

Behavioural Modelling of incentives in Ofwat's wholesale price limits consultation

Report sponsored by a group of
water companies

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Summary

We are grateful to the sponsors for supporting and participating in the work that has led to this report and to Ofwat for the input it has provided. Neither the sponsors nor Ofwat necessarily agree with the conclusions contained in the report.

Introduction

Ofwat is proposing changes to the way it regulates the water industry. Indepen and Volterra have been working with a group of water companies and Ofwat since summer 2011 on a modelling approach to analysing the effect of existing and proposed regulatory incentives. The purpose of the work is to inform the design of the incentives and this report considers the options for incentivising outcome delivery that are contained in Ofwat's wholesale consultation paper.

The base model considers the way that company behaviour affects outcomes under an incentive package that is a simplified view of that adopted at PR09. We have used this as the counterfactual against which to analyse some of the changes suggested by Ofwat.

The model contains behavioural dimensions relating to risk appetite, attitude to regulatory targets, and innovation. Risk appetite relates to a company's willingness to absorb the risk of missing a target and incurring a penalty; attitude to regulatory targets refers to whether companies are content to simply hit a target or whether they prefer to exceed them. We define a company as innovative if it is willing to spend on high risk projects which, if successful will reduce its costs in future periods.

This allows for eight behavioural combinations. In discussing the results we have focused on two extreme types – Risk Neutral Satisficers and Risk Averse Emphasisers, each with and without the propensity to innovate.

The base model provides the counterfactual for the analysis reported in this document, which evaluates the effects of

- different forms of customers' utility functions
- options proposed by Ofwat for the outcome delivery incentive
- outcomes delivered over more than one regulatory period.

Throughout the report we have used upper case for the first letter of variables and behavioural types in the model. We needed two outcomes to allow for trade-offs in the delivery incentive. We have characterised them as Quality, Environment and Price but they could be replaced by other outcomes without affecting the nature of the results.

Results

The model simulates a simplified regulatory regime and a set of notional company types displaying different attitudes to risk, meeting targets and innovation. We evaluate overall results in terms of changes in customers' utility, which is dependent on changes in prices and in the other outcomes. When we refer to better outcomes, we mean an increase in utility, having regard both to benefits - Quality and Environment and to cost - Price. When we refer to companies not delivering better outcomes, we mean they are not delivering improvements in Quality and/or Environment at a cost that is less than or equal to the Price customers are willing to pay for them.

We have not linked the behavioural types we have modelled to individual companies in the sector. In discussion of the behavioural dimensions, participants said that they believed they were realistic in terms of the way we have characterised them and the range of behavioural consequences generated by the model.

Effect of behavioural types on outcomes

Risk Averse Emphasisers are companies that wish to hit or surpass their targets and will spend more than the average to have a better chance of doing this. These companies deliver larger improvements in the Quality and Environment outcomes than do Risk Neutral Satisficers. The latter aim to hit outcome targets and they take the risk that, because of uncertainty in various forms, they will fail to do so.

Innovators direct a proportion of their expenditure towards a type of Capex that is focused on Innovation, which yields uncertain but potentially large improvements in the Environment outcome. As a result, innovators deliver bigger improvements in Environment. As a simplification and to make the effect of innovation more visible in the results, we have limited the effect of innovation to Environment. This is not necessarily realistic and should be borne in mind when considering the results.

Risk Neutral Satisficers spend less than do the other behavioural types. While on average they deliver smaller improvements in Quality and Environment they achieve larger price reductions than Risk Averse Emphasisers. In a one period model where innovation costs money and the benefit in the form of lower costs does not accrue, Innovators spend more, meaning they deliver smaller price reductions than do companies that do not innovate.

Effects of changes to the utility function

In the base model we assume that customers' utility functions are linear in outcomes and price. We consider three groups of customers with utility functions that respectively place 80% weight on one of the three variables (Quality, Environment, and Price) and 10% on each of the others. Under these assumptions

- Quality focused or Environment minded customers do best with Risk Averse Emphasisers
- Environment minded customers' utility is higher with Innovative companies.
- Price sensitive customers get the biggest utility improvement from companies that spend least - i.e. Risk Neutral Satisficers and companies that do not spend on Innovation.

We tested the effect of changes to the utility function and found the results were sensitive to the changes. One variant has customers giving 80% weight to their priority factor if that factor starts in the bottom quarter otherwise placing higher weights on the other factors. This is a way of reflecting diminishing marginal utility in combination with the widely discussed idea that there may be a discontinuity in customers' utility functions.

Introducing this change makes it difficult to generalise about which sort of company delivers the best utility improvements for the various customer types. Typically Emphasisers and Innovators still deliver better or at least equally good utility improvements but the extent of the improvement is sensitive to the form of the utility function.

Ofwat's delivery incentive options

The model allows us to analyse the various forms of delivery incentive with and without trade-offs including the options in Ofwat's wholesale price limit consultation. We find that

- allowing trade-offs between Environment and Quality outcomes provides some negation of risk but does not significantly increase Profit
- rewarding outperformance makes a significant difference to companies' ability to make higher Profits when delivering better Quality and Environment outcomes, notwithstanding higher spending.

Looking at Ofwat's options

- the option (A5) which includes both trade-offs and rewards gives the biggest financial incentives for outcome oriented behaviour and limits the risk to companies most effectively
- the results for option (A2) which has neither trade-offs nor rewards, suggest that Risk Averse Emphasisers (which achieve the best Quality and Environment outcomes but the lowest Profit) would be likely to switch to Risk Neutral Satisficing behaviour and that Innovator behaviour would become less attractive. This would reduce the Environment and Quality outcomes.

The scale of rewards has a significant effect on Profits and, potentially, behaviour.

- If penalties exceed rewards, then the penalty: reward mechanism narrows the difference in Profit between Risk Averse Emphasisers and Risk Neutral Satisficers although the Profit earned by the former is below that of the latter in all cases.
- Profits are equalised between company types when penalties and rewards are symmetrical.
- The same is true for Innovators and non-Innovators.

Effects on outcomes of changes over time

We have looked at the effect of potential changes in customer preferences over time. It may be that in economically difficult times, a customer will be sensitive to Price in the short term but will shift towards being interested in Environment in the longer term. Such a customer might tend to trade-off lower utility now in return for higher utility in future and would be best served by Innovative and Emphasising companies.

Another inter-temporal consideration is the period over which the pay-off from Innovation is deferred. In the one period model Innovators earn lower Profits than non-Innovators. Factoring in the potential for savings in a future period on the assumptions we have used mean that average Profits for Innovators are still lower than for non-Innovators. The range of potential shifts considerably with a possibility of large future savings if spending on Innovation is successful.

Conclusions and implications

Conclusions from the base model are as follows.

- The companies that spend least and deliver lower Environment and Quality outcome improvements usually achieve higher profits.
- The companies that spend the least on innovation achieve higher profits.
- Customer utility is sensitive to the form of the utility function.
- The introduction of a non-linear form of the utility function makes it difficult to draw general conclusions about which sort of company delivers the best improvements for the various customer types.

The last point is relevant to the question of proportionality of incentives. The base model assumes that the value of rewards and penalties is linked to the cost of delivery for the companies. Ideally, an incentive should be proportionate to customer valuation. The sensitivity of the results to the form of the function suggests that proportionality in this sense will require a good understanding of the form and parameters of the utility function and any factors that might cause them to shift over time.

With respect to options for the outcome delivery incentive, we conclude that

- allowing trade-offs between outcomes in determining penalties and rewards will provide limited mitigation of risk and does not significantly increase profit
- providing rewards for over-delivery as well as penalties for under-delivery makes a significant difference to companies' ability to make higher profits, even given higher spending
- increasing the size of rewards relative to penalties would strengthen the financial incentive for companies to deliver better Environmental and Quality outcomes for customers.

We note below some significant implications of the conclusions.

Incentive alignment and behaviour change

The observed relationship between profitability and the other outcomes across the different behavioural types may be unintended. If outcomes other than price are important to customers, it will make sense to reconsider the balance of incentives so that companies that seek to outperform Environment and Quality targets, or pursue efficiency through innovation, can earn higher profits.

We have not made behavioural change exogenous in the model but the analysis points to situations in which behavioural change is likely. In its current form, the model suggests that, over time, companies will tend towards spending as little as possible to "satisfice" Quality and Environment targets.

Customer utility functions

The conclusion that the results are sensitive to the specification of the utility function is important for the design of proportionate incentives. It means that there is a premium on better understanding of the form and parameters of customers' utility functions and any factors that might cause them to shift over time, for example a recession driven focus on affordability.

Without such information, there is a risk of poorly aligned incentives and unintended consequences. For example, if any affordability preference were to be reversed if the economy improved, customers' preferences in future would value more highly the outputs of Innovative and Emphasising companies.

Delivery incentives

The findings and conclusions on these have clear implications for the relative merits of Ofwat's options and the form of the incentives within them. The results show that allowing trade-offs does not increase profits significantly but that rewards and trade-offs together best rewards companies that produce the best outcome improvements. This would favour Ofwat's option A5.

Innovation

We have introduced innovation as an additional behavioural dimension and the results provide some useful insights. The topic would benefit from further consideration but initial results showed that the current incentive system does not financially incentivise companies to innovate to address the water sector's future challenges.

As modelled, innovation does not lead to higher profits in the short term and companies driven by short term considerations are unlikely to invest in innovation. This suggests that reducing the initial cost of innovation might prove an effective incentive.

Further development of the approach

We believe that the results of the modelling provide useful insights as summarised above. A crucial aspect of the value of the approach is the ability to set up and calibrate a counterfactual against which to consider options for change and their likely consequences. The approach is capable of further development. Areas where the results to date suggest this might be valuable include

- the behavioural dimensions we have used and the types of behaviour they entail
- the form and parameters of customers utility functions and the conditions under which they might vary
- the range of pay-offs to innovation and their timing
- further consideration of multi-period and inter-temporal issues generally
- the nature of a more complete sensitivity analysis of the model which might indicate areas for further refinement

- consideration of how the model can be used to avoid unintended consequences of incentive design.

We would welcome suggestions for refinements and uses of the model. If you have them please email them to felicity.furness@independen.uk.com; eevans@volterra.co.uk

1 Introduction

Ofwat is proposing changes to the way it regulates the water industry. Indepen and Volterra have been working with a group of water companies and Ofwat since summer 2011 on a modelling approach to analysing the effect of existing and proposed regulatory incentives. The purpose of the work is to inform the design of the incentives and this report considers the options for incentivising outcome delivery that are contained in Ofwat's wholesale consultation paper.

We have used agent based modelling to simulate and analyse the consequences of regulatory incentives. This is the report on the third phase of work¹ the objective of which was to evaluate options contained in Ofwat's consultation on wholesale price limits².

The work was sponsored by Anglian Water, Bristol Water, Severn Trent Water and Wessex Water. Ofwat participated in the project and attended the group meetings.

We thank all participants for their support for the project and their valuable contributions. Neither the sponsors nor Ofwat necessarily agree with the conclusions in the report.

The report has the following sections

- Overview of the model
- Main relationships and assumptions
- Results

2 Overview of the model

The model considers the way that company behaviour affects outcomes under an incentive package that is a simplified view of that adopted at PR09.

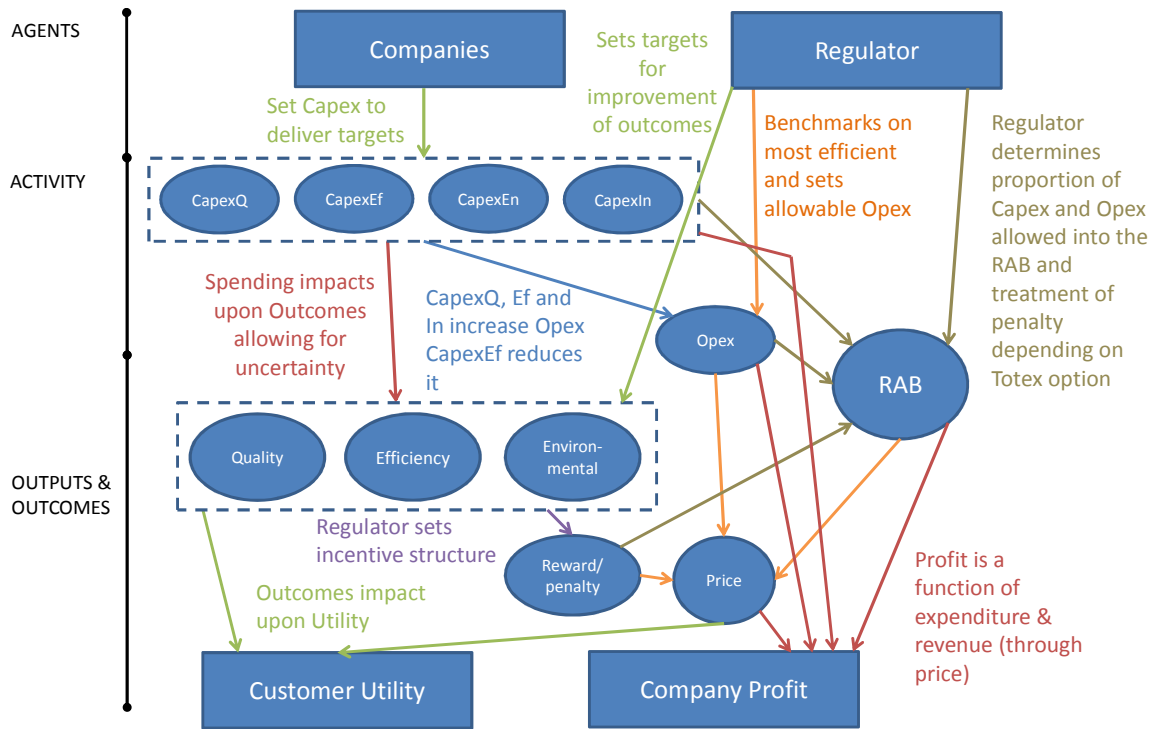
The base model provides the counterfactual for the analysis reported in this document, which evaluates the effects of

- different forms of customers' utility functions
- options proposed by Ofwat for the outcome delivery incentive
- outcomes delivered over more than one regulatory period.

The structure of the model is shown in the diagram on the following page.

¹ Reports on the first two phases of work were distributed to sponsors and Ofwat. A non-confidential version of the first report is to be found at <http://www.indepen.uk.com/news-and-publications.html>

² www.ofwat.gov.uk/Price_Review › [Price review 2014](#) › [Wholesale](#)



Throughout the report we have used upper case for the first letter of variables and behavioural types in the model.

3 Main elements of the model

3.1 Agents, decisions and relationships

The model contains behavioural dimensions relating to risk appetite, attitude to regulatory targets, and innovation. Risk appetite relates to a company's willingness to absorb the risk of missing a target and incurring a penalty; attitude to regulatory targets refers to whether companies are content to simply hit a target or whether they prefer to exceed them. We define a company as innovative if it is willing to spend on high risk projects which, if successful will deliver a better environment outcome and improve efficiency in the longer term.

This allows for eight behavioural combinations (2 risk appetites x 2 attitudes towards targets x 2 attitudes to innovation). In discussing the results we have focused on two extreme types – Risk Neutral Satisficers and Risk Averse Emphasisers, each with and without a propensity to innovate.

The agents we have modelled and the decisions they make are

- Companies, which decide the amount of their capex to be devoted to each of the outcomes and whether to spend on innovative projects (IN)
 - Quality (Q)
 - Environmental Improvements (EN)
 - Efficiency (EF)
- The regulator which decides
 - Quality, Environmental and Efficiency targets
 - Allowed Opex
 - How much Capex and Opex to allow into the RCV
 - Price cap
 - The size and symmetry of Penalties and Rewards, whether they are PAYG or into the RCV and whether to allow trade-offs between the Environment and Quality outcomes.
- Customers – who do not make decisions in this model but are the recipients of the outcomes that result from the decisions of the regulator and the companies.

We assume that certain key relationships are not known with certainty by the agents.

- Capex → improvements in Quality and Environmental outcomes and Opex efficiency
- Innovation capex → pay off
- Price, Quality and Environmental Improvement → changes in Customer Utility

As with any model the assumptions drive the results. The assumptions we have made have been the subject of extensive debate with senior people in the sponsoring companies and Ofwat as well as in the consultancy team. They have been refined over three rounds of modelling and the model has been calibrated to give results that are in feasible ranges, according to the participants.

3.2 Innovation

If a company is innovative, it has an additional type of Capex – CapexIN. We have modelled this as being, on average, 10% of total Capex. CapexIN is zero if the company is not innovative. We have assumed that CapexIN goes into the RCV in the same way as other types of Capex and that it affects the Environmental Outcome.

The expected outcome of CapexIN is a gain in the Environmental Outcome. While the expenditure pays off on average, we have modeled the actual outcome as being subject to uncertainty with

- 50% probability that nothing is achieved
- 25% chance of breaking even
- 25% chance of achieving 5 times the average level of improvement.

The expected outcome is therefore equal to $50\% \times 0.0 + 25\% \times 1.0 + 25\% \times 5.0 = 1.5$

If a company spends £100 on Innovation, on average it would expect to achieve improvements in the Environment outcome that are 'worth' £150 but there is considerable uncertainty around this result so that on half the occasions, the £100 will be lost, in a further quarter of times the company will break even, securing benefits worth £100, and in the remaining quarter of cases, the company will benefit from improvements worth £500.

As a simplification and to make the effect of innovation more visible in the results, we have limited the effect of innovation to Environment. This is not necessarily realistic and should be borne in mind when considering the results.

3.3 Delivery incentives

Delivery incentives consist of Penalties and Rewards related to under and over achievement of the Quality and Environment outcomes. The model allows their value to be linked either to the cost of delivery for the company or to the value to customers of the outcome.

In line with the Ofwat options, the model allows for one-sided (Penalties only) and two-sided (Penalties and Rewards) incentives and the possibility of trading-off penalties and rewards between the different outcomes.

The Ofwat options and the way we have treated them in the model are described in the box below. To distinguish between Options A4 and A5 we have removed the possibility of implicit trade-offs, such that with multiple outcomes a company could trade-off between a Reward on one and a Penalty on another, even if Ofwat did not explicitly sanction this. Ofwat's Appendix has more detail on Option A4 and suggests it could involve assessing the overall impact of individual Rewards and Penalties (i.e. implicit trade-offs would be enabled). This is distinguished from A5, which has explicit trade-offs between specific outcome measures, in part by the way in which the relative values of the outcomes are identified. Ofwat notes the relative weights could be more judgmental in Option A5. We have not attempted to model a judgmental approach and so have modelled A4 with the specific restriction that Rewards would not be allowed unless there were no penalties. This removes the possibility of implicit trade-offs.

Option A5 – Trade-offs and Rewards (as well as penalties). We sum the two Rewards/Penalties to get the overall Reward/Penalty - i.e. if both are penalties there is a big penalty; if one is reward and one penalty the sum can be positive or negative; and if both are rewards there is a big reward.

Option A3 – Trade-offs: no Rewards. As above but if the sum is positive the Reward/Penalty is set to zero - i.e. the Reward can be offset against any Penalty but Reward left over does not count.

Option A2 – No Trade-offs: no Rewards (penalties only). Sum the two penalties. With under-achievement on both there will be a big penalty; under-achievement on one returns the penalty irrespective of the other outcome; and if there is overachievement on both the result is zero.

Option A4 – No trade-offs: Rewards allowed. If a company gets penalties or rewards on multiple outcomes they are summed to give a large penalty or reward. If it fails on one target it gets a penalty and even if it overachieves on the other, the reward is lost as the two cannot be offset.

In the base analysis of the model, the rewards and penalties are estimated based on the cost of delivery for the companies. We have considered the sensitivity of the results to valuing improvements in terms of their utility to customers and this is discussed in 4.1.

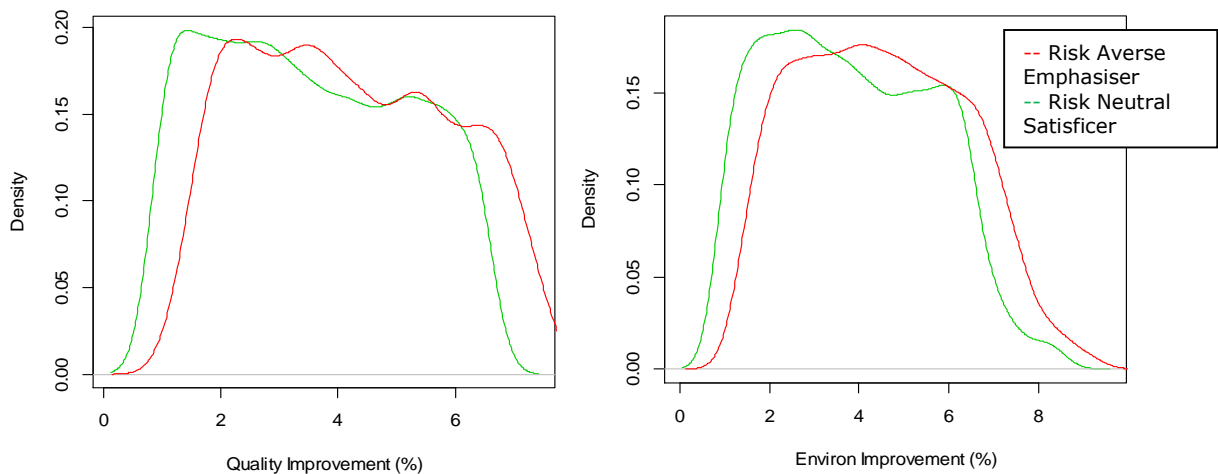
4 Results

In summarising the results, we have focused on Risk Averse Emphasisers (usually shown in red in the charts showing the results) and Risk Neutral Satisficers (usually green), and Innovators (blue) and non-Innovators (purple) as these company types deliver the most widely divergent and interesting outcomes.

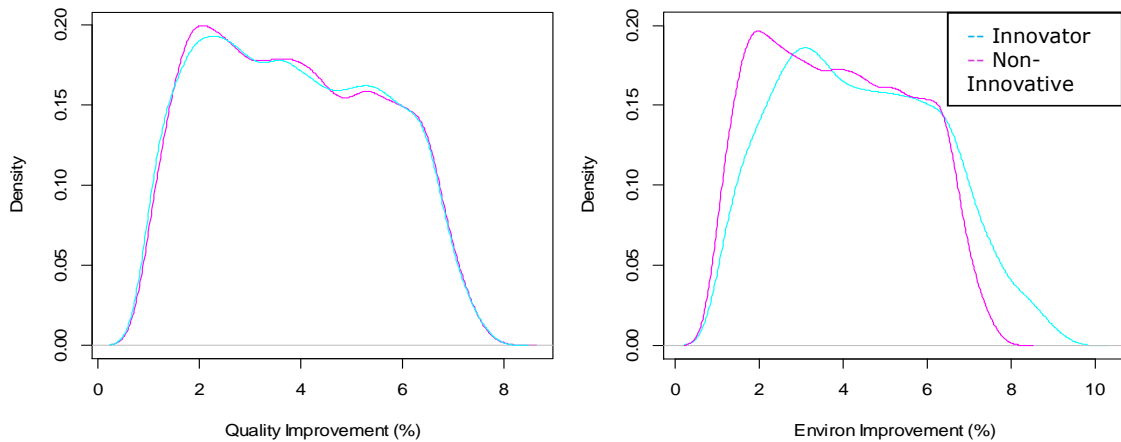
4.1 Outcomes and utility

Outcomes

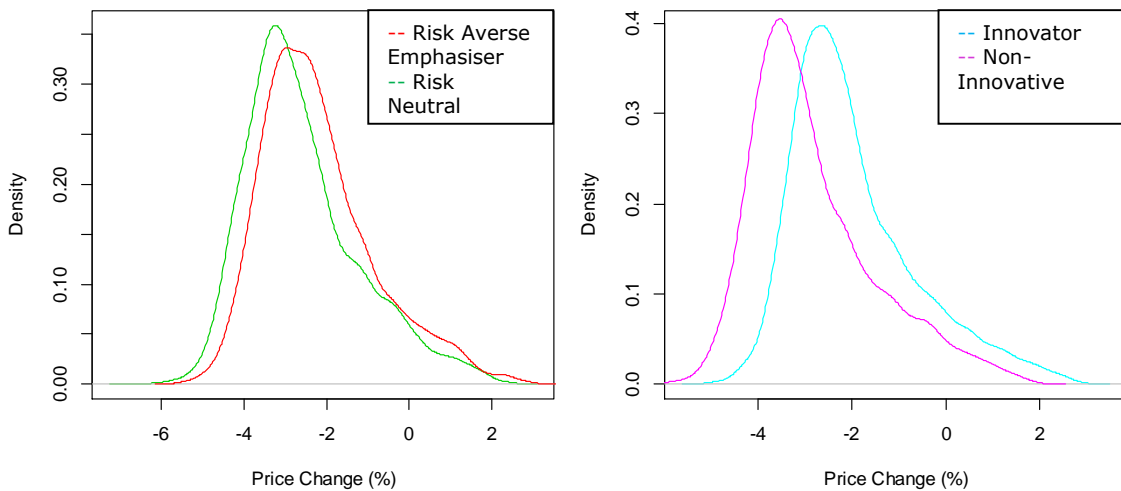
Risk Averse Emphasisers (red) are companies that wish to hit or surpass their targets and will spend more than the average company to give them a better chance of doing this. These companies deliver greater improvements in the Quality and Environment Outcomes than do Risk Neutral Satisficers (green). These aim to hit targets set by the regulator and absorb the risk that they will not.



Innovators direct a proportion of their expenditure to Capex that is focused on Innovation and yields uncertain but potentially large improvements in the Environment outcome. Environment outcomes are better from Innovative companies (blue) than those that do not Innovate (purple). As modelled, the Quality outcome does not depend on Innovation. This is shown by the graphs on the following page.



Risk Neutral Satisficers spend least. On average they deliver smaller Quality and Environment improvements and larger price reductions than Risk Averse Emphasisers. Innovators spend more, giving smaller price reductions than non-Innovators. A proviso here is that these results are from the one period model, where Innovation costs money to deliver and has no longer-term effect on efficiency. Payoffs from Innovation in the longer term are considered briefly in 4.5.

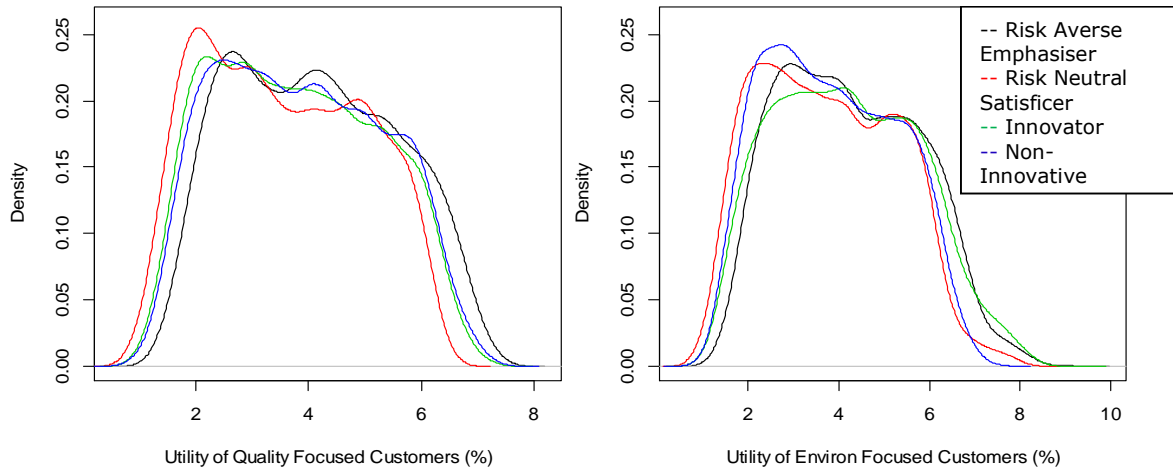


Utility

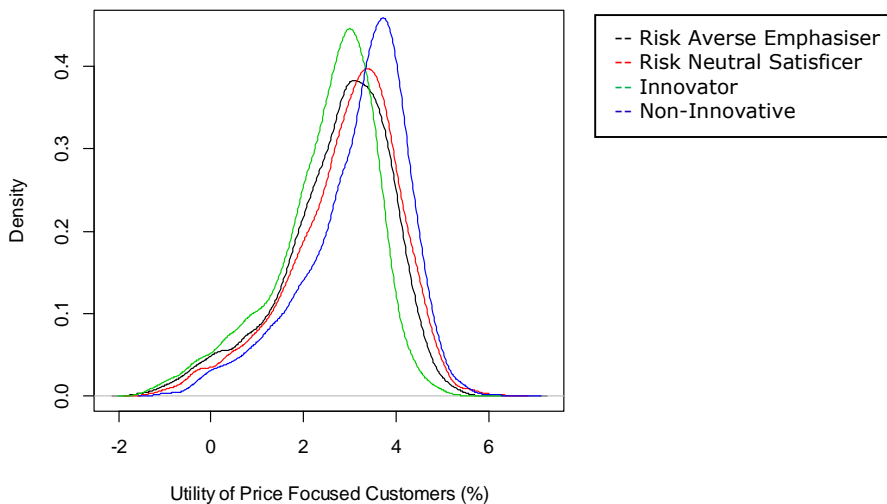
We evaluate outcomes for three types of customers – price sensitive, quality focussed and environmentally minded. In our base analysis, the three utility functions are each linear with customers placing 80% of their weight on Price, Quality or Environment respectively and 10% on each of the other two outcomes. This section considers customers who have a specific focus on certain outcomes in the short-term. In 4.5 we consider the utility of customers who have a short-term interest in price and a longer term interest in future Quality and Environment.

Our analysis shows that Quality focused and Environment minded customers do best with Risk Averse Emphasisers (the black lines in the charts below) and do worst with Risk

Neutral Satisficers (red). Environment minded customers' utility is higher with Innovative companies (the green line in the right-hand chart below). This is because we have assumed that innovation expenditure affects the Environment outcome.



In the one period model price sensitive customers get bigger utility improvements from companies that spend least – i.e. Risk Neutral Satisficers and companies that do not spend on Innovation (the red and blue lines in the chart below). They get the lowest utility improvements from Innovators which achieve the smallest price reductions because of their higher levels of spending.



It is important to note that these results are for a one-period model in which we have assumed that Innovation costs money and there is insufficient time to allow the efficiency payback for innovation to accrue. We discuss varying this assumption in 4.5.

4.2 Non-linear utility

We have considered how sensitive the results are to our assumption about the form of the utility function. Based on the linear utility function in a one period model, where customers place 80% of their weight on either Price, Quality or Environment and 10% on each of the other two factors, Price sensitive customers are best served by companies that spend least (Risk Neutral Satisficers and non-Innovators) and Quality focused and Environment minded customers are better served by Emphasisers and Innovators.

Still focusing on one period, we have compared the outcomes achieved under the base case as described with two non-linear utility functions. The three cases are

- Base Case: customers place 80% of their weight on either Price, Quality or Environment and 10% each on the two other factors
- Variant 1 "Equal weight": customers place 80% weight on their primary factor if that factor starts in the bottom quarter, and otherwise place equal weight (33%) on all factors
- Variant 2 "Shift focus": customers place 80% of their weight on their primary factor if that factors starts in the bottom quarter and switch that weight equally to the other two factors if not. So, a price focused customer where price was not in the lower quartile would switch to placing 10% weight on price and 45% each on Quality and Environment.

Emphasisers usually deliver greater utility improvements for customers who are not price focused but the size of the improvement is sensitive to the form of the utility function, as shown in the table.

Utility improvement	Price Focused Customer	Quality Focused Customer	Environ Focused Customer
UTILITY FUNCTION - BASE SCENARIO			
Risk Averse Emphasiser	2.70%	4.10%	4.30%
Risk Neutral Satisficer	2.90%	3.60%	3.80%
Innovator	2.00%	3.80%	4.20%
Not Innovator	2.90%	3.90%	3.80%
UTILITY FUNCTION - VARIANT 1			
Risk Averse Emphasiser	3.60%	4.10%	4.10%
Risk Neutral Satisficer	3.50%	3.70%	3.80%
Innovator	3.40%	3.80%	3.90%
Not Innovator	3.70%	3.90%	3.90%
UTILITY FUNCTION - VARIANT 2			
Risk Averse Emphasiser	4.10%	3.40%	3.50%
Risk Neutral Satisficer	3.70%	3.40%	3.50%
Innovator	3.90%	3.20%	3.30%
Not Innovator	3.90%	3.70%	3.70%

In Variant 1, Quality focused and Environment minded customers are better served by Emphasisers but those customers partly off-set the additional utility from the Environ Outcome achieved by Innovators against the higher prices they pay and the utility result is similar from Innovators and Non-Innovators. Price sensitive customers are no longer best served by Satisficers, because they partly off-set the small price reductions against improvements in other outcomes.

In Variant 2, customers shift their focus if their primary factor does not start in the bottom quarter (Quality and Environ shift to Price and vice versa). In this case, the relationships between utility and company type are less clear, with Price sensitive customers off-setting their price reductions with improvements in Quality and Environment which means they are best served by Emphasisers, and Quality and Environment focused customers off-setting improvements in those outcomes for reductions in Price, meaning that they are better served by non-Innovators.

Unsurprisingly, introducing non-linearity makes it difficult to draw general conclusions about which sort of company delivers the best utility improvements for the various customer types. It remains the case, under the assumptions we have tested, that companies that spend least usually achieve higher profits, implying that the simplified PR09 regime as we have modelled it incentivises companies to satisfice.

While we have not modelled endogenous behaviour change, it is reasonable to expect that under these rules, other company types will shift to become more like Risk Neutral Satisficers. As such they will make smaller Environment and Quality improvements. Evidently, different relationships between outcome delivery and cost performance incentives could produce different results but so far, we have not modelled these.

As stated in Ofwat's WPL document³, it is necessary to calibrate incentives so that there is a close link between the value of the incentive and the value of the benefit it delivers. This is what proportionality means. The results reported here suggest that the position will be sensitive to the form and parameters of the utility functions and that it will be difficult to generalise about the design of proportionate delivery incentives. This implies a premium on gaining a better understanding of the determinants of utility.

4.3 Rewards and penalties

Default model

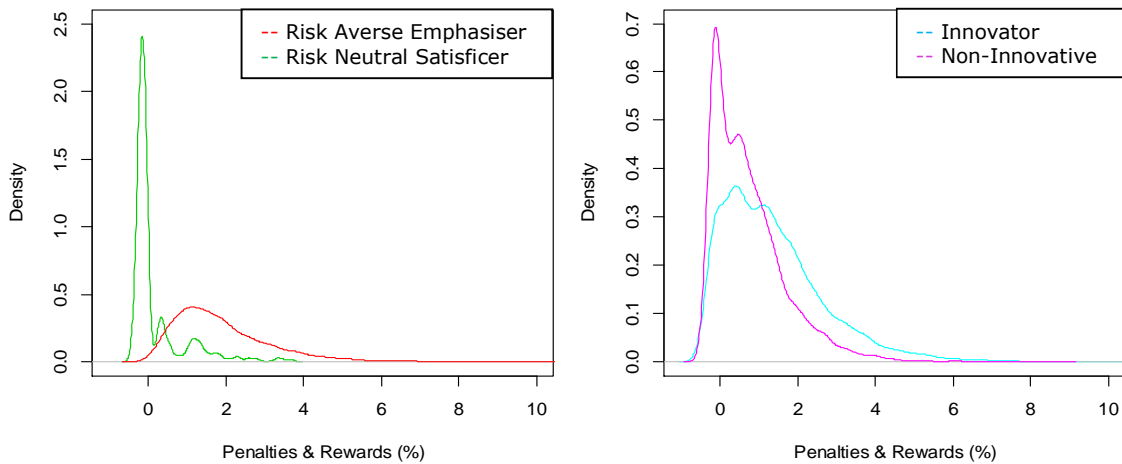
Based on discussion with the participants, our default model assumed rewards that would be one third the size of penalties. This is a modelling assumption and reflected participants' observations about the relative value of rewards and penalties in the regime. It was not based on any evidence or belief that customers' willingness to pay for improvements would have such a relationship with the value of outcome reductions.

On this assumption, even though Risk Averse Emphasisers and Innovators receive significantly higher Rewards than Risk Neutral Satisficers (which typically get Penalties)

³ P45 Wholesale Price Limits

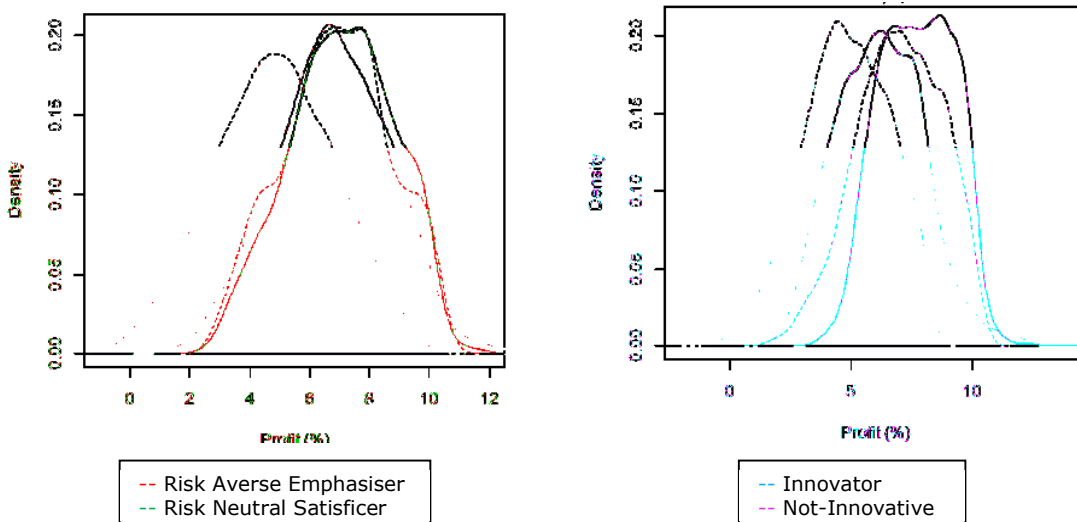
Profits (after Rewards/Penalties) on average are higher for the Risk Neutral Satisficers.

The charts show that Risk Neutral Satisficers typically achieve a penalty for underachieving targets and that the range of this is quite narrow (green line in the left-hand chart). Risk Averse Emphasisers have a wider distribution of outcomes – achieving reasonable rewards on average (red line). Similarly Innovators are likely to achieve higher rewards (blue line in comparison with purple line in right-hand chart).



The next set of charts shows how net profits are affected by penalties and rewards. Base profits (before penalties and rewards) are on average higher for Risk Neutral Satisficers than Risk Averse Emphasisers (dotted green line further to the right than dotted red line). Penalties and Rewards narrow the difference but it remains significant (the full red line moves closer to the green but is still on average lower). The same is true for Innovators (purple and blue lines in the second chart below).

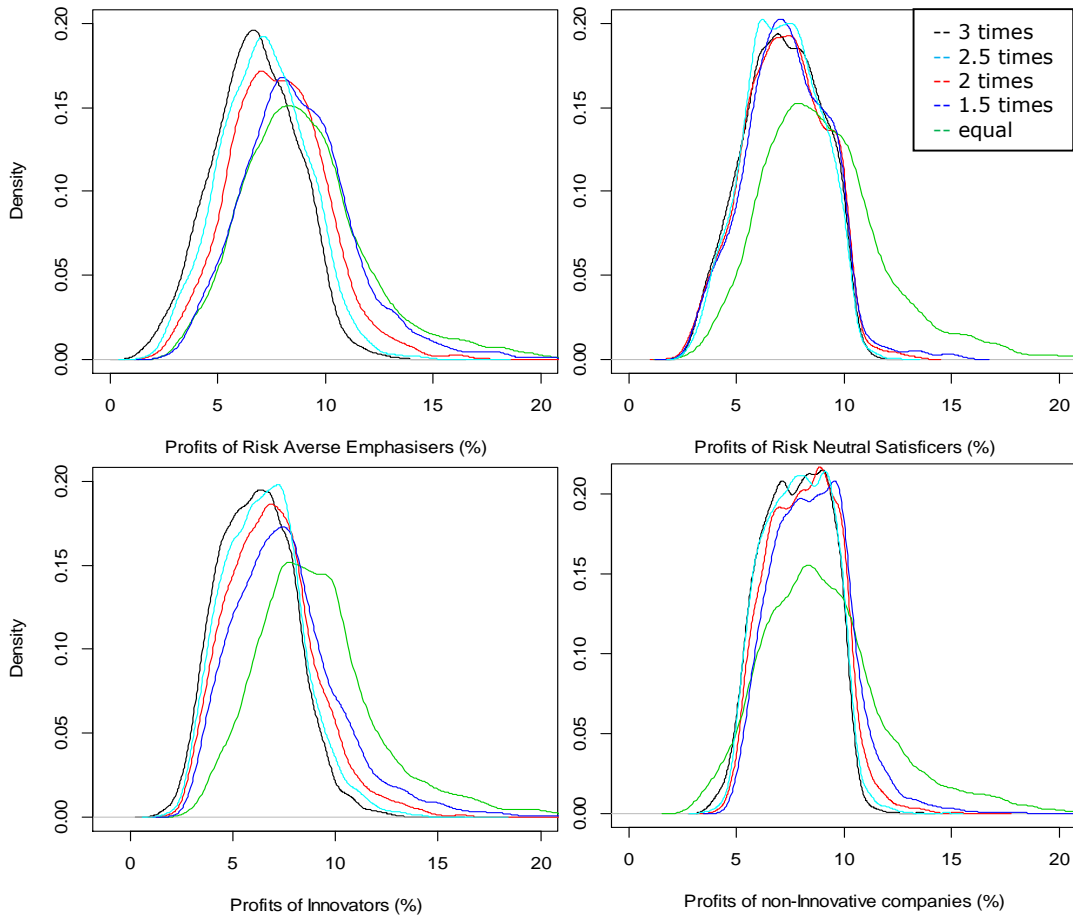
Considering likely behavioural changes, on the assumption of a ratio of 1 reward to 3 penalty, Risk Averse Emphasisers might switch to behaving more like Risk Neutral Satisficers and companies that innovate might innovate less. Such changes would reduce the level of the Quality and Environment outcomes over the long term. If Innovation would decrease costs in the long term, Prices are likely to rise more in the longer term if companies stop innovating.



Higher Rewards

We looked at the effect of varying the size of the Rewards. If Penalties are 3x the size of rewards then companies that do not provide the best utility get higher profits, in other words the Reward is not proportionate to the outcome.

The table and charts below show the average profits achieved by different company types depending on the relative size of the Penalties and Rewards allowed. Setting penalties equal to rewards equalises the payoffs, making them similar for the different company types.



Relative size of => Penalties and Rewards	3x	2.5x	2x	1.5x	equal
Risk Averse Emphasiser	6.7%	7.2%	7.8%	8.8%	9.1% ⁴
Risk Neutral Satisficer	7.1%	7.1%	7.2%	7.4%	9.1%
Innovator	6.2%	6.5%	6.9%	7.6%	9.1%
Not Innovator	7.7%	7.8%	8.1%	8.5%	9.1%

⁴ The profit for all companies is 9.1%. There are differences but these are not statistically significant.

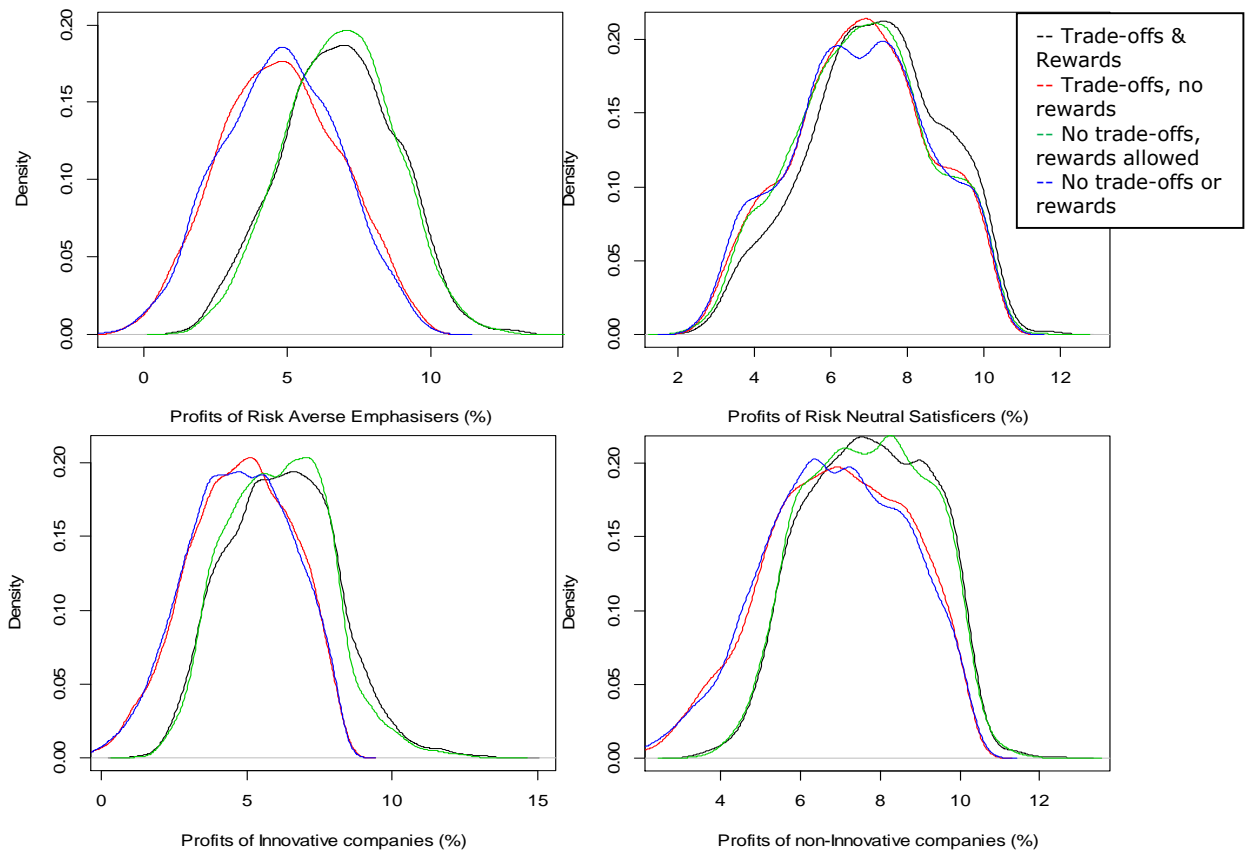
4.4 Trade-offs between outcomes

We tested the effect on outcomes of Ofwat's options for trade-offs and rewards.

- Trade-offs provide limited negation of risk but do not significantly increase Profits.
 Rewards make a significant difference to companies' ability to make higher Profits, when delivering better Environment and Quality outcomes, even given higher spending.
- Allowing both trade-offs and Rewards gives the highest financial incentive for outcome oriented behaviour.

The implications are that Under Option A2 Risk Averse Emphasisers might switch to Risk Neutral Satisficing behaviour and Innovator behaviour would become less rewarding. Option A5 (trade-offs and Rewards as well as Penalties) gives the highest financial incentives for outcome oriented behaviour and limits the risk to companies most effectively.

These results are illustrated in the charts below. The option allowing trade-offs and rewards typically delivers the highest profits for company types that deliver better Quality and Environment Outcomes (the black lines in the left-hand charts below). The option where rewards are allowed, without trade-offs also enable companies that deliver better Quality and Environment Outcomes to achieve higher profits (green lines).



4.5 Inter-temporal considerations

Changing customer preferences

In 4.1 we considered customers who have a short term focus on certain outcomes in a one period model. In this section, we consider the case where customers' interests shift over time towards the Quality and Environment outcomes. The table illustrates the utility improvements for various preferences.

Average Utility increase	100% Price	75% Price 25% Quality & Environment	50% Price 50% Quality & Environment	25% Price 75% Quality & Environment	100% Quality & Environment
Risk Averse Emphasisers	2.3%	2.8%	3.4%	3.9%	4.5%
Risk Neutral Satisficers	2.7%	2.9%	3.2%	3.5%	3.7%
Innovators	2.0%	2.6%	3.1%	3.7%	4.2%
Not Innovative	2.9%	3.2%	3.4%	3.7%	4.0%

Customers with a more than 50% focus on Price are best served by Risk Neutral Satisficers. As the balance of their preferences shifts towards Quality and Environment they become increasingly well-served by Risk Averse Emphasisers.

When we consider Innovation, the switching point is at a higher level (75%) for Innovators as they spend more than Risk Averse Emphasisers and deliver smaller price reductions. By assumption Innovation does not affect the Quality and cost (Price) outcomes and only customers with a more than 75% focus on Quality and Environment are better served by Innovators. The assumption may be unrealistic and this area may repay further consideration.

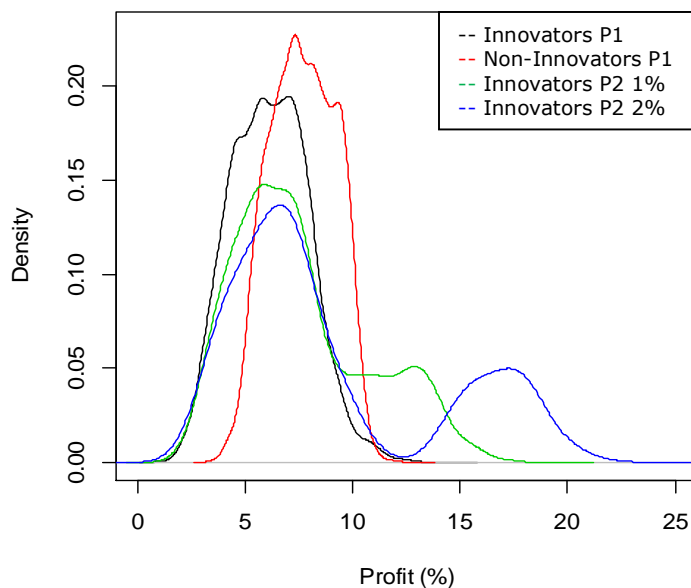
The long term pay-off to Innovation

In a one period model where Innovation costs money and achieves uncertain outcomes the incentive structure as modelled does not encourage Innovation.

We have explored the size of longer term benefits of Innovation that would be needed to make Innovators more profitable. The chart shows multi-period results for Innovators and non-Innovators compared with the base case one period outcome.

- The black and red lines show the profits achieved by Innovators and non-Innovators in the one period model. This shows that the cost of innovation is not fully offset by the rewards.
- The green line shows the profits of Innovators in period 2, assuming that if their Innovation broke even in period 1 then it would reduce future costs by 1% and if it paid off five-fold in period 1 then as well as delivering better Environmental outcomes it would reduce future costs by 5%.
- The blue line shows the scenario with double the rate of future cost savings.
- The table shows the average and range of profits achieved under the different assumptions.

In the one period model Innovators typically have lower profits than non-Innovators but factoring in the benefits of future savings provides the potential for larger profits in future periods, although on the assumptions we have adopted, average profits are still lower for Innovators than for non-Innovators.



The table shows the average and range of profits achieved in periods 1 and 2. In the one period model Innovators typically have lower profits than non-Innovators. When we consider future savings, Innovators have the potential for larger profits although on average, their profits are lower than those of non-Innovators. Evidently, the crucial assumptions are the size and timing of the pay-offs to innovation.

Profits	1st quartile	mean	median	3rd quartile
Innovators P1	4.80%	6.10%	6.10%	7.40%
Non-Innovators P1	6.50%	7.70%	7.70%	8.90%
Innovators P2 w 1% future saving	5.20%	7.60%	6.90%	13.40%
Innovators P2 w 2% future saving	5.40%	9.00%	7.20%	13.40%

In reality we do not face two periods and so spending on Innovation now may have benefits over a much longer term future. Whilst the incentive structure as modelled does not appear to reward innovative behaviour in the short term, it may be that some companies would choose this option.

4.6 Implications of Totex

We tested the impact on outcomes of Ofwat's scenarios around Totex and PAYG/RCV penalties. We note that there is regulatory precedent for both sorts of treatment of penalties.

We found that moving from the PAYG to the RCV treatment of Rewards and Penalties gives lower Profits for Risk Averse Emphasisers and Innovators in the short term which, other things being equal, might discourage this behaviour. In the long term it could pay off through the RCV: we have not explored the conditions for this.

We found that moving to a Totex approach did not alter materially the results for outcomes, compared with the default model. The simplified financial aspects of our model may not capture any existing Capex bias and might mean that that it is not the most appropriate tool for evaluating the effect of the Totex options.