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# Risk, regulation and behavioural modelling

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# Executive summary

The right incentives are vital to the success of economic regulation. Without them, companies may act in ways that are contrary to the regulator's aims, which may be contrary to the interest of consumers and in the longer term to those of the companies themselves and society more widely.

The modern science of behavioural economics is being used increasingly by marketing departments and advertising agencies to understand consumer behaviour. David Cameron has created a policy unit in the Cabinet Office to draw on its insights.

These ideas are just as relevant to the behaviour of companies and regulators. Indepen and Volterra have recently undertaken research into the use of behavioural economics and agent based modelling to help design better incentives. The work was focused on the water industry and, the results so far suggest it is very useful Two examples of benefits are: The process of developing the model involved explicit consideration of motivations and responses. This was an interactive process involving the modelling team and senior people from the regulator and the regulated businesses. The process provided a constructive basis for dialogue and improved understanding of how incentives will work.

- The model and the interaction that was involved in its creation and use allow for experiments on incentive designs at no risk to customers and investors. This will be of particular value when regulatory reform is under consideration and there is a need to develop incentive packages that are consistent with better and risk-based regulation.

These benefits have the capacity to change how regulatory engagement and incentives work and if it is applied effectively, will help to reduce regulatory risk and unintended consequences, creating better outcomes for customers. Modelling of this kind will be of value wherever relationships between incentives and outcomes are complex so that enhanced understanding from both sides is needed to ensure that unexpected outcomes do not occur.

The art of behavioural modelling is to create a model sufficiently realistic to be useful and sufficiently simple for the results to be understood. The balance is key to engagement which in turn is essential to creating a strong regulatory framework with the right incentives.

An article in the September 2011 *Harvard Business Review* by Gokce Sargut and Rita Gunther McGrath summarises these and other benefits of our approach

- Better risk mitigation for both companies and regulators:

  - Limits the need for accurate forecasts in an uncertain world by enabling us to explore those policies which are robust and generate benefits across a range of outcomes

- Allows companies and regulators to get a handle on potential unintended consequences of regulatory change

- Makes sense of a situation

  - By focusing on the key relationships and how they interact, we cut through the complications which prevent us from seeing the wood from the trees

# Introduction

The purpose of this note is to describe the work that Indepen and Volterra have recently undertaken to assess the use of behavioural modelling to improve our understanding of reactions to regulation in the water industry, and inform the way in which regulatory incentives are designed to deliver the sector's objectives. This is work in progress but the results so far suggest this is a promising route to exploring regulatory relationships and structures, providing a form of quantitative evaluation of their effectiveness and the basis to structure engagement between regulators and companies.

Regulatory decisions can influence company policy to different extents and in different ways. Without the right incentives, companies may act in ways that are contrary to the regulator's aims, which may be contrary to the interest of consumers and in the longer term those of the companies themselves and society more widely. It is clear that the framework within which regulation happens is of paramount importance and, for both regulators and firms, understanding the possible ramifications of different regulatory decisions and incentives is vital to creating an effective system.

At a general level, the critique of incentives takes a number of forms.

- The incentive discourages potentially beneficial cooperation between sector participants, for example the lack of any incentive for cooperation between NR and OCs to improve capacity availability on the network.
- The incentive is not dynamic reflecting regulatory thinking that is static or single period. This may encourage short term solutions rather than solutions that would be optimal over time – end of pipe capex rather than upstream opex initiatives in water.
- The incentive encourages a downgrading of customer service, for example rail operators opted to cancel trains rather than run delayed services during the adverse weather conditions in winter 2010.
- The incentive does not encourage innovation – targeting specific solutions rather than leaving it to the service providers.

All of these issues and others move us away from the optimal solution for which regulator's aim. Factors leading to non-standard reactions and unintended consequences include the following.

- Complex motivations. Companies' decisions are affected by constraints and motivations other than short-term profitability. By this we mean not just the well known agency problem but a series of other incentives deriving from ownership, financial structures, internal governance and reward arrangements and various forms of "constrained rationality"
- Uncertainty, combined with search costs, about a number of issues including
  - the current situation and the consequences of decisions
  - how incentives will be implemented and changed in future
  - the actions of others that may affect outcomes.

- The involvement of other players, not just companies and their regulators. In infrastructure sectors and services, the behaviour of stakeholders and customers can profoundly influence outcomes.
- The extensive presence of externalities. These mean a wide divergence between private and social costs and benefits.

If these problems were not present we might achieve a better result as shown in Figure 2. In reality the situation described in fig. 3 is far more likely.

**Figure 2: Virtuous process of regulatory decision**

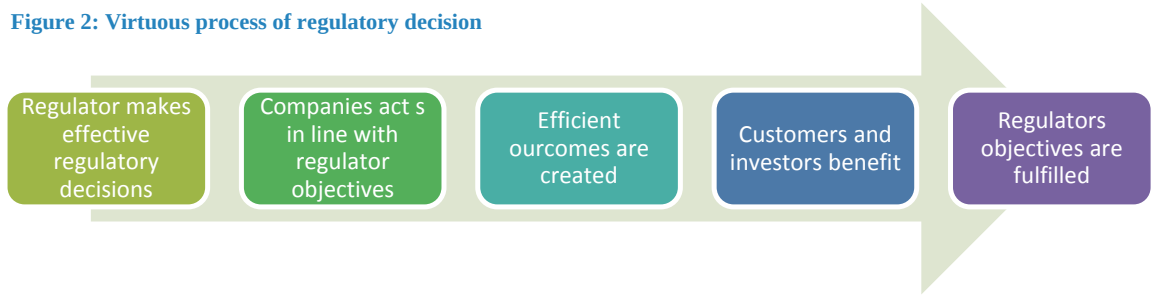
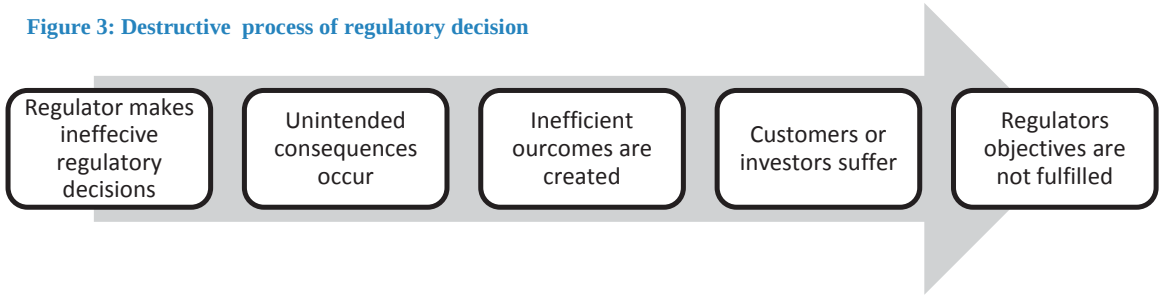



**Figure 3: Destructive process of regulatory decision**




The modelling we have conducted and described in this paper highlights areas which need to be considered for change within the regulatory system and acts as a constructive aid to effective engagement on the issues.

# Background

## Behavioural economics

Behavioural economics is the study of economics using social, cognitive and emotional factors in understanding economic decisions of agents. This is in contrast to the conventional approach to economic analysis which assumes perfectly rational agents who will always maximise their own utility. Behavioural economics admits that in practice many agents will make decisions through social learning (copying) or may hold personal views on the desirability of adopting a particular mode of behaviour, these are instances of "bounded rationality". For example some companies will be more or less risk averse due to a belief held by management as to what is the best course of action, not just as a reaction to a profit function which they may not have the knowledge to predict accurately. In many situations behavioural economics can allow us to assess the reality of economic decisions more accurately than standard economics.

This thinking is becoming popular with government as behavioural factors, such as bounded rationality among customers, are recognised in economic and policy decisions. This is indicated by the establishment of the Behavioural Insight Team (Nudge Unit), lead by David Halpern and initiatives such as the introduction of a compulsory organ donation question in driving licence applications. So far little work of this flavour has been done on the topic of economic regulation and the regulated infrastructure industries. The work by Indepen and Volterra shows that this is an area worth further investigation, particularly given Government's focus on infrastructure and conditions in the capital market.

## Behavioural modelling

Behavioural modelling seeks to model the outputs from a system of rules and relationships between economic agents. It determines the rules from empirical evidence and or discussion with the relevant parties, this therefore acknowledges the motivations and constraints which behavioural economics recognises as part of the way in which economic decisions are made . In most cases the rules or principles could not be used directly as part of any conventional analysis. This is because the traditional profit maximising model does not allow for what it would class as "irrational" behaviour. This is any behaviour which is not profit maximising, instead it is based on beliefs which influence actions. For example a belief could be that copying another agent is likely to bring about the best result, or that a company ought to stick to the most risk-averse path.

Behavioural modelling is valuable because it will cover more of the potential outcomes of an action than does conventional analysis. If the constraints and motivations affecting economic agents are significant determinants of behaviour, using conventional analysis will not suffice. In infrastructure this could mean that significant investment was wasted, reputations were damaged or customers were adversely affected.

## Agent based modelling

We used a technique known as agent based modelling. We chose this because it allows us to define a set of relationships and map out how decision makers interact and the outcomes this creates. This allowed us to create a model that was simple enough to be understood and used in engagement, while reflecting reality to a sufficient extent to provide useful results.

The elements of an agent based model include

- defined agents
- decision rules and interactions between agents based on characterisations of behaviour
- a representation of key factors that are outside the model
- specification of uncertainty in the relationships.

In the case of modelling regulatory decisions and incentives we believe this may be able to create a model which is sufficiently realistic to be useful and sufficiently simple to be understood. Achieving the right balance between simplicity and realism is important.

# The water regulation model

Indepen and Volterra have recently conducted a project with a group of water companies. It has given promising results, which were presented at a seminar with Ofwat in June 2011. A **paper** [Risk, regulation and behavioural modelling of water company performance] describing the approach was published in July 2011.

The purpose of the project was to explore the feasibility of using behavioural modelling to inform the design of water regulation, especially the incentives set by Ofwat which may currently have unintended consequences. It was funded by three water and sewerage companies, Anglian, Severn Trent and Wessex. Representatives of the companies formed a steering group for the work of which a director of Ofwat was also a member. This enabled us to create a model with reasonable, supported assumptions from both sides.

The model has as its 'agents' the regulator, water companies and customers. There are different company types defined by their attitudes to risk and quality. The regulator sets the output target for each company. We characterised the output as quality improvement, but in further analysis the target could relate to any other output or to several, for example efficiency and quality. The different company types make different decisions on how much they spend to try to meet this target. Given spending decisions and consequent quality improvements, the regulator assigns a penalty or reward for each company.

A key feature of the model is the inclusion of uncertainty. We have said that the quality improvement delivered by a given amount of capex is uncertain and we have modelled the starting points of the individual companies, in terms of initial quality level and relative efficiency, are drawn randomly from a fixed range. Simulation works by running the model many times with the random elements varying. Running the model enough times results in a frequency distribution of outcomes.

Our sponsors found the model reflected reality and allowed us to inform the answers to questions including the following.

- What is the effect of regulator decisions on company profitability?
- What is the effect of regulator rules and changes therein on customer utility?
- How big is the effect of variation in company behaviour on customer utility?

The model has enhanced our understanding of the outcomes of regulation and shown that feasible differences in company and customer preferences and behaviour, combined with a one size fits all approach to regulation can have potentially unintended consequences. It has also highlighted that the incentive package is not necessarily aligned with how policy objectives are described.

The understandings we have gained so far suggest the use of this model not only as an assessment tool and a counterfactual for further modelling, but also as a vehicle for engagement. The localism agenda, the increasing diversity between water companies and Ofwat's proposed changes to regulation admit of more diverse and tailored company and regulatory approaches and outcomes. Given these developments, the potential benefits of this sort of modelling are likely to increase.

This work is relevant not just to the water industry but in many areas of regulation where complex relationships exist. For example the approach could be of use in engagement between National Rail and the rail operators to look at network capacity, OFGEM and the DNOs and many other relationships; they key is creating a structure in which constructive engagement can then take place and modelling of this kind has a contribution to make.

# Other applications

We are considering further applications of three kinds.

- Extensions of the existing water model
- Application to other sectors
- Applications involving other parties

Evidently, there is scope for extending the existing water model, including the following.

- Reverse engineering; we can use this type of model to identify the extent of any change in a "policy" variable that would be needed to generate a given outcome.
- Sensitivity analysis; the model can be used to examine the sensitivity of customer utility or any other variable to changes to variations in the assumptions, behavioural factors and relationships.
- Analysis of alternative objectives
  - Innovation
  - Efficiency targets
  - Investment targets
  - Customer experience

- Use as a counterfactual for analysis of alternative incentives set by regulators. This may be of particular interest to sectors which may be reconsidering the way in which incentives are set, at this moment in time this seems most applicable to rail and water.

Potential applications of behavioural modelling in the regulated sectors more widely may be numerous. We would welcome opportunities to explain what we have done and discuss applications in other sectors.

The scope of this approach does not end with regulators and companies: it might be used in considering how to align incentives within companies and also in interactions with stakeholders and customers.