6 that a limit based system is best able to handle one-off random demand shocks but has much more difficulty with shocks that shift demand in a particular direction. So, the risk of certain types of shock should be considered and then the type that is best able to handle that form of demand shock can be chosen.

This raises an additional issue of whether a mixture of smoothing options could be brought together into a single correction factor. This may be the best way of handling the risk of shocks in that specific system but may fail on the next criteria.

7.4 Ease of application

Regulatory regimes are prone to be over-complicated. Although it is important to establish systems that create the appropriate incentives for the company it is also important to ensure that a relatively simple mechanism is put in place:

- to assist in developing a clear and transparent workable regime; and
- to ensure that while institutional and human capital constraints exist, a viable regime is being operated.

This is a practical reality check that should always be considered to ensure that if an option is chosen it will help, rather than hinder, the regulatory regime.

7.5 Assessment of option

This Section makes a very brief first attempt at reviewing the options set out in Section 6 against the criteria established above. This assessment is, however, preliminary and based on theoretical considerations. It is important that the approaches are evaluated against the actual requirements for the situation to which it is being applied leading to a specific assessment.

Table 7-1: Assessment of options against criteria

Option	*Incentives*	*Gaming*	*Financial viability*	*Ease of application*
Averaging	Possibly adverse	Possibly adverse	Limited impact	Simple
Limits	Possibly	Possibly	Depends on	Depends on

	adverse	adverse	type of shock. May be significant	type of shock. May be difficult
Revenue fund	Limited	Limited	None	Could prove difficult

Obviously the specifics of a system will have an impact on the assessment. For example, a revenue fund could have significant adverse incentive and gaming properties if it is designed to only pay-out when there are funds available. It may then be in a company's interest to under-estimate demand in the initial years so as to ensure that there are funds available that can then be recaptured in the later years.

8 Summary and Conclusions

The desire to establish regulatory regimes that provide the right incentives for operators has led to interest in revenue-cap and hybrid (mixtures of revenue-cap and price-cap regimes) type systems. This paper has started to address the significant issues that arise from the desire to smooth the volatility in prices that is created by the use of either of these types of approach. It has only been able to start scratching the surface of the issues involved for three reasons:

- little or no work appears to have been undertaken on this issue and few examples exist. So a significant amount of work from first principles has had to be undertaken;
- the financial model that has been employed to assess the options is extremely simple. This was for two reasons:
  - to ensure that clear signals regarding the impact of alternative regimes or smoothing options was found; and
  - to provide a user-friendly model without investing significant resources in its development;
- the latter point was important in as much as significant resources could be required if the issue of designing a smoothing option was to be fully developed.

To determine whether there is a need for a smoothing option for any system it is important to consider the following questions:

- What types of demand shock could occur?
- What are the risks of large shifts in demand? And
- What are the political and consumer attitudes to price volatility?

If the answers to these questions suggest that a smoothing option is required then, in addition to the issues identified in the earlier Sections of the paper, the following points should be considered. These include:

- What are the impacts of shifting the focus of the modelling from a five year horizon to a longer one?
- What are the impacts of expanding the modelling to include a series of positive and negative demand shifts?

- Can a more complex model be established to consider more detailed issues?

Annex 1

Framework

It is worth thinking about the underlying principles involved from a theoretical perspective when developing the cost model used in this paper. This annex considers a variety of key concepts and elaborates some points.

The basic revenue-cost relationships

Consider the profit, revenue and cost relationship for a company:

$$\text{Profit} = \text{Revenue} - \text{Cost}$$

In turn, this can be restated as:

$$\text{Profit} = (P \times Q) - (C \times Q)$$

Where in the case of water:

P is the price per cubic meter sold;[17]

Q is the number cubic meters of water and sewerage sold; and

C is the cost per unit sold.

Again, this could be restated as:

$$\text{Profit} = (P - FC - VC) \times Q$$

or alternatively as:

$$\text{Profit} = (P - (FCC + FUC + VCC + VUC)) \text{ x } Q$$

Where:

FC is fixed cost per unit sold

VC is variable cost per unit sold

FCC is fixed controllable cost per unit sold

VCC is variable controllable cost

FUC is uncontrollable cost per unit sold

VUC is variable uncontrollable costs.

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[17] The price is specified the price per unit delivered to the customer. In the case of water the units produced will differ from the units sold due to unaccounted for water (UFW - technical losses and illegal consumption). It is presumed that issues arising from UFW are handled elsewhere in the pricing mechanism or contract.

Both the concepts of fixed and variable costs and of controllable and uncontrollable costs may be important to the regulator. Controllable costs are those that the company can directly influence, for example wage costs.[18] Uncontrollable costs are those that are outside of the control of the company, for example the unit cost of chemicals for water treatment—although, of course, a company does have some control over the specific treatment approach adopted and so the type of chemicals etc, but it is unlikely to have any control over the price of chemicals once a treatment system has been put in place. The concept of controllability should be considered in relation to the price and volume elements of any cost. Both fixed and variable costs are likely to have controllable and uncontrollable elements. The weighting given each of these elements in the regulatory formula will determine the degree of cost and risk pass through from the concessionaire to consumers.

The reason why it may be useful to distinguish between controllable and uncontrollable costs is that it enables the regulator to increase pressure on firms to achieve efficiency gains in controllable costs, while allowing greater pass through of cost changes in uncontrollable items.

Splitting fixed and variable cost into controllable and uncontrollable elements, however, adds to the complexity of the regulatory decision. In the water industry, the additional complexity may not be justified because of the high proportion of costs that are essentially uncontrollable relative to other sectors, such as transport. The high level of uncontrollable costs in the water sector is due to the high proportion of investment in long lived assets. Further, it is far from clear that the added complexity will be cost effective for regulation. This paper focuses on the simpler formulation of costs and revenues.

The regulatory process is defined as being concerned with establishing forecast values for volumes, and fixed and variable costs that then allow a price to be established. So, in all cases that will be considered, at a price review the regulator will establish:

$$\overline{P} \times \tilde{Q} = \left(\tilde{F}C \times \tilde{Q}\right) + \left(\tilde{V}C \times \tilde{Q}\right) + \tilde{P}\text{rofit}$$

Where: ~ indicates a forecast value and – a fixed regulatory determined variable.

Each of the regulatory regimes can then be considered in the way in which these different elements are controlled.

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[18] Of course, controllability itself is a far from clear cut area. For example, with wages the volume of workers may be controllable while the price per worker is only partly controllable - general wage changes may be outside management control. Further thought about the price volume split and the degree of controllability would be required before this was a workable concept.

Note that in all the cases considered, it is assumed that the interval between price reviews is sufficiently long for firms to have real incentives to improve efficiency.

Risk

Since risk is a key element of the framework, it is useful to define some of the key risks that a regulated firm may face. These risks arise partly from the considerations of the cost and revenue structure as noted above and partly from the wider aspects of the regulatory regime. Risks include:

volume risk: this is the risk that out-turn volume will differ from forecast demand;

cost risk: this arises if the actual costs are different to those that were forecast;

regulatory risk: this is a difficult form of risk to define. It can take many forms and depends on the type of regime that has been put in place. For example, regulatory risk may be attached to the discretion given to a regulatory body *vis-à-vis* the operation of a price review. Alternatively, regulatory risk may be the risk that a stranded asset will be written out of an asset base when there is no mechanism for compensating the company for the cost associated with the stranded asset; and

political risk: this is distinct to regulatory risk in as much as political risk is really a more general risk that the whole framework of regulation may be changed. A good example of political risk is the recent windfall tax applied to the regulated utilities in the UK or the threats of general action over the '*fat-cat*' director abuses perceived by politicians and the public in general arising from the high pay-rises awarded within regulated companies.

Annex 2

Further example of hybrid price-revenue controls

Apart from the NIE case described in the main body of the paper, there are some other examples of hybrid systems.

Regional electricity companies in England & Wales

Another example of where a hybrid has been adopted is the formula adopted by Offer in 1994 to regulate the RECs' distribution businesses. The formula used to regulate the RECs' distribution businesses is more complex than that applied to NIE. The principal differences between the two formulae are:

- in the RECs' formula, the variable component (average per unit) is a tariff basket. This is a weighted average of prices for different customer types, similar to that used between 1990 – 1994 for the RECs'. The NIE variable component is an average unit price;
- the weighting of fixed and variable costs. The RECs are assumed to have a cost structure of 50:50 fixed to variable, compared to NIE's 75:25. This is primarily because NIE is both transmission (high fixed costs) and distribution whereas REC's are distribution businesses only; and
- the RECs formula separates prices to allow for different changes in prices for metered and un-metered customers. This appears to be motivated by the regulator's desire to maintain the ability to adjust the metered component of the control within the period of the price review if necessary, but to limit his own discretion to adjust the whole formula in order to reduce regulatory risk.[19]

The first point is likely to have practical implications, as the specification of the unit price may affect the production and pricing decisions. The later two differences are seen to be largely presentational.

England and Wales Water and Sewerage Companies (WaSCs)

Since the privatisation of the WaSCs in 1989, the regulated water and sewerage services have been controlled using a price cap formula. However, the way in which the tariff basket in the formula is specified means that companies have some revenue components that are fixed in any one year. In this sense, the formula could be regarded as an implicit hybrid. It is not a true hybrid, however because it does not include a correction factor that adjusts revenue for under or over recovery in a previous year.

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[19] The Distribution Price Control : Proposals, Office of Electricity Regulation (Offer) 1994 - pp25-26

In 1997 a consultation paper was published looking at reviewing the tariff regulation mechanism. A new tariff formula has recently been released which will be implemented in 2000. The formula outlined below is the current formula.[20]

The current tariff formula is specified as follows:

$$RPI + K + U \geq W_t = \sum_i \left[\frac{A_{ti}}{A_{t-1i}} \times r_i \right] + \sum_j \left[\frac{B_j}{B_{t-1j}} \times r_j \right] - 1$$

Where

K — is each company's allowed annual increase or decrease in prices over and above inflation. K can be described as -X +Q where X is the assumed efficiency gains (as in other RPI-X formulae) and Q is the amount required for finance requisite capital expenditure. K factors are set for each company. In the current period the K factors for the WaSCs range from 0.5 to 4.

U — is the correction factor, specified as the amount of K not taken up in previous years. U is therefore asymmetric in that it only allows for increases in the weighted average charge.

W_t — is the weighted average charges increase for the charging year

$A_{(t-n)i}$ — is the average charge per customer for unmeasured item $_{(i)}$

$B_{(t-n)j}$ — is the weighting year revenue for measured basket item $_{(j)}$.

A measured item is one where all, or some of, the charges are based on quantities consumed. For example, the volumetric charges and the standing charges associated with a metered connection are considered as measured items. An unmeasured item is any other item.

r_i or r_j — is the proportion of revenue generated from basket item $_i$ or $_j$. This is the weighting factor attributed to each basket item. The weight used is a lagged value based in the proportion of revenue contributed by item in year $_{t-2}$. This is because $_{t-2}$ is the most recent year for which information is available at the time the price adjustment occurs.

[20] The key change incorporated in the new formula is a adjustment to the way in which revenue differentials resulting from customers switching from charges based on rateable value to metered volumetric charging are dealt with. Under the new formula the company can no longer increase unmeasured tariffs in response to a reduction in revenue from a customer switching to metered supply.

There are five basket items that make up the weighted average charge. These are unmeasured water supply, unmeasured sewerage services, measured water supply, measured sewerage services, and the reception and treatment and disposal of trade effluent.

The measured charges represent a variable element in the formula.

A revenue cap component of the formula results from the charges for unmeasured items which appear as fixed components in the regulatory formula. They are calculated as an amount R/N which is fixed in advance. R is the annual revenue which would accrue to a company based on standard charges at the end of the preceding period, and N is the number of customers in the previous period.

The reason for the asymmetry of the correction factor (U), is that the specification of the tariff basket prevents the company from over recovering revenue. This is because the revenue drivers (weights, number of customers, and revenue per customer) are determined by lagged values of the relevant variables. As a result, unlike the RECs, the WaSCs do not face the possibility of charging more than the allowed weighted average charge in any one year if the weights on each customer basket change during the relevant year.

Manila

The Manila water and sewerage concession, let in 1997 provides an example of a price cap with a range of cost pass-through and adjustment mechanisms. The various pass-through clauses increase the complexity of the regulatory formula and effectively render it an implicit hybrid.

The maximum annual change in tariffs, the 'rate adjustment limit' is defined as "the percentage either positive or negative equal to the sum of C, E, and R"

Where:

C	is the percentage change in CPI.
E	is an 'Extraordinary Price Adjustment (EPA)'. EPA can be grouped into four categories: changes in contractual or legal obligations that lead to changes in expected levels of expenditure; breaches of the Agreement by the concessionaire; benefits associated with receipt of grants of subsidised loans; and a range of specific risks such as changes in the basis of CPI, exchange rate movements and cost or time overruns on key projects.
R	is any 'Rebasing Convergence Adjustment'. The intention of R is to incorporate a correction mechanism, while retaining strong incentives on the concessionaire to maximise efficiency.

> To try to achieve this, R is designed to pass on the effects of 'good/bad fortune' to customers but with a significant lag.

An important feature of E is that it is intended to operate independently from the financial performance of the concessionaire. The adjustments to the rates that are generated by E should be determined only by the causal variable, and should not take into account the level of profitability of the concessionaire.

R is designed to adjust the annual allowed change in tariffs in future years to maintain a smoothed net present value of future cash flows. The effect of this is to ensure a certain level of revenue over the relevant (five year) time period. In this sense it introduces a revenue cap element into the price cap.

The complexity of the Manila price regulation formula, makes it extremely difficult to assess the incentives it imposes on the concessionaire. Aspects such as E and R are clearly designed with the intention of reducing risk to the concessionaire, consumers, and the regulator. Introducing such complex interventions may, however, well impose significant risks and costs on all parties.

Annex 3

Volatility and Smoothing Results

General modelling results

Price and volatility

The first area of concern is the impact of the demand shocks on the average price and volatility, as measured by the standard deviation of the prices. For each of the classes of scenario a table presents the set of results.

Table A-1: Impact of one-off changes in demand

	Average Price			*Volatility*		
	1% shock	*5% shock*	*10% shock*	*1% shock*	*5% shock*	*10% shock*
Forecast	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
Revenue	1.0020	1.0100	1.0200	0.0045	0.0224	0.0447
Hybrid 40	1.0008	1.0040	1.0080	0.0018	0.0089	0.0179
Hybrid 60	1.0012	1.0060	1.0120	0.0027	0.0134	0.0268
Hybrid 90	1.0018	1.0090	1.0180	0.0040	0.0201	0.0402

Table A-2: Impact of 'shift' changes in demand

	Average Price			*Volatility*		
	1% shock	*5% shock*	*10% shock*	*1% shock*	*5% shock*	*10% shock*
Forecast	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
Revenue	1.0081	1.0416	1.0864	0.0045	0.0233	0.0485
Hybrid 40	1.0032	1.0162	1.0330	0.0018	0.0091	0.0185
Hybrid 60	1.0048	1.0246	1.0502	0.0027	0.0137	0.0281
Hybrid 90	1.0072	1.0373	1.0772	0.0041	0.0208	0.0433

From these first two tables it is possible to see that the impact of a one-off change in demand is limited unless it is a significant change. However, a shift in demand has a much greater impact, although it is necessary to still have a relatively significant change in demand for the impact to be noticeable.

Table A-3: Impact of freak 20% change in demand for two years

	Average Price	*Volatility*
Forecast	1.0000	0.0000
Revenue	1.0880	0.1213
Hybrid 40	1.0333	0.0456
Hybrid 60	1.0509	0.0699
Hybrid 90	1.0785	0.1081

The 'freak' conditions, as exemplified by the on-going El Nino problems in many parts of the world have significant impacts. Although these changes in demand may be rare, they can lead to significant price changes and very high volatility.

Revenue

A second area of concern, apart from the price issue addressed above, relates to the impact on revenue. If a significant impact on revenue occurs it is likely that this will be reflected in the rates of return earned by the company since water and wastewater are capital intensive activities.

The following three tables provide the results from the three stylised classes of demand change.

Table A-4: Impact of one-off changes in demand

	Total Revenue			*Average annual % divergence from forecast*		
	1% shock	*5% shock*	*10% shock*	*1% shock*	*5% shock*	*10% shock*
Forecast	500.0	500.0	500.0	0.00	0.00	0.00
Revenue	500.0	500.0	500.0	0.00	0.00	0.00
Hybrid 40	499.4	497.0	494.0	0.12	0.60	1.20
Hybrid 60	499.6	498.0	496.0	0.08	0.40	0.80
Hybrid 90	499.9	499.5	499.0	0.02	0.10	0.20

Table A-5: Impact of 'shift' changes in demand

	Total Revenue			*Average annual % divergence from forecast*		
	1% shock	*5% shock*	*10% shock*	*1% shock*	*5% shock*	*10% shock*
Forecast	500.0	500.0	500.0	0.00	0.00	0.00
Revenue	499.0	494.7	488.9	0.20	1.05	2.22
Hybrid 40	496.6	482.7	464.8	0.68	3.46	7.03
Hybrid 60	497.4	486.7	472.6	0.52	2.67	5.48
Hybrid 90	498.6	492.7	484.7	0.28	1.46	3.06

Again, as with prices, it requires either a significant one-off change for there to be a noticeable impact or a relatively significant shift over the whole period. With the Hybrid 40 regime, a 10% fall in demand over the five years of the price control period leads to an annual reduction in revenue of a little over 7%. If the company really faced a cost structure that was 90% fixed, this reduction could lower the achieved rate of return quite significantly.

Table A-6: Impact of freak 20% change in demand for two years

	Total Revenue	*Average annual % divergence from forecast*
Forecast	500.0	0.00
Revenue	500.0	0.00
Hybrid 40	475.0	4.99
Hybrid 60	483.0	3.39
Hybrid 90	495.6	0.87

Again, the freak condition can have a significant impact, depending on which regime is chosen.

Overall, what this shows is that the choice of regime, which may be partly governed by the desire to create incentives, could create significant volatility risk and revenue risk for the company. This latter point is important if the actual cost structure is relatively more fixed than the assumed regulatory cost structure.

Smoothing system results

Ex-post averaging

Table A-7 shows the impact of the two averaging processes considered in this report, three and five year averaging, compared to forecast and out-turn quantity, in the scenario when there is a 5% fall in demand in year one and this lasts for the whole of the price control period. It is assumed that demand before the start of the period reported in the table was constant at 100 units. This assumption has been included to allow maximum clarity regarding the underlying concept being considered.

Table A-7: Impact of changing the quantity

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Average*
Forecast	100	100	100	100	100	100
Actual	95	95	95	95	95	95
3-year	100	98.33	96.67	95	95	97
5-year	100	99	98	97	96	98

As can be seen, the averaging processes dampen the quantity figures.

Table A-8: Impact of averaging on average annual price

	Average price			*Standard deviation of price*		
	Basic	*3-year*	*5-year*	*Basic*	*3-year*	*5-year*
Forecast	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
Revenue-cap	1.0416	1.0205	1.0122	0.0233	0.0224	0.0133
Hybrid 40	1.0162	1.0081	1.0048	0.0091	0.0088	0.0053
Hybrid 60	1.0246	1.0122	1.0073	0.0137	0.0133	0.0079
Hybrid 90	1.0373	1.0184	1.0199	0.0208	0.0201	0.0119

As can be seen from the tables, the impact on the average price of the shock is lowered when compared to the situation of no dampening. Further, the volatility of the prices, as measured by the standard deviation, is lowered.

Table A-9: Percentage impact of averaging on average annual revenue			
Regime	***Basic***	***3-year***	***5-year***
Forecast	0.0	0.0	0.0
Revenue-cap	-1.05	-3.06	-3.85
Hybrid 40	-3.46	-4.23	-4.54
Hybrid 60	-2.67	-3.85	-4.31
Hybrid 90	-1.46	-3.26	-3.96

Table A-9 shows that the aspect of risk being re-allocated by the smoothing system can be quite strong. Under a revenue-cap the 5% fall in demand leads to an average annual reduction in revenue of a little over 1% over the five-year price control period. Under the three-year and five-year rolling smoothing systems this drop in average annual revenue increases to over 3% and almost 4% respectively. Hybrid systems, owing to their arrangement, have even greater impacts.

Impact under limit based smoothing

The two tables below report the results of applying the limit based smoothing system to a demand shock that occurs for only one year. The scenario that has been used is the 5% fall in year two scenario. As can be seen from the tables, the smoothing systems reduce price volatility and in most cases have no impact on the amount of average revenue when compared to a no smoothing scenario. This suggests that this approach may be better placed to handle this type of random event rather than the shift type of event considered in the main body of the report.

Table A-10: Average prices under the limit based smoothing system (5% fall in demand in one year scenario)						
	Average price			***Standard deviation of price***		
	Basic	***1% limit***	***3% limit***	***Basic***	***1% limit***	***3% limit***
Forecast	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
Revenue-cap	1.0100	1.0060	1.0010	0.0224	0.0055	0.0141
Hybrid 40	1.0040	1.0040	1.0040	0.0089	0.0055	0.0089
Hybrid 60	1.0060	1.0060	1.0060	0.0134	0.0055	0.0134
Hybrid 90	1.0090	1.0060	1.0090	0.0201	0.0055	0.0134

Table A-11: Percentage impact of averaging on average annual revenue under the limit based smoothing system (5% fall in demand in one year scenario)

Regime	*Basic*	*1% limit*	*3% limit*
Forecast	0.00	0.00	0.00
Revenue-cap	0.00	0.40	0.00
Hybrid 40	0.60	0.60	0.60
Hybrid 60	0.40	0.40	0.40
Hybrid 90	0.10	0.40	0.10

Annex 4

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