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Evaluating Negotiation-Based Approaches in the Context of Danish Utility Regulation

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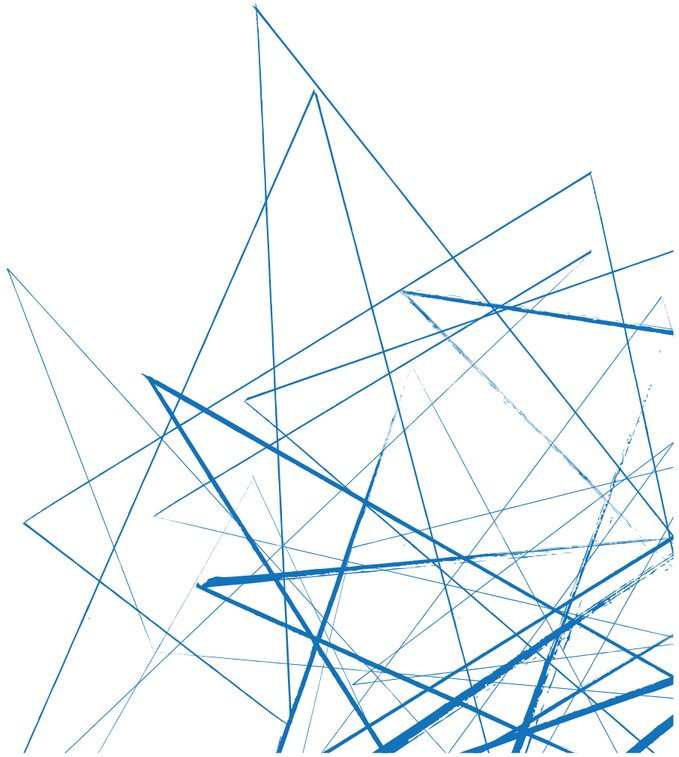

PhD Series 16.2021

Anita Eskesen

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EVALUATING NEGOTIATION-BASED APPROACHES IN THE CONTEXT OF DANISH UTILITY REGULATION

CBS PhD School | **PhD Series 16.2021**

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HANDELSHØJSKOLEN

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Evaluating Negotiation-Based Approaches in the Context of Danish Utility Regulation

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Preface

This thesis is the result of my PhD studies at the Department of Economics at Copenhagen Business School. I am grateful to the *Danish Utility Regulator*, the *Danish Energy Agency*, the *Danish Ministry of Climate, Energy and Utilities*, and *Copenhagen Business School* for jointly funding this work.

In addition, I'd like to take this opportunity to extend my sincere thanks and gratitude to the following:

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Abstract

This thesis consists of four self-contained chapters concerning utility regulation. Chapter 1 compares four different regulatory frameworks in terms of how they each prioritise three overall goals of contract design: coordination, motivation, and minimisation of transaction costs. Prioritising one objective may come at the cost of assigning a lower priority to another objective. While revenue-cap regulation can be said to minimise transaction costs, at the same time, it assigns a lower priority to coordination of production, i.e. ensuring that the right combination of outputs is produced compared to consumers' preferences. Conversely, the frameworks that explicitly incorporate stakeholder engagement or negotiation prioritise coordination of production while assigning a lower priority to minimisation of transaction costs and information rents.

Chapter 2 focuses on the trade-off between rent extraction and service differentiation. Consumers in different regions may prefer different service levels and service mixes. The services provided should therefore ideally be aligned with the preferences of the regional consumers. The utilities, however, have superior information about the cost of different services. This allows them to extract information rents by claiming high cost on the provided services. Relative performance evaluation in the form of benchmarking is typically used to limit the information rents, but benchmarking is less efficient when service profiles are heterogeneous. Hence, there is a trade-off between minimising the information rents and maximising the adjustment to consumer preferences via service differentiation. The chapter studies this trade-off in a simple principal-agent model and discusses how the trade-off may limit the usefulness of recent regulatory frameworks based on dialogue and negotiations with utilities about which services to provide.

Chapter 3 evaluates different ways to address issues with the current regulation of Danish electricity distribution networks that have been pointed out by the regulated industry.

Amongst other suggestions, the industry argues that regulation is too focused on economic efficiency instead of maximising value to customers and that electricity DSOs are not sufficiently incentivised to support the green transition. The evaluation of the different ways in which regulation could be adjusted is based on how the options affect the three overall goals of contract design. While the option of introducing a negotiation-based regulation, as suggested by the industry, has the advantage of being able to address the issues, it is also associated with a number of disadvantages. For example in terms of higher transaction costs and potentially higher information rents. Therefore, it may be more appropriate to address the issues in a different way. Specifically, the chapter considers alternatives in the form of new cost-drivers, application procedures or mandated flexibility tenders as alternatives that address the issues but likely at a smaller increase in transaction costs.

Chapter 4 investigates the value and costs of subjective information in utility regulation and the implications it may have for the structure of an optimal incentive scheme. Specifically, the chapter compares findings from the literature on managerial bonus pools to an example from the regulation of transmission networks in Great Britain, the Environmental Discretionary Reward Scheme, which illustrates the applied use of a bonus pool that incorporates subjective information about companies' focus on environmental issues. The comparison shows that the costs of relying on subjective information in utility regulation are likely lower than in principal-agent relationships where the principal faces incentives to renege on compensation promises. Nevertheless, the regulatory example bears some similarities to the incentive schemes that are found to be optimal under the assumption that the principal faces an incentive problem. Such characteristics may however reflect pragmatic considerations associated with the use of bonus pools in practice, for example in regard to increasing perceived fairness of the performance evaluation.

Resumé (Abstract in Danish)

Denne afhandling består af fire selvstændige kapitler, der omhandler regulering af forsyningsselskaber. Kapitel 1 sammenligner fire forskellige typer af regulering med hensyn til, hvordan de hver især prioriterer tre overordnede mål for kontraktdesign: Koordination, motivation og minimering af transaktionsomkostninger. Når et mål opprioriteres, kan det samtidig medføre, at et andet mål nedprioriteres. Hvor en indtægtsrammeregulering kan siges at minimere transaktionsomkostninger, tillægger den samtidig en lavere prioritet til koordination af produktion, som er et udtryk for overensstemmelse mellem forbrugernes præferencer og den producerede kombination af services. De typer af regulering, som eksplicit anvender interessentinddragelse eller forhandling, prioriterer omvendt koordination af produktion, men nedprioriterer samtidig minimering af transaktionsomkostninger og informationsafkast.

Kapitel 2 fokuserer på afvejningen mellem informationsafkast og servicedifferentiering. Forbrugere i forskellige områder kan have forskellige præferencer for niveauet og kombinationen af services. De leverede services bør derfor, ideelt set, tage højde for forbrugerens præferencer i de forskellige områder. Forsyningsselskaberne har dog bedre information om omkostningerne ved at levere de forskellige services. Det giver dem mulighed for at tjene et informationsafkast, da de kan hævde, at de leverede services er forbundet med høje omkostninger. Relativ performanceevaluering i form af benchmarking bruges typisk til at reducere informationsafkast, men er mindre effektivt, når serviceprofilerne er heterogene. Der må derfor foretages en afvejning mellem minimering af informationsafkast og maksimering af tilpasningen til forbrugernes præferencer gennem servicedifferentiering. Kapitlet belyser denne afvejning i en simpel principal-agent model og diskuterer, hvordan afvejningen af de to hensyn kan begrænse anvendeligheden af reguleringstyper, som er baseret på dialog og forhandlinger med forsyningsselskaber om den leverede kombination af services.

Kapitel 3 evaluerer forskellige tilgange til at adressere problemstillinger, som er påpeget af den regulerede industri, i den nuværende regulering af danske eldistributionsselskaber. Industrien fremfører blandet andet, at reguleringen fokuserer for meget på økonomisk effektivitet i stedet for at skabe værdi for kunderne og ikke giver selskaberne tilstrækkelig incitament til at understøtte den grønne omstilling. Evalueringen af, hvordan reguleringen eventuelt kan justeres, er baseret på påvirkningen af de tre overordnede mål for kontraktdesign. Industriens forslag om at indføre en aftalebaseret regulering kan adressere de påpegede problemstillinger, men er også forbundet med en række ulemper. For eksempel i form af højere transaktionsomkostninger og potentielt højere informationsafkast. Det kan derfor være hensigtsmæssigt at adressere problemstillingerne på en anden måde. Specifikt overvejer kapitlet muligheder i form af nye cost-drivers, ansøgningsprocedurer eller pålagte udbud af fleksibilitetsydelser som alternativer, der kan adressere problemstillingerne, men formentlig vil medføre en mindre stigning i transaktionsomkostninger.

Kapitel 4 undersøger værdien og omkostningerne ved at inddrage subjektiv information i reguleringen af forsyningsselskaber og de implikationer, det måtte have for det optimale incitamentsprogram. Specifikt sammenligner kapitlet resultater fra litteraturen om bonus puljer i virksomheder med et eksempel fra reguleringen af transmissionsselskaber i Storbritannien, 'the Environmental Discretionary Reward Scheme', som illustrerer anvendelsen af en bonus pulje i praksis, der inddrager subjektiv information om selskabers fokus på miljømæssige hensyn. Sammenligningen viser, at omkostningerne ved at basere reguleringen af forsyningsselskaber på subjektiv information sandsynligvis er mindre end i andre principal-agent forhold, hvor principalen kan have incitament til ikke at opfylde sit løfte om betaling. Ikke desto mindre har det regulatoriske eksempel nogle elementer til fælles med incitamentsprogrammer, som anses for optimale, når det antages, at principalen har et incitamentsproblem. Sådanne elementer kan dog være udtryk for pragmatiske hensyn forbundet med anvendelsen af bonus puljer i praksis, såsom at øge opfattelsen af retfærdighed i performanceevalueringen.

Contents

Introduction

The natural monopoly status of utility companies, such as operators of electricity, gas, and water networks, is a potential source of economic inefficiencies. If left unregulated, such companies could potentially charge consumers prices well above the costs of production. This motivates utility regulation. A central question for utility regulators is then: how to provide the regulated companies with good incentives, for example incentives to improve efficiency, produce high-quality outputs, innovate, invest sufficiently, etc. In turn, the provision of incentives affects the prices paid by consumers and the services they receive.

The ways in which regulators approach their objectives, such as promoting high efficiency and security of supply, sometimes differ across countries and jurisdictions. In the US, utility regulators in each state (the public utilities commissions) have traditionally followed a process whereby utilities, in practice, are left alone unless they propose price increases, which would prompt a rate review. Traditionally, the rate review involved a formal hearing, similar to a trial, where the utility must demonstrate that its proposed rates are just and reasonable, expert witnesses are cross-examined and exhibits are presented. The regulator then assesses the evidence, which is used to determine the different variables that affect allowed revenue and the price structure, and makes its decision (Krieger, 1995).

The nominal prices between rate reviews were originally supposed to remain constant unless approved by the regulator. Joskow (1974) accounts for the developments in US state utility regulation during the 1950s and 60s and refers to the regulatory process as being 'extremely passive'; regulators take no action regarding prices unless initiated by the firms. In theory, prices should reflect the cost of service, i.e. prices are set so that total revenues equal total costs, including a fair return on investments. In practice, however, since prices are only adjusted at rate reviews, the actual rate of return earned by the utilities at any point in time may be above or below the level determined by the regulator (Joskow,

1974). By the late 1960s, higher levels of inflation and rising nominal interest rates led to increases in nominal production costs and debts, which in turn triggered a large number of firms to request rate reviews in order to increase their prices. The US state regulators did not have the staff or administrative resources to deal with the increasing number of rate reviews. Combined with a growing pressure from environmental groups and other consumer advocates, this generated a need to change the regulatory approach. The resulting changes included automatic inflation adjustments, among other mechanisms.[1]

As a way of expediting the large number of rate cases, many states appointed consumer advocates during the 1970s and 1980s and began to use settlements between consumer advocates and utilities as either a supplement or an alternative to the existing regulatory process (Krieger, 1995; Littlechild, 2009b). Some US state regulators thus use settlements as additional evidence to be considered in the formal hearing, while others use settlements in place of the formal hearing. Littlechild (2009b) describes the typical rate review in Florida as beginning with the utility applying for a rate increase or the regulator ordering a review, which may be pushed by the consumer advocate or other parties. By demonstrating a substantial interest in the case, interested parties, such as the consumer advocate or customers and competitors, can be accepted as interveners in the case, which allows them to file testimony to the regulator and to challenge other testimonies. The role of the regulator has thus changed. Where the regulator was previously responsible for representing consumers' interests, the regulatory staff are now required to be impartial when balancing the interests of the utility, the consumer advocate, and other interested parties (Littlechild, 2009b).[2]

Meanwhile, in most other countries, the traditional process has been kept in place, whereby the utility regulator is responsible for safeguarding consumers' interests, typically without direct engagement of consumers. Different types of regulation have been applied over time to target different problems. To avoid overcompensating companies, regulators have set allowed revenue equal to total cost. In this way, the company can always cover its costs but has no incentives to improve efficiency. This type of regulation is known as cost-of-service regulation. Alternatively, the regulator could fix allowed revenues (or prices) at a given level and allow the company to profit from lowering its costs below the allowed

[1]See Joskow (1974) and Krieger (1995) for comprehensive reviews of the changes to the regulatory process

[2]See also Doucet and Littlechild (2009) and Littlechild (2009a, 2012a,b) for a series of papers documenting the process and role of consumer advocates in negotiated settlements in the US and Canada

level. This provides strong incentives to improve efficiency but may leave the companies with high profits. This type of regulation is known as price-cap or revenue-cap regulation. Over time, price-cap regulation has experienced growing support as an alternative to cost-of-service regulation. However, regardless of the regulatory framework, regulators have generally maintained a role of balancing the interests of consumers and utilities without directly involving consumers or consumer advocates in the regulatory process.

However, Hahn, Metcalfe and Rundhammer (2020) report that over the course of the last decade, utility regulation has experienced a paradigm shift from a regulator-focused to a more customer-focused regulation. In a European contest, examples of this shift can be found in the British regulation of gas and electricity networks (RIIO), where utilities are required to carry out a stakeholder engagement programme, and in the regulation of Scottish Water, which is based on direct negotiations between Scottish Water and a Customer Forum. Nevertheless, the differences between US and European regulatory practices are still noticeable. In contrast to the US, where negotiated settlements in some states can replace the formal hearing, the British regulators have maintained their decision-making power. The motivation for introducing stakeholder engagement also appears to differ. Negotiated settlements were initially introduced in the US to expedite a large number of cases, whereas in Great Britain, stakeholder engagement was strengthened to increase value to consumers and improve the perceived legitimacy of regulation by letting stakeholders influence the regulatory outcomes (Ofgem, 2010b; Water Industry Commission for Scotland, 2013). Accordingly, utility regulators in the US introduced settlements with an aim of reducing transaction costs, whereas the introduction of stakeholder engagement initiatives in Great Britain contributes to increasing transaction costs, cf. Chapter 1. Moreover, whereas the US state utility regulators process rate reviews on a case-by-case basis, the British (and other European) regulators usually review cases for all utilities simultaneously, at regular time intervals in a pre-determined regulatory period. Also, the regulatory framework and associated mechanisms typically apply to all utilities in a given sector, whereas the US case-by-case processing may lead to more diversity and flexibility in the mechanisms applied across cases.[3]

[3]For example, Littlechild (2009b) reports that settlements in the Florida electricity sector have changed the regulatory approach from a rate-of-return regulation to a fixed-price approach, and later again to other incentive schemes

According to Joskow (2014), cost-of-service regulation evolved as the preferred regulatory approach in US utility regulation while price-cap regulation gained support in the UK and globally after Littlechild (1983) developed the idea. Nevertheless, regulatory practices often combine elements from different types of regulation. Accordingly, a widespread type of regulation is the price-cap mechanism combined with elements from cost-of-service regulation and yardstick regulation, which specifies the allowed revenue of a firm to depend on the costs of identical firms. This also applies to Danish Utility Regulation. However, perhaps inspired by the RIIO framework, the Danish utility sector has recently shown interest in a negotiation-based framework as outlined below.

The Danish Utility Regulator regulates the national electricity and gas transmission system operator (TSO), three gas distribution companies, around 40 electricity distribution companies, and around 400 district heating companies. Water and wastewater companies are regulated by the Danish Competition and Consumer Authority. The regulatory framework differs from sector to sector. Traditionally, the economic regulation of all Danish utility companies followed a cost-of-service regulation, where companies are allowed to recover actual costs including a fair return on investments. While the transmission system operator, the district heating companies, and the smaller water companies are still regulated by a cost-of-service regulation, the other sectors are now regulated by a revenue-cap regulation combined with elements from cost-of-service regulation and efficiency benchmarking.

In 2016, the Danish government proposed that all sectors gradually move towards an incentive-based economic regulation which in broad terms resembles the regulation of the Danish electricity distribution sector (The Government of Denmark, 2016). The government at the time further suggested considering whether it would be appropriate, over time and under certain conditions, to employ a "negotiation-based" regulation. This is described as a more flexible regulation based on negotiations between the regulator and regulated companies on their business plans for the coming regulatory period with a fall-back option in case an agreement cannot be reached. Specifically, the framework is seen as a way to facilitate solutions customised to the individual companies, thereby creating the basis for achieving additional efficiency improvements while securing the right investments.

The regulated industry also sees opportunities for improving regulation along these lines. Specifically, the industry has criticised current regulation for being inflexible and for focus-

ing too much on efficiency improvements as opposed to other aspects that create value to consumers. Moreover, regulation is considered retrospective in the sense that allowed revenue depends on historical accounting figures instead of expected future costs and investments.[4] Moving towards a negotiation-based regulation is seen as a solution to these problems. The suggested new direction in regulation has also been described as "forward-looking", "agreement-based", and "dialogue-based". The common denominator appears to be a regulation that relies less on historical data and more on expected future developments, where allowed revenue is determined less mechanically and instead allows for negotiations/agreements/dialogue between the regulator and each of the companies to affect regulatory outcomes.

Following the expressions of interest from several parties in developing a new regulatory framework, the Danish Utility Regulator set up the present PhD project with an overall aim of developing an understanding of the merits and drawbacks of a negotiation-based regulation. The thesis pursues this aim by investigating which theory can be used to study the subject and which insights can be gained from coupling theory and practice.

Deciding on the most appropriate type of utility regulation is complicated since it involves balancing different, often conflicting, considerations. The attempt to address one problem often leads to new problems. For example, while a price-cap mechanism improves efficiency incentives compared to a cost-of-service regulation, it may be costly in terms of sub-optimal risk-sharing and/or higher costs of administering regulation, depending on the specific arrangement. The magnitude and relative importance of such problems depend on the particular context. In some contexts, the most important objective may be to improve efficiency incentives while in other contexts, a different concern, such as ensuring that consumers' preferences are taken into account, may be the most important objective of the regulation.

Therefore, the priority assigned to different objectives seems essential for the choice of regulatory framework in a given context. To assess, in a structured way, how different types of regulation prioritise different objectives, the thesis relies on a framework for contract analysis, developed by Bogetoft and Olesen (2004), which is based on findings from the literature

[4]For example, these views appear in publications by Copenhagen Economics (2018) and Danish Energy (2018)

of economics of organisation and transaction cost economics.[5] The framework consists of a hierarchy that organises the various aspects to consider, when designing a contract, within three overall objectives: coordination, motivation and minimisation of transaction costs. Together, these objectives contribute towards the overall goal of the regulator; to maximise social welfare, i.e. taking into account consumers' surplus and rents earned by the firm.

The coordination objective concerns coordination of production and coordination of risk. Coordination of production ensures that the right combination of outputs is being produced by the firms compared to what consumers would prefer, given what is feasible on the production possibilities frontier. Coordination of risk is concerned with minimising the costs of risk. Motivation is about incentivising effort and sufficient investments while ensuring that companies are willing to participate in the contract. Transaction costs can be described as the costs of providing solutions to the problems of coordination and motivation. The objective of minimising transaction costs therefore often conflicts with the objectives of coordination and motivation.

The objectives covered by the hierarchy comprise both the provision of incentives, which is the primary focus of agency theory, but also coordination aspects and minimisation of transaction costs, which are important aspects of contract design in practice. In this way, the hierarchy combines both theoretical and practical aspects of contract design, which are also relevant for the design of utility regulation. The trade-offs between coordination, motivation, and minimisation of transactions costs therefore provide a strong starting point for studying multiple effects of different types of regulation and play a central role in the thesis, as reflected in the following chapters.

Chapter 1, *"A Contract Design Perspective on Balancing the Goals of Utility Regulation"*, compares four different regulatory frameworks in terms of how they each prioritise these three objectives. Specifically, the current revenue-cap regulation of the Danish electricity distribution sector is compared to three other regulatory examples, which can be characterised as negotiation-based or forward-looking: the British regulation of electricity and gas network companies (RIIO), the regulation of Copenhagen Airport, and the regulation of Scottish Water. By doing so, the chapter aims to explore the notion of a negotiation-based/forward-looking regulation, i.e. to clarify the mechanisms that make up these regu-

[5]See for example Milgrom and Roberts (1992) for a comprehensive coverage of central themes in economics of organisation and Williamson (1996) for the study of transaction cost economics

latory frameworks, and determine the benefits and drawbacks compared to a revenue-cap regulation.

As demonstrated by a number of examples in Chapter 1, prioritising one objective may come at the cost of assigning a lower priority to another objective. For example, the comparison suggests that the more forward-looking frameworks appear to prioritise coordination of production to a larger extent than revenue-cap regulation. These frameworks thus incorporate elements that aim at improving the alignment between consumers' preferences and outputs produced by the companies. At the same time, these elements increase transaction costs. Conversely, a revenue-cap regulation allows for standardised contracts that reduce transaction costs but also assign a lower priority to coordination of production. The relative importance of the different objective in each of the cases is justified by the prevailing circumstances that are specific to each context. The trade-offs that have been found optimal in one context may therefore not be optimal in a different context. Accordingly, the chapter does not intend to portray any of the studied frameworks as 'best practice'. Nevertheless, the chapter provides an overview of the different trade-offs associated with a large number of mechanisms used in practice, which may be useful to consider for regulators looking to change regulation in this direction.

Chapter 2, *"Balancing Rent Extraction and Service Differentiation"*, focuses on the trade-off between coordination of production and motivation, specifically the trade-off between minimising information rents and ensuring that the right combination of services is produced compared to consumers' preferences. When a utility regulation incorporates elements such as direct negotiations or stakeholder engagement, the services produced by each utility can be adapted to the preferences of consumers and other stakeholders in each of the license areas. This can lead to an improved alignment between consumers' preferences and the combination of services produced by utilities, which creates higher value to consumers. At the same time, it may complicate the cost comparison of different firms and increase the firms' information rents.

The chapter uses a principal-agent model to study a simplified example of the problem: a regulator must determine the remuneration and service mix of two utilities operating in two separate geographic areas. Consumers in one area prefer a service mix, which is different from the preferred service mix of consumers in the other area. The regulator would therefore

like the two firms to produce two different service mixes. However, the firms have private information about the cost of providing different services and may claim that the deviation from the other firm's production plan is associated with high costs, which would increase the price paid by consumers. The regulator is assumed to maximise the net value to consumers of a given production plan. It turns out that despite the different preferences of consumers, in some cases, it is optimal to let the two utilities produce the same service mix since the information rents associated with a differentiated service mix outweigh the added value to consumers. The results imply that the regulator should be cautious about allowing for specialised solutions. However, the results are sensitive to a number of assumptions, including the number of utilities and service dimensions.

Chapter 3, *"Negotiation-Based Regulation: The Next Step in Danish Utility Regulation?"*, looks more closely at the critique of the revenue-cap regulation brought forward by a group of larger Danish utilities. The utilities have pointed out a number of issues with the current regulation and suggested introducing a negotiation-based regulation as a way to resolve the issues. This chapter considers the feasibility of a negotiation-based regulation, in the given context, by comparing the industry's suggestion to alternative ways to address the issues. The advantages and disadvantages of different options are assessed based on how they each affect three overall objectives for contract design; coordination, motivation, and minimisation of transaction costs. In this way, Chapter 3 can be seen as a continuation of Chapter 1, but with a more specific focus on conditions relating to the Danish regulation of electricity distribution companies.

Introducing a negotiation-based regulation, as suggested by the industry, may address the issues but is also associated with a number of disadvantages, such as higher transaction costs and potentially higher information rents. Higher transaction costs may occur because of higher administrative costs and increasing influence activities. A particular pronounced manifestation of influence activities is the problem of soft capture, which refers to a situation where regulation is based on biased information produced by the utilities. To reduce the disadvantages of the suggested regulation, it may be more appropriate to address the issues in a different way. However, the costs and benefits associated with different regulatory policies are difficult or even impossible to quantify, which complicates the comparison. While the chapter discusses the industry's proposal and points to alternatives that are likely

associated with a smaller increase in transaction costs, it does not recommend any specific alternative. Instead, the paper sheds light on how the choice of regulation affects different objectives.

Chapter 4, *"Use of Subjective Information in Utility Regulation: Comparing Theory and Practice"*, is concerned with the regulator's use of subjective information when evaluating the performance of utilities. Subjective information may be valuable to include in a regulatory contract since it allows the regulator to take more aspects of a utility's performance into account. Thereby, subjective information can provide a more balanced view of performance. For example, objective information, such as accounting information, may not reflect a utility's environmental considerations, but the regulator may still wish to incentivise high performance on such aspects. However, in contrast to objective information, which is verifiable to third parties, such as a court, this is not the case for subjective information. In general, contracts based on subjective information therefore become vulnerable to incentive problems for both the agent and the principal. The agent's actions are unobservable, which causes a moral hazard problem on the part of the agent, but the principal may also face an incentive to misrepresent the agent's performance in order to minimise payments, which causes a moral hazard problem on the part of the principal.

The Environmental Discretionary Reward (EDR) Scheme, which applies to three electricity transmission networks in Great Britain, provides an example of how subjective information is used in utility regulation. The scheme takes the form of a bonus pool, which is distributed between companies on the basis of their performance in a number of aspects related to low carbon objectives and wider environmental benefits. Chapter 4 reviews the literature on discretionary bonus pools and compares the findings to the structure of the EDR scheme. A fundamental difference between the principal-agent relationships studied in the bonus pool literature and the context of utility regulation is that a utility regulator typically does not face incentives to renege on its compensation promises. In this situation, influence costs, uncertainty about measurement criteria, and the effect on perceived fairness may be more pertinent problems. Taken together, the comparison of theory and practice provides a review of potential cost and benefits associated with the use of discretion in the context of utility regulation.

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Chapter 1

A Contract Design Perspective on Balancing the Goals of Utility Regulation

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Abstract

Designing utility regulation involves trade-offs between different goals of contract design. Prioritising one objective may come at the cost of assigning a lower priority to another objective. This study compares four regulatory frameworks in terms of how they each prioritise different goals of contract design. While revenue-cap regulation can be said to minimise transaction costs, it also assigns a lower priority to coordination of production. Conversely, the frameworks that explicitly incorporate stakeholder engagement or negotiation prioritise coordination of production while assigning a lower priority to minimisation of transaction costs.

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1.1 Introduction

Economic regulation of natural monopolies can take various forms, as demonstrated by the nature of different practices that have prevailed over time, across sectors and countries. In a cost-based model, such as 'cost-of-service' or 'rate-of-return' regulation, the regulator will determine allowed revenue in such a way as to let companies recover actual costs, including a fair return on investments. This approach was developed in the US in the late nineteenth century, has been applied extensively across various sectors globally, and has remained common during the twentieth century. Towards the end of the twentieth century, incentive-based regulation gained support as an alternative to the cost-based models. In an incentive-based regulation, allowed revenue is decoupled from actual costs to provide strong incentives for cost-reduction.[2] A popular form of incentive regulation is RPI-X regulation. According to this remuneration formula, the prices or revenues earned by network companies are updated annually according to inflation and a factor X, which represents the annual target for efficiency gains defined by the regulator. The RPI-X approach is widespread across regulators and is also the foundation of the current revenue-cap regulation of Danish electricity and gas distribution companies. However, since allowed revenue is essentially mechanically determined and based on historical figures, the approach is sometimes considered inflexible and backward-looking.[3]

Expectations of substantial future changes in conditions that affect the role and operating environment of utility companies have, in some cases, led to a change in the regulatory framework and motivated a more forward-looking approach. In 2008, for example, the British regulator of gas and electricity networks (Ofgem) decided to review the RPI-X regulation in order to determine if it would be robust to future challenges. Among other matters, Ofgem feared that a continuation of RPI-X might not support the changing nature of energy network services and the associated uncertainty about which investments are necessary for the transition to a low carbon economy (Ofgem, 2009). Following the review, Ofgem adopted an approach which encourages production of outputs that are valuable to consumers, extensive stakeholder engagement, and innovation. Another development

[2]However, the difference between cost-based and incentive-based models may be smaller in practice than it is in theory, as discussed by Joskow (2014)

[3]In a Danish context, examples of this view appear in publications by Copenhagen Economics (2018) and Danish Energy (2018)

in this direction is seen in the regulation of Scottish Water, where a Customer Forum negotiates directly with the company to obtain an agreement on the company's business plan. The economic regulator of Scottish Water adopted this approach in 2015 in light of future challenges such as climate change, population growth, and migration along with customers demanding more tailored services and a toughening of financial and economic circumstances. The new framework aims to incentivise Scottish Water to understand and react to customers' priorities and thereby to pursue potentially better alternatives. A third related example of how customers' preferences can be better reflected in regulatory outcomes is the regulation of Copenhagen Airport, where airlines negotiate directly with the airport on the level and structure of charges that airlines pay to use the airport as well as service and capacity levels.

A regulation may be labelled "backward-looking" when it relies mainly or solely on historical data, such as accounting information. In turn, a regulation that relies on information, such as expected future costs and deliverables, may be labelled "forward-looking". For a regulation to be forward-looking, it is necessary to clarify and focus on what to achieve in the future. At the same time, in a changing environment, contracts are entered based on limited information about future circumstances. Among other issues, this uncertainty can affect risk-sharing arrangements in forward-looking contracts. This analysis illustrates how the prioritisation of goals in contract design differs across different regulatory frameworks. To this end, the study utilises the framework for contract analysis, developed by Bogetoft and Olesen (2004), that organises the various aspects to consider in a hierarchy with the following three overall goals of contract design;

i) Coordination

ii) Motivation

iii) Minimisation of transaction costs

Four regulatory frameworks are compared in terms of how they each prioritise these three goals of contract design. The four frameworks consist of the revenue-cap regulation of Danish electricity distribution companies along with three different cases that can be characterised as forward-looking; the regulation of Copenhagen Airport; the British regulation of electricity and gas network companies (RIIO); and the regulation of Scottish Water.

In particular, the comparison suggests that the more forward-looking frame-works prioritise the goal of coordinating production to a higher degree than revenue-cap regulation. The case descriptions indicate that a better alignment between consumers' priorities and companies' production possibilities was one of the motivating factors for introducing negotiated settlements and stakeholder engagement into the regulatory frameworks studied here. However, trade-offs between the three objectives imply that when assigning a higher priority to one objective, it comes at the cost of assigning a lower priority to other objectives. The study does not consider any of the regulatory practices to be 'best practice' but aims to uncover the prioritisations and resulting trade-offs associated with the different cases. The choice of whether to change the regulation will depend in part on the relative importance of the three objectives in a given context. The four cases can be seen to each represent a given set of circumstances that have affected the balancing of goals in each of the cases. The mechanisms employed in these settings may not be suitable under different circumstances, such as in different countries or under different development stages of the energy system or the regulatory framework. The chosen regulatory approach in a given case should thus be considered in light of the given circumstances.

The four cases selected for comparison have in common that the regulation applies to infrastructure providers in developed countries with well-established traditions for regulation. The cases, however, also vary in the type of infrastructure and the extent and means with which consumers' and other stakeholders' preferences are reflected in the regulatory outcomes. The revenue-cap regulation of Danish electricity distribution companies is an example of a widespread type of incentive regulation, where stakeholder engagement is not a central part of regulation. The regulation of Copenhagen Airport is characterised by effective user representatives in the form of airlines. In the other two cases, consumers' interests are represented by either the regulator, based on input from stakeholder engagement, or a Customer Forum. The four cases can thus be seen as different points on a spectrum of stakeholder engagement initiatives. In addition to achieving variation on this dimension, the frameworks were selected based on access to relevant information about the respective practices. Conversely, the cases are not selected with the aim to represent a broader range of regulatory cases. Therefore, conclusions cannot be extended to all cases of regulation that involve stakeholder engagement.

The article proceeds as follows; Section 1.2 briefly accounts for developments in the theory and practice of utility regulation. Based on the framework for contract analysis described in Section 1.3, four regulatory frameworks are compared and contrasted on different goals for contract design in Sections 1.4-1.7. Section 1.8 concludes.

1.2 Developments in Utility Regulation

After price-cap regulation gained support as an alternative to cost-of-service regulation,[4] price-cap mechanisms (in combination with elements of cost-of-service regulation and yardstick regulation) were introduced in several countries and have become the most popular form of incentive regulation globally (Joskow, 2014). In particular, Littlechild (1983) recommended the use of RPI-X regulation of British Telecommunications. The RPI-X approach has since become well known and adopted by regulators around the world for the regulation of different sectors, including electricity and gas networks. The RPI-X formula implies that average prices cannot increase more than the growth rate of the retail price index minus a target productivity growth, X. According to the RPI-X formula, the price-cap in period 1 is given by: $p_1 = p_0(1+RPI-X)$. In practice, the initial price-cap, p_0, is determined by some form of cost-based regulation (Joskow, 2008). The target productivity growth, X, for the individual firms can be determined by statistical benchmarking methods of their efficiency relative to comparable regulated firms. As noted by Joskow (2008), inefficient firms have incentives to move towards the efficiency frontier, and efficient firms are incentivised to stay on the frontier in a way that resembles yardstick competition. Under yardstick competition, the allowed revenue of the regulated firm depends on the costs of identical firms. Changes in circumstances that affect all firms identically do not invalidate the cost comparison. In terms of accommodating future uncertainties, yardstick competition may therefore have an advantage over RPI-X and cost-of-service regulation. However, pure yardstick competition is rarely used in practice.[5]

[4] See Acton and Vogelsang (1989)

[5] A DEA-based yardstick regulation, based on Bogetoft (1997), was introduced in 2007 by the Norwegian Water Resources and Energy Directorate (NVE)

1.2.1 Customer Engagement Initiatives

After years of advancing incentive regulation and the associated mechanisms, the focus has in some countries shifted from cost-reduction to investment and various dimensions of service quality (Joskow, 2014). This focus is also reflected in the cases reviewed in Section 1.2.2. Moreover, the cases demonstrate a greater focus on involving consumers and other stakeholders more explicitly in regulatory decision-making. This practice is sometimes referred to as 'negotiated settlements' and 'constructive engagement'.[6] In general, negotiated settlements refer to agreements reached via direct negotiations between regulated firms and their stakeholders, such as consumers or consumer representatives, on prices, investments, and service quality.[7] The regulator thus plays a reduced role in the decision-making process compared to a case where the regulator decides on revenue-caps while attending to the interests of consumers. The constructive engagement approach was introduced in 2005 by the Civil Aviation Authority, the regulator of UK airports, and has since spread to other UK regulators (Civil Aviation Authority, 2005; Littlechild, 2012a). One of the questions addressed by the CAA was how to enhance elements of the regulation through negotiation between airports and airlines so that outcomes would more closely reflect users' needs.

Without attempting a complete overview of all regulatory cases that focus on customer engagement, it is also worth mentioning the case provided by the Australian Energy Regulator as an example of how some regulators are looking into alternatives to the traditional regulatory approach in this regard. In June 2017, the Australian Energy Regulator agreed with Energy Networks Australia, representing the Australian energy network industry,[8] and Energy Consumers Australia, representing Australian energy consumers, to develop and trial a new regulatory process. Their vision was to ensure "that energy consumers' priorities and stated preferences drive energy network businesses' proposals and regulatory outcomes". The process is referred to as "New Reg: Towards Consumer-Centric Energy Network Regulation" and involves a pilot project, conducted by one of the Australian network companies, AusNet Services. The process entails the establishment of a Customer Forum to negotiate with the network company.[9] In this way, the process bears similarities to the Scottish Wa-

[6] See Littlechild (2012a) and Decker (2013)

[7] See Doucet and Littlechild (2006, 2009) and Littlechild (2009a, 2012b)

[8] Electricity distribution and transmission and gas distribution networks

[9] The background and draft process of the New Reg project is described in the approach and directions papers by Energy Consumers Australia, Australian Energy Regulator and Energy Networks Australia

ter case, outlined in Section 1.2.2, which is also characterised by negotiations between the regulated company and a Customer Forum.

Direct negotiations between firms and stakeholders allow the parties to make trade-offs across price-control issues as a package without having to agree separately on each issue (Decker, 2013; Littlechild, 2012a). Likewise, research on multi-attribute negotiations shows that it allows for the possibility of reaching "win-win" solutions, where both parties are better off because they can make trade-offs across different attributes.[10] This possibility is one of the advantages of the negotiation approach, which is highlighted by Littlechild (2012a). Littlechild further suggests that the time has come for UK regulators to learn from the developments in the US and Canada where utilities and customer groups negotiate settlements on regulatory issues. According to Littlechild, the advantages of negotiated settlements include that customers' interests are more directly reflected in regulatory decisions and the regulatory process is less burdensome since it is less time-consuming, less costly, and less uncertain compared to the conventional process. Moreover, the negotiated settlements have been more flexible, more innovative, better adapted to the needs of users and customers, and therefore preferred by both utilities and consumers to the previous outcomes of the conventional process.

While Littlechild encourages the UK regulators to learn from the US and Canadian experiences with negotiated settlements,[11] these lessons may not be transferable to utility regulation for most countries. As illustrated here, the choice between different regulatory frameworks entails trade-offs between different goals of contract design. The optimal trade-offs are likely dependent on specific conditions, such as a country's experience and tradition for engaging citizens in policy-making processes. The balancing of goals may, therefore, not only be the result of a deliberate consideration of relevant trade-offs, but is also affected by underlying circumstances specific to the regulatory context.

The four regulatory frameworks are: the regulation of Danish electricity distribution companies (revenue-cap regulation), the regulation of Copenhagen Airport (based on direct negotiations between the airport and airlines), the British regulation of electricity and gas network companies (RIIO), and the regulation of Scottish Water (based on negotiations

(2018a,b)

[10] See Lai, Li and Sycara (2006) for research on multi-attribute negotiations when the parties have incomplete information about each other's preferences

[11] See Littlechild (2008, 2012a)

between Scottish Water and a Customer Forum). The role of stakeholder engagement and negotiated settlements in RIIO and the regulation of Scottish Water has previously been studied by Hahn, Metcalfe and Rundhammer (2020), Heims and Lodge (2016) and Littlechild (2012a, 2014), among others. These studies discuss reasons to employ stakeholder engagement and negotiated settlements. They account for several related issues, including the regulatory processes involved, and the role of the regulator. This study compares the four frameworks in terms of how they each prioritise three different goals of contract design; i) coordination, ii) motivation, and iii) minimisation of transaction costs. The comparison is based on the hierarchy of goals for contract design developed by Bogetoft and Olesen (2004).

1.2.2 Four Regulatory Frameworks

This section reviews the main elements of four different regulatory frameworks that differ in how and to what extent consumers and other stakeholders are involved. Further details are reviewed in later sections when relevant.

Revenue-Cap Regulation of Danish Electricity Distribution Companies

The maximum allowed revenue of Danish electricity distribution companies is determined by a revenue-cap.[12] The revenue-cap consists of a cost-cap, an allowed return on investment, and several adjusting factors, as illustrated in Figure 1.1. The cost-cap is calculated as the average costs of the previous five-year period, adjusted with a price index, and indicators for changing activity levels. The cost-cap is thus independent of actual costs in the period. Likewise, allowed return on investments during the period is independent of actual investments in the period as the asset base is based on average assets of the previous period, adjusted for price developments, and factors such as activity levels. When transitioning to the next regulatory period, the cost-cap and asset base are recalibrated to reflect actual costs and investments during the period. The allowed return on investment is the sum of the return on the 'historical asset base' and the 'forward-looking asset base'. The historical asset base comprises the book value of investments that were put into operation in the year 2017 or

[12]The account given in this section is based on regulations no. 969 of 27/06/2018 (Danish Ministry of Climate, Energy and Utilities, 2018)

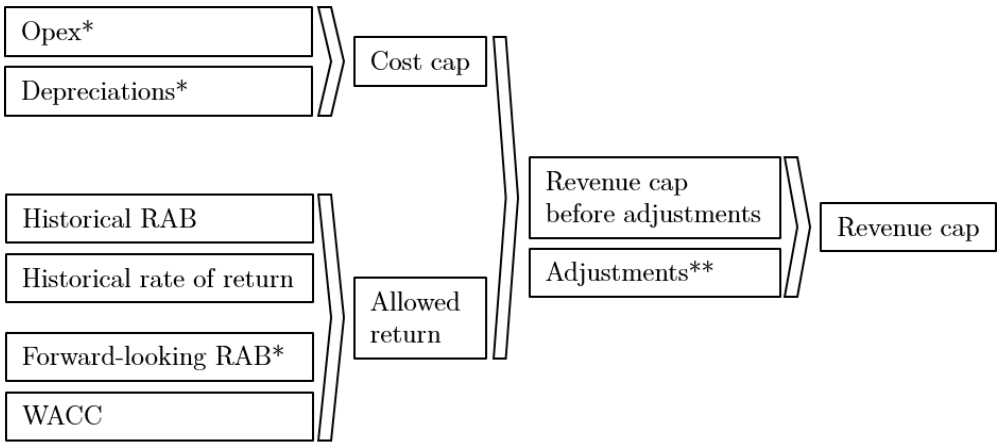
earlier. The forward-looking asset base is determined as the total asset base (the average, adjusted, asset base of the previous period) less the historical asset base. The historical and future asset bases yield different rates of return to reflect the regulatory conditions under which the investments were made.

Within the regulatory period, the cost-cap and the forward-looking asset base are subject to a number of different adjustments that reflect changes in conditions beyond the companies' control. These adjustments protect the companies from cost changes outside of their control by allowing for changes to allowed revenue during the regulatory period. The adjustments intend to encompass all conceivable uncontrollable circumstances that could lead to changing levels of costs and investment. Adjustments can be made either on application from the companies or by an automatic link to a price index or activity-indicators. The companies can apply for application-based adjustments to the revenue-cap in response to considerable cost increases resulting from a specified list of changing conditions, including the connection of new supply areas, replacement of overhead lines by underground cables, and changes in tasks. The companies are subject to both general and individual efficiency requirements. The general requirements are based on measures for labour productivity development in relevant Danish sectors, whereas the individual requirements are determined by total expenditure (Totex) benchmarking. The efficiency requirements lead to annual reductions in the next period's revenue-cap. Aside from efficiency requirements, the revenue-cap is reduced annually for factors such as insufficient quality of supply and the cost of grid losses.

Copenhagen Airport

Copenhagen Airport is considered a geographical monopoly and is there-fore subject to regulation by the Danish Transport, Construction and Housing Authority. The regulation of Copenhagen Airport is based on a negotiation between the airport and its operating airlines. The parties negotiate on the level and structure of charges that airlines pay to use the airport as well as service and capacity levels. Given the different profiles of airlines operating out of Copenhagen airport, the airlines may disagree among themselves about the relationship between charges and the associated service and capacity levels. All airlines do not necessarily have to approve of the agreement, but it must have some level of support.

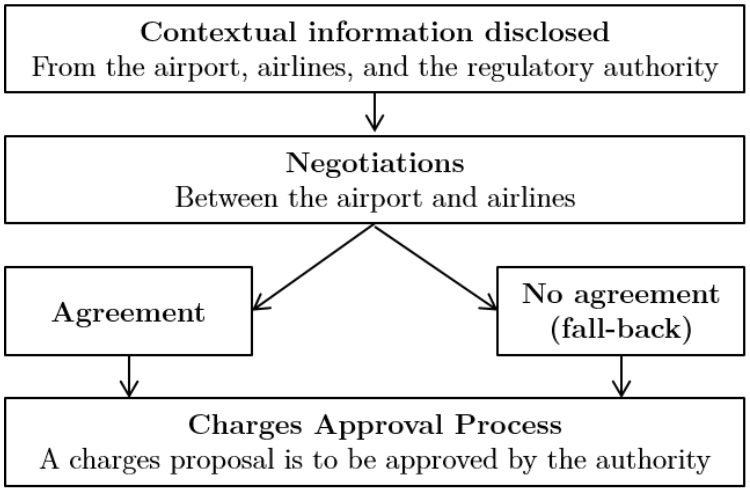
Figure 1.1: Main Elements of the Revenue-Cap



*Adjusted from the previous to the current period with several factors, including price index, activity indicators, changing tasks, and external factors
**Adjustments include efficiency requirements, penalties for factors such as insufficient quality of supply and costs of grid losses
Note: Figure 1.1 is based on regulations no. 969 of 27/06/2018 (Danish Ministry of Climate, Energy and Utilities, 2018)

When the airport considers an agreement to be sufficiently supported by airlines, it will present a charges proposal to the Danish Transport, Construction and Housing Authority. On a case-by-case basis, taking into account the proportion of airlines in support of an agreement, the authority then evaluates whether an agreement has been reached. If the parties cannot come to an agreement, a fall-back model, determined by the authority, will be used to determine the allowed revenues of Copenhagen Airport. The fall-back model is a revenue-cap model made up of a cost-cap that covers operating costs and depreciation expense, and an allowed return on invested aeronautical assets. Moreover, a fixed share of the excess return (return above 'reasonable return' as determined by the authority) from the commercial activities in the airport will lower the revenue-cap. During negotiations, the parties can, therefore, regularly assess the negotiated outcome against the expected outcome of the fall-back model. However, all parameters of the fall-back model are not expressed in exact terms upfront but rather as intervals which then determine the zone of agreement. The regulation of Copenhagen Airport is set out in the 'Regulations on payment for using airports (airport charges)' (Danish Transport, Construction and Housing Authority, 2017). The main elements of the process are illustrated in Figure 1.2.

Figure 1.2: Regulation of Copenhagen Airport



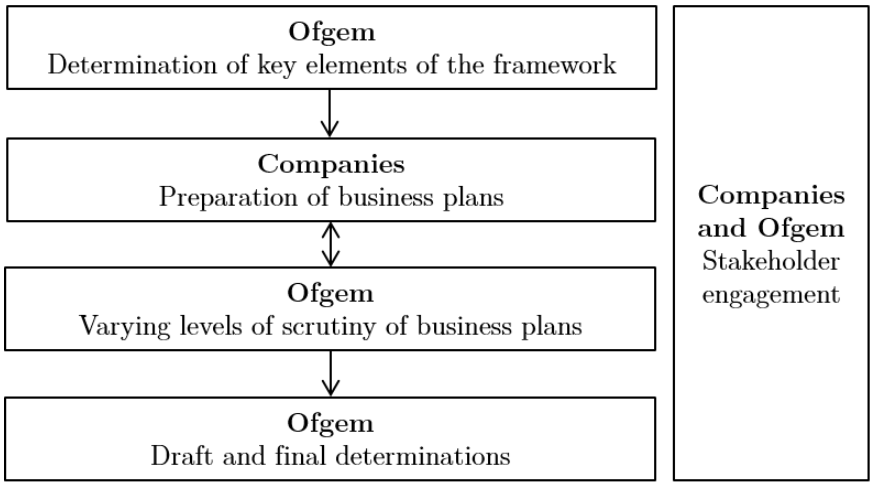
Note: Figure 1.2 is based on "Regulations on payment for using airports (airport charges)" (Danish Transport, Construction and Housing Authority, 2017)

The RIIO Framework

The British regulator of electricity and gas networks, Ofgem, regulates gas and electricity transmission and distribution companies in the so-called RIIO framework (Revenue = Incentives + Innovation + Outputs). The companies' business plans for the coming regulatory period form the basis for determining the allowed revenue. If a business plan is realistic, well-justified, and of value to consumers, the company may face less regulatory scrutiny by Ofgem, and it is more likely that the business plan is reflected into the final price-control (Ofgem, 2010a). Less regulatory scrutiny may include fast-tracking where Ofgem accepts the business plan as submitted, thereby reaching an early decision on the price-control. Companies that are not fast-tracked must submit revised business plans which are further scrutinised by Ofgem via a range of assessment tools. If Ofgem found elements of the business plans not to be of good value for consumers, Ofgem themselves proposed alternatives (Ofgem, 2017). RIIO was developed to address various concerns, including the concern that companies are not focused on outputs which are valuable to consumers. The result is an output-based framework where the allowed revenues of companies partly depend on their performance according to certain outputs. Another issue was the matter of how to maintain legitimacy and accountability of Ofgem's decisions in anticipation of higher energy bills (Ofgem, 2010b). This concern, combined with a perception that network companies are not focused on their final energy consumers or customers, led Ofgem to allow stakeholders

a greater role in the decision-making debate. Stakeholder engagement was therefore introduced as a central element of RIIO, and one that plays an essential role in the development and assessment of business plans. The main elements of the RIIO process are illustrated in Figure 1.3.

Figure 1.3: The RIIO process



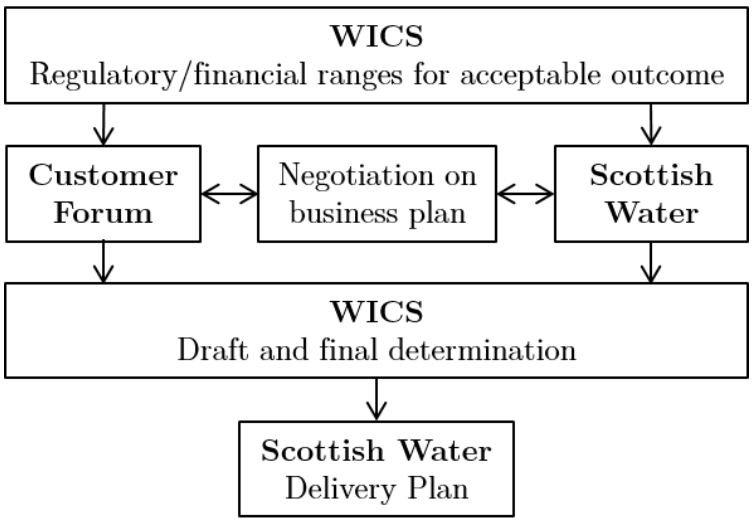
Note: Figure 1.3 is a rough outline of the RIIO process. Ofgem provides a more detailed explanation of the process in its handbook for implementing the RIIO model (Ofgem, 2010a)

Scottish Water

Scottish Water is the national, government-owned, provider of water and wastewater services in Scotland. Scottish Water is regulated by an economic regulator, the Water Industry Commission for Scotland (WICS), and two quality regulators, the Scottish Environment Protection Agency (SEPA) and the Drinking Water Quality Regulator (DWQR). DWQR and SEPA monitor compliance with the relevant drinking water and environmental standards, whereas WICS sets price-caps based on business plans developed by Scottish Water. To increase transparency, making Scottish Water accountable to its customers rather than the economic regulator, and incentivising Scottish Water to understand and react to customers' priorities, an independent Customer Forum was established to negotiate directly with Scottish Water. The Customer Forum is empowered to reach an agreement with Scottish Water on areas of price setting, which the regulator, within acceptable ranges, would then put forward in its draft determination. The regulator supports the negotiation by deciding on ranges for the most material assumptions in price setting and by commenting

on Scottish Water's reports and business plan in detail. Moreover, the Customer Forum can request assistance from the regulator during its negotiations with Scottish Water. The main elements of the regulatory process are illustrated in Figure 1.4.

Figure 1.4: Regulation of Scottish Water



Note: Figure 1.4 is based on Figure 2 in "Innovation and Collaboration: future proofing the water industry for customers" by Water Industry Commission for Scotland (2017)

1.3 Contract Design

When regulating a natural monopoly, the regulator establishes a contractual relationship with the monopoly concerning the supply of services to consumers in exchange for the right to collect payment from consumers. Determining the payment to the monopoly is complicated by private information: actions are unobservable, which generates a moral hazard problem, and the monopoly has exclusive knowledge about its costs, which generates an adverse selection problem. The regulator's problem of determining the payment to a monopoly can therefore be viewed as a principal-agent problem, that is, a problem of characterising the optimal form of contracts between two parties when one party may be able to influence the outcome through his actions.[13]

Contract theory has identified various issues relevant to contract design. The literature on the economics of organisations studies problems of motivation and coordination of

[13]Early analyses of regulation as an agency relationship include Baron and Myerson (1982) and Sappington (1982, 1983). See also Laffont and Tirole (1993) for an extensive presentation of incentive theory in a regulatory context

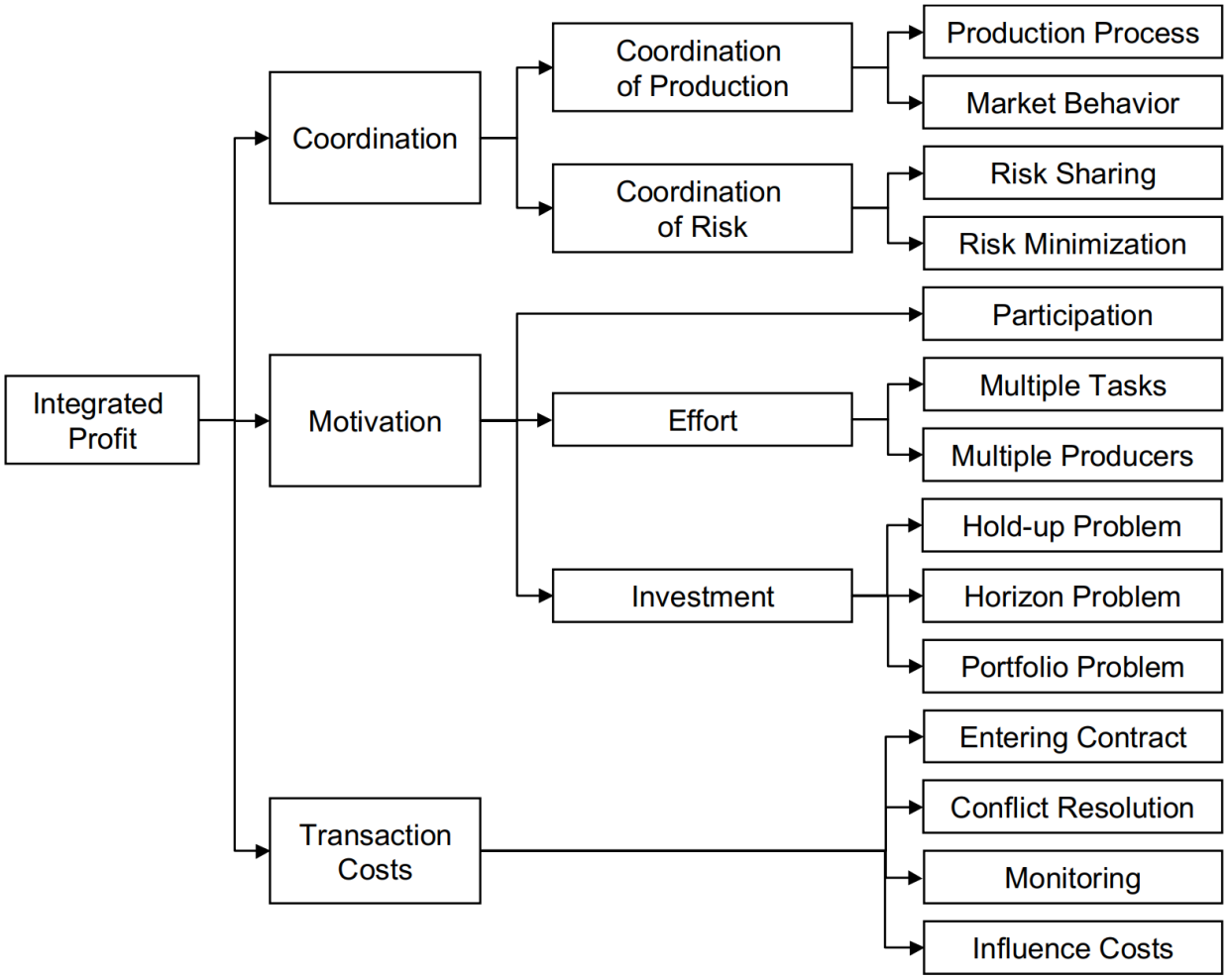
activities while transaction cost theory considers the costs of preparing and administering a contract.[14] Based on this literature, Bogetoft and Olesen (2004) have developed a theoretical framework for contract analysis which rests on the concepts of coordination, motivation and minimisation of transaction costs. These are the three main objectives that contribute to the overall goal of maximising integrated profit, that is, the sum of profits of all the contracting parties, in a production chain context as analysed by Bogetoft and Olesen. In the context of utility regulation, the overall goal of the regulator would be to maximise social welfare, that is, taking into account consumers' surplus and rents earned by the firm.

Bogetoft and Olesen organise the various aspects to consider, when designing a contract, in a hierarchy, as illustrated in Figure 1.5. Their framework is based on many of the partial findings of contract theory. While the provision of incentives is the primary focus of agency theory, in practice, coordination aspects and minimisation of transaction costs are also important aspects of contract design, which are represented in Bogetoft and Olesen's hierarchy of goals for contract design. The framework thus represents a holistic approach to analysing contracts that combines theory and practice. This study similarly aims to cover both theoretical and practical concerns of importance for the design of regulatory frameworks. The hierarchy thus serves as a suitable foundation for characterising the four regulatory frameworks.

The balancing of the three main objectives differs across the regulatory frameworks described in Section 1.2.2. It is necessary to balance the objectives since they may conflict in a way where focusing on one objective comes at the cost of assigning a lower priority to another objective (Bogetoft and Olesen, 2004). A trade-off between the objectives of coordinating risk and motivating effort may arise if the division of risk between the regulated company and consumers entails that the company is not exposed to sources of risk that give information about the company's effort. A cost-of-service regulation illustrates this scenario; when a company's compensation is always set to cover the costs, the company is protected from risk but has weak incentives to provide effort when compensation is independent of the choice of effort. Another example is the trade-off between coordination of production and minimisation of transaction costs: coordination of production can be described as the extent to which the companies' production is aligned with consumers' preferences; transactions

[14]See for example Milgrom and Roberts (1992) for a comprehensive coverage of central themes in economics of organisation and Williamson (1996) for the study of transaction cost economics

Figure 1.5: Hierarchy of Goals for Contract Design



Source: Bogetoft and Olesen (2004), Figure 3.1

costs reflect the costs of achieving the goals of coordination and motivation. Transaction costs include the cost of administering regulation or stakeholders' costs of engaging with the utility company. The objectives and associated trade-offs are further described in Sections 1.4-1.7.

A comparison of the four different regulatory frameworks described in Section 1.2.2 suggests that coordination of production is assigned a higher priority in the frameworks that incorporate stakeholder engagement or direct negotiations between the regulated company and its customers. At the same time, these coordinating activities may be costly in terms of increasing transaction costs, such as higher costs of entering a contract when abandoning the use of standardised contracts. Table 1.1 summarises the different trade-offs between goals of contract design in each of the regulatory frameworks. The comparison in Table 1.1 suggests that the cases incorporating negotiated settlements and stakeholder engagement prioritise the goal of coordinating production to a higher degree than the Danish revenue-cap regulation of electricity distribution companies. However, this prioritisation may come at the cost of increasing transaction costs.

The remaining sections of the article present the case for this assessment of the different types of regulation. The different mechanisms will be referred to by the enumeration given in Table 1.1, as they are mentioned in the following sections. It should be noted that while Table 1.1 provides an overview of specific mechanisms that can help strengthen a particular dimension of a given regulation, it does not encompass all mechanisms incorporated in the different frameworks. Moreover, since Table 1.1 only summarises the elements of the different frameworks, the number of pluses and minuses is related to the number of formalised elements in each framework so Table 1.1 cannot be used to determine which regulatory framework performs best. Instead, it serves to illustrate trade-offs between goals of contract design *within* a given framework.

Table 1.1: Trade-offs between Goals of Contract Design

	Mechanism	Coordination		Motivation			Minimisation of transaction costs
		Production	Risk	Participation	Effort	Investment	
Danish electricity DSOs (revenue-cap regulation)	Symmetric cost cap adjustment between periods (1)		+		−		
	Uncertainty mechanisms (2)		+			+	−
	Benchmarking (3)		+	+	+	+	−
	Standardised contracts (4)	−	−	−	−	−	+
	Decisions can be appealed to complaints board (5)						+
Copenhagen Airport (negotiation with customers (airlines))	Negotiation between airport and airlines (6)	+					−
	Fall-back model (7)		+	+			−
	Service level agreement (8)	+			+		−
	Provisions on settlements of disputes (9)						+
RIIO (stakeholder engagement)	Outputs (10)	+	−	+	+		−
	Stakeholder engagement (11)	+					−
	Individualised contracts (12)	+	+	+	+	+	−
	Efficiency incentive rate (13)		+		−		
	No retrospective adjustments (14)				+	+	
	Uncertainty mechanisms (15)		+			+	−
	Mid-period review (16)		+	+	−		−
	Ofgem's general financing duty (17)		+	+			−
	Assessment of efficient costs via benchmarking, etc. (18)		+	+			−
	IQI mechanism (19)			+			−
	Monitoring (20)				+		−
	Longer regulatory period if approved upon application (21)		−		+	+	−
	Secondary deliverables (22)					+	−
	Innovation stimulus package (23)					+	−
	Proportionate assessment of business plans (24)			+			+
	Decisions can be appealed to complaints board (25)						+
Scottish Water (negotiation with Customer Forum)	Negotiation between Customer Forum and Scottish Water (26)	+					−
	Customer research programme (27)	+					−
	Financial tramlines (28)		+	+	−	−	−
	Allowed revenue is linked to deliverables (29)	+		+	+		−
	Guidance notes (30)			+			
	Assessment of efficient costs via benchmarking, etc. (31)		+	+			−
	Output monitoring group (32)				+		−
	Long term payback initiatives (33)				+	+	
	25-year strategic vision (34)					+	−
	Decisions can be appealed to complaints board (35)						+

Notes: Brief descriptions of the mechanisms can be found in the appendix, Tables A1-A4. The different mechanisms in Table 1.1 will be referred to by their numbers as they appear in later sections. An elaboration of the stated trade-offs is available from the author upon request.

1.4 Coordination of Production

In the context of utility regulation, coordination of production can refer to the alignment between companies' production possibilities and consumers' preferences. For an electricity distribution company, the production possibilities frontier may span outputs such as security of supply, the time it takes to connect new consumers or producers, environmental impact. Coordination of production will ensure that the right combination of such outputs is being produced compared to what consumers would prefer, given what is feasible on the production possibilities frontier. Coordination of production plays an explicit role in the regulation of Copenhagen Airport, RIIO, and the regulation of Scottish Water. The regulation of Danish electricity distribution companies stands in contrast to these three cases when it comes to prioritising the objective of coordinating production. In the revenue-cap regulation, consumers' preferences are only indirectly represented through the legislator's consideration of consumers when formulating the regulations. In the regulation of Copenhagen Airport, an explicit objective of the regulatory model is for the regulation to be based on voluntary agreements between the airport and airlines **(6)**. Airlines can thereby influence the structure of charges, service and capacity levels as well as the duration of the regulatory period. In this way, the framework supports better coordination of production when compared to charges being determined between the airport and the regulator.

Coordination of production was also a driver for developing the RIIO frame-work. When reviewing the existing RPI-X framework, Ofgem found that it tended to focus more on economic efficiency than on outputs which are valuable to consumers. To meet this concern, RIIO was designed with outputs at the centre of the framework **(10)**. The output categories aim at encouraging companies to play a full role in the delivery of a sustainable energy sector and deliver long-term value for money network services for existing and future consumers. Moreover, companies will have to demonstrate effective engagement with their stakeholders on the development of their business plans **(11)**. With RIIO, Ofgem thus attempts to mimic better the outcome of a competitive market where companies must understand and respond to consumer needs to stay in business. RIIO thus creates better opportunities for alignment between the goods produced by companies compared to what consumers prefer.

In the regulation of Scottish Water, customer engagement is also a central part of the regulatory process. WICS believes that customer engagement can only be truly effective

if customers are empowered to take meaningful decisions (Water Industry Commission for Scotland, 2017). WICS finds that customers are best placed to make judgments on what are reasonable costs but will support customers by issuing guidance on the lowest overall cost in a particular area or for a particular initiative. The Customer Forum was therefore established to negotiate and reach an agreement with Scottish Water on behalf of the entire customer base **(26)**. The aim was to encourage Scottish Water to focus on its customers rather than on its regulator, thereby creating the basis for better alignment between customers' preferences and the company's production possibilities. To understand the priorities and preferences of the broader customer base, the Customer Forum and Scottish Water must jointly carry out a customer research programme **(27)**. The role of the Customer Forum is to represent those priorities and preferences to WICS and Scottish Water and seek to reach an agreement with Scottish Water that meets the expectations of customers as a whole.

1.5 Coordination of Risk

Another goal for contract design is to minimise the costs of risk. Bogetoft and Olesen (2004) list two ways to attain this goal: i) risk should be shared in a way that makes the total cost of risk-bearing as low as possible, and ii) the contract should minimise total risk. These two aspects are considered separately below.

1.5.1 Risk-Sharing

There is a trade-off between balancing risk and providing regulated companies with strong incentives. If the compensation to companies depends only on the outcome, then the contract would provide the right incentives to companies, but it would subject the companies to risk associated with the outcome. On the other hand, if the compensation to companies is made completely risk free and unrelated to performance or outcomes, companies would have weak motivational incentives as there would be no rewards or penalties related to performance levels. Shavell (1979) proves that if the agent is risk-averse, the payment would always, to some extent, depend on the outcome, but the agent would never bear all the risk. There is thus a trade-off between protecting the companies from risk and providing motivational incentives. The trade-offs are illustrated in this section.

In the revenue-cap regulation of Danish electricity distribution companies, the risk of costs and investments being different from what was assumed prior to the regulatory period is shared between companies and consumers when transitioning to the next regulatory period **(1)**. If a company's actual costs turn out to be lower than its cost-cap, the revenue-cap will be lower in the next period, all else equal. In this way, efficiency improvements are shared with consumers at the end of each period. If, on the other hand, a company's costs exceed the cost-cap, the revenue-cap may be adjusted upwards in the coming period. In itself, the upward adjustment dampens efficiency incentives and thereby compromises motivational objectives. However, in order to balance the risk-sharing objective against motivational objectives, the upward adjustment of cost-caps between periods is conditional on the company documenting and justifying the cause of its excess costs to the Danish Utility Regulator. The regulator will then assess whether the excess costs are due to exogenous factors beyond the company's control. If this cannot be verified, the company is not entitled to a full upward adjustment of its cost-cap (Danish Ministry of Climate, Energy and Utilities, 2018).

The RIIO framework specifically targets risk-sharing by incorporating a mechanism which is referred to as the 'efficiency incentive rate' (or the 'sharing factor') **(13)**. If the efficiency incentive rate is set at 40 percent, it means that the company's investors will earn £40 for every £100 saved by the company during the regulatory period and conversely, investors will bear £40 of each £100 overspend. The remainder will be passed on to consumers through lower or higher network charges. The efficiency incentive rate thus shares the risk of actual costs being different to what was assumed in the price-control. Investors and consumers share the benefits when the company has lower costs than assumed in the price-control. Likewise, they share the additional costs in cases where the company needs to spend more money than was assumed. In this way, the mechanism provides companies with some protection against uncertainties related to the price-control. According to Ofgem (2010a), the primary sources of uncertainty within the price-control period relate to outputs, input prices, and volumes of activity required. When deciding on the efficiency incentive rate, Ofgem recognises that if the level is set too low, companies may not face exposure to overspending risk, and could spend money unnecessarily to increase their regulatory asset values and thus future income streams. In this way, Ofgem tries to balance the trade-off

between risk-sharing and motivational objectives.

The Customer Forum-based regulation of Scottish Water also incorporates a sharing mechanism in the form of the so-called financial tramlines **(28)**. The financial tramlines are used to monitor Scottish Water's financial performance and ensure that Scottish Water maintains an appropriate level of financial strength. If Scottish Water performs better than its target to the extent that financial strength reaches an upper limit, and is forecast to stay there for the remainder of the price-control, the outperformance will automatically be shared with customers in the following year. The proportion to be shared with customers is agreed between Scottish Water and the Customer Forum at the start of the price-control (Water Industry Commission for Scotland, 2014). However, knowing that the gains from outperformance above an upper limit are shared with customers may dampen the company's motivation to outperform, which again illustrates the trade-off between risk-sharing and motivational incentives.

1.5.2 Risk Minimisation

The second aspect of minimising the cost of risk is to minimise total risk. In all of the above-described cases, allowed revenue adjusts in line with a measure of inflation. This uncertainty mechanism protects companies from general price inflation which is outside their control and in turn benefits customers through a lower risk premium.

Besides a measure of inflation, the revenue-cap of Danish electricity distribution companies adjusts in line with activity indicators which comprise the number of electricity meters and stations in the distribution area **(2)**. The activity indicators are specified with the intention to capture variation in cost components, thereby reducing the level of risk. Moreover, the revenue-cap is adjusted within the regulatory period, on the request of companies, for changes in conditions that are generally outside the company's control and associated with changing cost levels. In the negotiation-based regulation of Copenhagen Airport, an activity indicator in the form of passenger development is included in the fall-back model **(7)** as an adjustment to operating expenditures (Opex) during the regulatory period. It is, however, up to the negotiating parties to settle on uncertainty mechanisms to be included in the agreement. Ofgem has also incorporated several uncertainty mechanisms in the RIIO framework **(15)**. Some revenue adjustments are triggered automatically in line with an agreed rule

specified at the beginning of the price review. In contrast, others require Ofgem to carry out a review to adjust revenue during the price-control period. Moreover, Ofgem manages uncertainty through a mid-period review of output requirements **(16)** and by evoking their general financing duty **(17)**. By virtue of Ofgem's general financing duty, companies can request changes to be made to the price-control if finance-worthiness is put at risk due to highly significant uncertain events which would occur during the price-control period (Ofgem, 2010a).

Through the financial tramlines **(28)**, WICS has incorporated a mechanism in the Customer Forum-based regulation of Scottish Water that resembles Ofgem's general financing duty. If the financial strength decreases to a specified lower limit, WICS will review the company's performance and may take actions such as reducing the capital investment programme or increasing consumer charges. Some concern has been expressed that this could be seen as a regulatory 'bail-out plan' which might impair management incentives and lead to Scottish Water becoming inefficient (Oxera, 2012). While within-period adjustments in the contract minimise the total level of risk, they can simultaneously generate motivational problems. As a solution to this concern, a warning line was set between the lower tramline and the midpoint, at which point Scottish Water would explain in its Delivery Plan how and when performance will improve. The consequences of financial strength reaching the lower limit depend on whether the situation is caused by external factors beyond the influence of Scottish Water. This is to prevent circumstances in which customers would compensate Scottish Water for inefficiency or poor management.

The duration of regulatory contracts also affects the total level of risk. This effect was observed by Ofgem in their review of the RIIO framework after analysing the reasons for companies earning higher than expected returns. While this was partly due to newfound efficiencies, which may be a result of the move to an eight-year price-control period, one of the main reasons is that the assumptions for some cost categories did not reflect the actual costs that companies subsequently incurred (Ofgem, 2018a). The extended price-control period meant that the impact of these issues affected consumers for an extended period of time. Against this background, Ofgem has decided to shorten the period from eight to five years with effect from the next regulatory period. However, a shorter regulatory period may mean that companies would not find it worthwhile to invest in new ways of operating

their networks that could improve efficiency. There is thus a trade-off between minimising risk, by shortening the regulatory period and incentivising innovation. Ofgem balances this trade-off by allowing companies an extended regulatory period if they make a compelling case for this, such as greater efficiencies or innovation **(21)** (Ofgem, 2018b).

1.6 Motivation

Following the hierarchy of Bogetoft and Olesen (2004), the motivational objective breaks down into the objectives of participation, effort, and investment. To encourage the contracting parties to participate, the contract must provide the parties with utilities at least equal to what they could obtain outside the contract; the reservation value. This constraint is known as the individual rationality constraint. Participation problems include the adverse selection problem where companies have private information about their costs before a contract is written.[15] The private information prevents the regulator from distinguishing between high-cost companies and low-cost companies. The regulator could address this problem by allowing the compensation of a company to equal the company's total costs, as in a cost-of-service regulation. However, this leads to the moral hazard problem; the company does not profit from reducing its costs, as this would also reduce its compensation. Weak efficiency incentives may lead to the incurrence of costs that are higher than the efficient level. On the other hand, if the regulator were to fix compensation at a level corresponding to the average cost of the companies, only the companies with low costs would be willing to enter the contract, and this would lead to over-compensation of the low-cost companies. They would, however, have strong incentives to provide effort as they would profit from reducing costs below the level of compensation.

As reviewed below, the cases illustrate different ways in which the adverse selection and moral hazard problems can be addressed. The third aspect of the motivational objective is about incentivising investments to ensure future profits.

[15] See Akerlof (1970) for an important contribution to the research on adverse selection

1.6.1 Participation and Adverse Selection

The RIIO framework incorporates several measures to reduce the adverse selection problem. One feature in RIIO is that allowed revenues depend on the level of different outputs **(10)**. RIIO is thus a performance-based contract, which is more attractive to productive agents than to less productive agents.[16] Secondly, RIIO incorporates a mechanism that aims at encouraging companies to submit more accurate expenditure forecasts to Ofgem (Ofgem, 2010a). The mechanism is referred to as the information quality incentive (IQI) **(19)**. When business plans are used to set allowed revenues, companies will have an incentive to submit inflated forecasts in order to profit from underspending in subsequent years. Through the IQI mechanism, the efficiency incentive rate varies according to the extent by which a company's business plan forecast differs from Ofgem's assessment of expected efficient costs of delivering outputs. Ofgem rewards companies that submit better forecasts (closer to Ofgem's assessment of efficient costs) through additional income and higher efficiency incentive rates and penalises companies with high cost forecasts compared to Ofgem's view through penalties and lower efficiency incentive rates. Ofgem has calibrated the IQI such that companies that submit expenditure forecasts equal to Ofgem's assessment of their efficient expenditure will earn a return equal to Ofgem's estimate of their cost of capital (Ofgem, 2012d). Companies that submit expenditure forecasts higher than Ofgem's assessment of their efficient expenditure could earn a return which is lower than Ofgem's estimate of their cost of capital. The IQI mechanism thereby intends to differentiate high-cost companies from low-cost companies and allow Ofgem to offer different contracts to different companies. This strategy reduces overcompensation in the form of informational rent to companies.

Additional to the IQI mechanism, Ofgem employs a number of other tools in their assessment of efficient costs. The tools include benchmarking, random inspections, expert evaluations, and market testing **(18)**. Moreover, based on an initial sweep of business plans, Ofgem divides companies into three categories (A, B, and C) which determine the level of scrutiny that will be applied to business plans **(24)**. Companies in category A receive relatively lower levels of scrutiny of their business plans which may include fast-tracking.

[16] See for example Lazear (1986) for an analysis of worker sorting across jobs with salaries vs. piece rates and Lazear (2000) for empirical evidence of the selection effect

Although fast-tracking implies less regulatory scrutiny, which could lead to overcompensation, the purpose of the opportunity to be fast-tracked is to encourage companies to make sure their costs are efficient (Ofgem, 2017).

The Danish revenue-cap regulation takes a different approach to reduce adverse selection problems. The payment to companies does not depend on output levels. Instead, relative performance evaluation is used to reduce the companies' information rent **(3)**. Relative performance evaluation can also insulate companies from common risk, which affects all companies and thereby improve risk-sharing (Holmström, 1982). In contrast to RIIO and the regulation of Scottish Water, a benchmarking of economic efficiency directly influences the revenue-cap. In the regulation of Scottish Water, the regulator provides guidance to the Customer Forum in the form of indicative ranges for key financial and performance variables **(30)**. Here, too, is benchmarking one of the tools used to assess the company's business plan **(31)**. Although benchmarking does not mechanically affect the allowed revenues of the company, it serves as an input to the regulator's assessment of cost efficiency to be reflected in the guidance notes.

1.6.2 Effort

Ideally, to provide strong incentives for effort, the compensation of companies would be directly linked to their level of effort. However, in practice, this is difficult, since it is often not possible to observe effort. Instead, payment can be linked to output levels, as is the case in RIIO **(10)**. Rewards and penalties are thus linked to performance levels on certain outputs whereby the payment to companies varies with their output levels. Output levels are in this case used as an indicator for effort levels. Ofgem considers various aspects when deciding on the strength of rewards and penalties. One of these aspects relates to the controllability of performance levels. Uncontrollable performance levels, which may be due to factors such as weather conditions, will lead to uncertainty in the evaluation of the company's efforts. Ofgem thus follows the principle that network companies should have full or sufficient control over performance against outputs (Ofgem, 2010a). Highly controllable outputs thus call for stronger incentives. The precision with which outputs are measured also affects the connection between unobservable actions and observed outputs. Therefore, incentivising effort could make the payment to companies dependent on random

and uncontrollable factors which would increase the cost of risk.

Milgrom and Roberts (1992) have identified three principles for determining the optimal strength of incentives. One is the incentive intensity principle, according to which the optimal intensity of incentives depends on four factors; i) the profitability of incremental effort, ii) the agent's risk tolerance, whereby more risk-averse agents, with a higher cost of risk-bearing, should be subject to weaker incentives, iii) the precision with which performance is measured, and iv) the responsiveness of effort to incentives. In general terms, the incentive-intensity principle is about balancing the strength of incentives with the cost of risk-bearing. When determining the strength of incentives, Ofgem balances the two objectives by taking into account the value to consumers of the concerned output, the accuracy and reliability of the information used to measure performance and the controllability of performance levels (Ofgem, 2010a).

Another principle is the monitoring-intensity principle, according to which the strength of the agent's incentives should be chosen together with the level of monitoring by the principal as the profitability of both instruments is interdependent. It becomes more important to measure performance correctly when rewards or penalties are higher. Likewise, although stronger incentives increase uncertainty, greater measurement precision will reduce uncertainty in the evaluation of companies' performance and in this way reduce the risk premium paid to companies. Greater monitoring thus enables stronger incentives.

The performance of Scottish Water is monitored quarterly by the Output Monitoring Group and annually by WICS **(32)**. The monitoring group was set up by the Scottish Ministers to monitor and report on Scottish Water's performance in delivering outputs. Although there are no explicit rewards or penalties associated with certain output levels, allowed revenue is linked to the deliverables **(29)** agreed between the Customer Forum and Scottish Water assisted by WICS's guidance notes. If Scottish Water subsequently outperforms by delivering outputs at a lower cost than was assumed, the company is rewarded to the extent that financial strength stays within levels defined by the financial tramlines **(28)**. Underperformance to the extent that financial strength decreases below the lower limit will lead to WICS reviewing the company's performance and taking action to improve financial strength. While the financial tramlines insure the company against unexpected shocks, they may at the same time dampen the incentive to outperform to the extent that financial

strength increases above the levels defined by the tramlines. This situation again illustrates the trade-off between minimising the cost of risk and providing motivational incentives.

Multi-tasking is another issue of importance when deciding on the strength of output-based incentives.[17] The balancing of different incentives can affect the prioritisation between different tasks which can be thought of as different characteristics of a given product, such as customer service, reliability, and conditions for connection. If incentives are not balanced, companies may focus too much on one task at the expense of other tasks. According to the equal compensation principle, if the agent cannot be monitored and if the marginal rate of return from time spent in each of two activities is not equal, the activity with the lower marginal return receives no time or attention. The activities at Copenhagen Airport can be characterised as multi-tasking on the part of both airports and airlines. To ensure incentive compatibility, Copenhagen Airport and the airlines sign a service level agreement which defines the minimum level of service that the airport and the airlines must deliver **(8)**. The agreement applies to a range of tasks including baggage handling, check-in and security waiting time, baggage transfer, and other service parameters. Compliance to the agreement is encouraged by rewards and penalties depending on performance. The airport must compensate airlines if it has not met the agreed service levels. Likewise, airlines will be compensated if they meet the agreed airline service levels. In the revenue-cap regulation of Danish electricity distribution companies, payment is linked to relative efficiency as measured by Totex benchmarking which takes into account the degree of controllability of different cost types **(3)**. However, to prevent companies from improving economic efficiency at the expense of disregarding security of supply, the payment to companies also depends on their security-of-supply levels relative to predetermined targets.

1.6.3 Investment

In order to incentivise the contracting parties to invest in order to ensure future profits, the contract must solve issues such as the hold-up problem and the horizon problem as reviewed below.

[17] See Holmström and Milgrom (1991) for a general treatment of the multi-task problem

The Hold-Up Problem

The hold-up problem refers to a situation where one party of a contract has invested in assets that are specific to a particular use or which, for other reasons, are less valuable if the contractual relation terminates. The party may therefore worry about being forced to accept disadvantageous terms later, as the other party's bargaining power has increased.[18] The fear of hold-ups may deter investments in specific assets and can lead to underinvestment.

In the regulation of Scottish Water, hold-up problems could, in principle, be generated by changes in the composition of the Customer Forum in Scotland. In the next regulatory period, covering the years 2021-27, the Customer Forum will comprise ten members of whom three are appointed from the previous Customer Forum (Water Industry Commission for Scotland, 2017). There is thus a risk that the Customer Forum will change its priorities from period to period, which could discourage Scottish Water from making specific investments. Long-term payback initiatives, however, reduce this problem **(33)**. Long-term payback initiatives refer to agreements between the Customer Forum and Scottish Water that allow the company to retain cost savings from long-term projects until the accumulated savings have paid the upfront cost of the investment, including the cost of capital (Water Industry Commission for Scotland, 2013).

Ofgem addresses the hold-up problem by committing to not making retrospective adjustments **(14)** in case an innovation project turns out to be ineffective at delivering the intended benefits (Ofgem, 2010a). Innovation projects are specified by Ofgem (2010a) as 'projects which require upfront costs but have the potential, with some uncertainty, to deliver benefits in terms of long-term value for money in future periods'. The uncertainty of innovation projects may discourage companies from undertaking them if they fear Ofgem will lower allowed revenues in case an innovation project fails to deliver benefits. Moreover, to promote long-term investments, Ofgem also commits to not making retrospective adjustments to the regulatory asset value as long as outputs are delivered. By its commitments, Ofgem encourages investment at the risk of overcompensating the company if investments are not carried out efficiently. Ofgem will, however, consider using ex-post adjustments if outputs are not delivered or if they have a concern that a company has manifestly wasted

[18] Hart and Moore (1988), Klein, Crawford and Alchian (1978) and Williamson (1979) were among the first to study the hold-up problem

money (Ofgem, 2010a).

The Horizon Problem

The horizon problem refers to the effect of time on incentives, such as concerns about the effects of current performance on future compensation.[19] If companies, for instance, face uncertainty about which conditions apply to the next regulatory period, the incentive to invest in projects of which the return falls after the regulatory period may be reduced. The matter of encouraging long-term thinking is explicitly addressed in both RIIO and the regulation of Scottish Water. In the RIIO framework, business plans should demonstrate consideration for the longer-term which requires the companies to consider not only the expenditure they will need for the coming regulatory period but also the effects on future required investment and efficiency. Other elements include the use of long-term primary outputs to increase stability in regulation across periods and secondary deliverables **(22)** that allow for costs in the current period which are linked to the delivery of primary outputs and long-term efficiency savings in the future (Ofgem, 2010a). Moreover, Ofgem encourages companies to invest in innovation projects. Companies can apply for funding via the innovation stimulus package **(23)** or include expenditure related to innovation projects in their business plans.

The Customer Forum-based regulation of Scottish Water also incorporates elements to encourage long-term thinking. One element is the 25-year strategic vision **(34)** prepared by Scottish Water in dialogue and negotiation with the Customer Forum and the quality regulators. The vision statement provides a long-term context for business planning, and identifying the financial resources needed to carry out necessary improvements. Scottish Water and the Customer Forum can agree on specific arrangements to increase innovation and incentivise specific investments. An example is the long-term pay-back initiatives **(33)** which reduce the behavioural uncertainty that is associated with a resetting of prices at the beginning of every new regulatory period. The purpose is to incentivise the company to undertake long-term initiatives, where the payback extends beyond the regulatory period and investments would benefit customers through lower prices or higher quality.

[19] See Gibbons and Murphy (1992), Holmström (1999) and Smith and Watts (1982) for studies of the horizon problem among executives, workers, and managers, respectively

1.7 Minimisation of Transaction Costs

Transaction cost economics is based on the premise that contractual designs are created to minimise transaction costs.[20] Transaction costs can be viewed as the costs of providing solutions to the problems of coordination and motivation. Consequently, the objective of minimising transaction costs may conflict with the objectives of coordination and motivation. Following the hierarchy by Bogetoft and Olesen (2004), four sources of transaction costs are considered in the following: i) influence activities, ii) entering a contract, iii) monitoring, and iv) conflict resolution.

1.7.1 Influence Costs and Costs of Entering a Contract

The concept of influence costs as an element of transaction costs was developed by Milgrom and Roberts (1988, 1990). They define influence costs as "the losses that arise from individuals within an organization seeking to influence its decision for their private benefit (and from their perhaps succeeding in doing so) and from the organization's responding to control this behavior" (Milgrom and Roberts, 1990, p. 58). By influence activities, the authors refer to manipulation information, such as lying about facts, suppressing unfavourable information, or by presenting information in a way that emphasises the arguments which support the preferred decision. These activities are costly in terms of the time spent influencing and the time spent limiting influence activities or their effects. To reduce influence activities, the principal may want to limit communication prior to decision-making. This choice, however, entails a trade-off between reducing influence costs and obtaining information that could be valuable for decision making.

Bogetoft and Olesen (2004) summarise the costs of entering a contract as the costs associated with foreseeing all possible outcomes, the costs of formulating a contract that takes the different contingencies into account as well as associated actions, and the costs of making the contract legally binding. The transaction costs of entering a contract can be reduced by using a standard contract with all companies. This approach to minimising transaction costs is adopted in the revenue-cap regulation of Danish electricity distribution companies since the same procedure and model for determining revenue-caps applies to all

[20] See for example Holmström and Tirole, 1989; Milgrom and Roberts, 1990

companies as specified in regulations **(4)**. Individual circumstances, not accounted for in the regulations, cannot influence any individual contract.

The RIIO framework exemplifies the opposite since the contract of each company is highly dependent on company-specific circumstances **(12)**. Moreover, RIIO has expanded the areas of focus compared to its predecessor, RPI-X. Among other things, RIIO entails that the regulator defines different outputs and sets rewards and penalties appropriately to reflect the benefit and losses of increasing and decreasing outputs to the system as a whole. Consequently, the costs of entering a contract are higher compared to RPI-X.

On the other hand, the transaction costs reflect activities which provide the information required to improve coordination and motivation. Ofgem has thus prioritised the objective of minimising transaction costs at the expense of optimising coordination and motivation. Ofgem does, however, employ a proportionate approach to assessing the business plans **(24)** whereby the level of scrutiny of business plans varies according to the quality of business plans submitted, the company's performance in previous periods, and a benchmarking of business plans. Less regulatory scrutiny may include fast-tracking, which means that Ofgem accepts the business plan as submitted, thereby reaching an early decision on the price-control. The proportionate assessment of business plans reduces transaction costs but entails a risk of overcompensating the company.

1.7.2 Monitoring and Conflict Resolution

Monitoring is one way to incentivise effort, as discussed in Section 1.6.2. The costs of monitoring include the cost of having financial statements verified by independent auditors and the costs of monitoring performance in order to determine rewards or penalties. Ofgem monitors performance on an ongoing basis, first of all by collecting information on and monitoring performance on primary outputs and secondary deliverables **(20)**. If a company does not meet the targets that were assumed in the price-control, Ofgem will assess the reason for this and consider what action to take, if any (Ofgem, 2010a). Furthermore, Ofgem allows for a mid-period review **(16)** of output requirements that could lead to changes in the output levels that companies are required to deliver. The regulation of Scottish Water also includes ongoing monitoring of the company by the Output Monitoring Group **(32)** that meets every three months to discuss and ensure progress in meeting the objectives set

by the Scottish Ministers.

Incomplete contracts may leave room for situations not covered by the contract, which can generate conflicts. While court enforcement is one option for dispute resolution system, arbitration represents a less costly system (Joskow, 1985). According to Joskow (1985), contracts should support arrangements that allow for the smooth functioning of the agreement and settlement of disputes without resorting to litigation in order to reduce the costs of dispute resolution. Accordingly, the Danish revenue-cap regulation, RIIO and the Customer Forum-based regulation of Scottish Water have complaint procedures in place whereby companies can have the merits of their decision examined by an arbitrator, such as a complaints board **(25, 35, 5)**. Likewise, the charges agreement and the service level agreement between Copenhagen Airport and airlines must include provisions on the settlement of any disputes about the agreement **(9)**.

1.8 Conclusion

In Sections 1.3-1.7, the four regulatory frameworks have been broadly compared in terms of how they each prioritise different goals of contract design. As demonstrated, the goals may conflict in a way where focusing on one objective comes at the cost of assigning a lower priority to another objective. For example, whereas revenue-cap regulation allows for standardised contracts, the use of negotiations and stakeholder engagement calls for individualised contracts, which can create a better alignment between consumers' preferences and companies' production possibilities. In this way, revenue-cap regulation minimises transaction costs, however, also assigns a lower priority to coordination of production. Conversely, negotiated settlements and stakeholder engagement prioritise coordination of production at the expense of assigning a lower priority to the minimisation of transaction costs.

The resolution of trade-offs in each of the frameworks is justified by specific circumstances which have determined the relative importance of different objectives. Where minimising transaction cost may have been a primary objective of revenue-cap regulation, the other cases assign higher importance to the coordination of production. A better alignment between consumers' priorities and companies' production possibilities and uncertainty about future challenges in the sectors are some of the motives that generated the need to review existing

regulatory frameworks in the UK

The UK represents a country where it has been found worthwhile to engage consumers and other stakeholders in the regulatory process. Likewise, the regulation of Copenhagen Airport is a context that perhaps lends itself well to a negotiation-based regulation, since the airlines, as professional players in the market for airport services, constitute a natural negotiating party. For other countries or under different circumstances, customer engagement initiatives may not be easily implemented. It appears probable that customer engagement initiatives are harder to implement in countries with low levels of social capital since customer engagement requires cooperation both within the customer group and between customer groups, firms and authorities. The transaction costs associated with customer engagement may also, in some circumstances, be considered too high relative to the benefits of improved coordination in countries with high social capital.

Furthermore, the development stage of both the energy system and regulatory framework can play a role in the uptake of customer engagement initiatives. For a newly established regulator with limited resources, efficiency and security of supply are likely more pressing issues than customer engagement. The cases of RIIO and the Customer Forum-based regulation of Scottish Water both represent well-developed regulatory frameworks, which after years of advancing their regulatory mechanisms, are now focusing on customer engagement. The balancing of goals reflected in these cases can thus be seen as a product of the social context and the development stage of regulation.

The relevance of the approaches for customer engagement studied here is thus highest for developed countries with well-established traditions for regulation. The study does not intend to portray any of the four frameworks as a best practice; how goals are balanced in a given situation largely depends on the context. The implications of transitioning to a low carbon economy motivated customer engagement in RIIO and the regulation of Scottish Water. For regulators looking to change regulation in this regard, it can be useful to consider the regulatory frameworks studied here while evaluating the associated increase in transaction costs pertinent to the given situation. The study contributes with an overview of the advantages and disadvantages associated with various mechanisms used in practice that may be helpful in the process.

Finally, it should be noted that since the aim here is to understand features specific

to four particular cases, conclusions do not automatically generalise to a broader range of regulators or regulations. Transferability would require the four cases to be representative of a larger population of regulations, which has not been ensured by their selection.

A next step could be to refine the case descriptions by further illustrating how the regulators try to minimise the drawbacks of different mechanisms and including insights into the regulators' administrative discretion. These aspects can potentially relax the characterisation of frameworks given in Table 1.1. The central issue of balancing consumers' preferences and regulatory outcomes is also a candidate for further research. As a starting point, we can use the stylised model of Antle and Bogetoft (2019). They show that the agent's superior information about the relative costs of different products or activities leads to inertia in the mix of products or activities pursued, that is, a favouring of the status quo. Specifically, if the principal and the agent cannot communicate, the asymmetric information leads to 'mix stickiness', that is, changes in technology or preferences do not influence the mix of product or activities. However, if the parties can communicate, they can obtain a better balance between consumers' wishes and the companies' production possibilities, although the optimal solution is still biased toward the historical outcome. This bias is because larger variations in the production plan allow the agents to take greater advantage of the asymmetric information by claiming that the change in production is associated with high costs.

In this way, such a stylised model can help shed light on the value of communication between the parties and the trade-off between coordination and motivation, such as why the parties do not coordinate optimally because of motivational problems such as the agents' ability to extract information rents.

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Appendix

Explanation of Mechanisms

Table A.1: Explanation of Mechanisms in the Revenue-Cap Regulation of Danish Electricity Distribution Companies

Mechanism	Explanation
Symmetric cost cap adjustment between periods (1)	– The revenue-cap for a given period is based on the average levels of costs and asset base from the previous period – This means that the risk of costs and investments being different from what was assumed prior to the regulatory period is shared between companies and consumers when transitioning to the next period
Uncertainty mechanisms (2)	– Allowed revenue automatically adjusts in line with inflation and activity indicators – Companies can also apply for adjustments in allowed revenue for changes in conditions outside the company's control
Benchmarking (3)	– A benchmarking of economic efficiency directly influences allowed revenue
Standardised contracts (4)	– Standard contract with all companies where allowed revenue is mechanically determined
Decisions can be appealed to complaints board (5)	– The Danish Utility Regulator's decisions can be appealed to the Danish Energy Board of Appeal

Table A.2: Explanation of Mechanisms in the Regulation of Copenhagen Airport

Mechanism	Explanation
Negotiation between airport and airlines (6)	– The regulation is based on voluntary agreements between the airport and airline
Fall-back model (7)	– If the parties cannot come to an agreement, a fall-back model, determined by the regulator, will be used to determine the allowed revenues of Copenhagen Airport – The fall-back model is a revenue-cap model made up of a cost cap, covering operating costs and depreciations, and an allowed return on invested aeronautical assets – Moreover, a fixed share of the excess return (return above reasonable return) from the commercial activities in the airport will lower the revenue-cap
Service level agreement (8)	– The service level agreement defines the minimum level of service that the airport and airlines must deliver – Compliance to the agreement is encouraged by rewards and penalties depending on performance
Provisions on settlements of disputes (9)	– The agreement must include provisions on the settlement of disputes

Table A.3: Explanation of Mechanisms in RIIO

Mechanism	Explanation
Outputs (10)	– A number of outputs of value to consumers have been defined and the allowed revenue of companies partly depends on their performance on each of the different aspects
Stakeholder engagement (11)	– Companies are required to engage with a range of stakeholders on the development of business plans – In the business plans, the companies must document the views of stakeholders and demonstrate how they have been influenced by their stakeholder engagement
Individualised contracts (12)	– The contract with each company is highly dependent on company-specific circumstances
Efficiency incentive rate (13)	– The efficiency incentive rate determines by which share investors and consumers split the benefits that arise when the company delivers outputs for less money than was assumed in the price control review – Similarly, investors and consumers will share the additional costs if the company spends more money than assumed
No retrospective adjustments (14)	– Ofgem commits to not making retrospective adjustments to allowed revenue in the event that costs turn out to be different to what was assumed in the price control or in case an innovation project turns out to be ineffective at delivering the intended benefits, apart from cases where outputs are not delivered or there is a concern that a company has manifestly wasted money
Uncertainty mechanisms (15)	– Adjustments to allowed revenue to ensure funding during the regulatory period for elements Ofgem could not determine up front – Uncertainty mechanisms include, for example, compensation for changes in general price inflation, volume drivers, and annual adjustments to the cost of debt
Mid-period review (16)	– A mid-period review of output requirements can lead to changes in the output levels that companies are required to deliver
Ofgem's general financing duty (17)	– Companies can request changes to be made to the price control in the event that financeability is put at risk due to highly significant uncertain events occurring during the price control
Assessment of efficient costs via benchmarking, etc. (18)	– Ofgem employs a number of tools in their assessment of efficient costs – The tools include benchmarking, random inspections, expert evaluations, market testing, etc.

Continued on next page

Table A.3: Explanation of Mechanisms in RIIO, continued

Mechanism	Explanation
IQI mechanism (19)	– By the incentive quality incentive (IQI), the efficiency incentive rate varies according to the extent by which a company's business plan forecast differs from Ofgem's assessment of expected efficient costs of delivering outputs – The IQI intends to improve the quality of information that companies submit in their business plans by rewarding companies that submit better forecasts (closer to Ofgem's assessment of efficient costs) and penalising companies with high cost forecasts compared to Ofgem's view
Monitoring (20)	– Ofgem monitors performance on an ongoing basis, first of all by monitoring performance on primary outputs and secondary deliverables
Longer regulatory period if approved upon application (21)	– Ofgem has decided to shorted the regulatory period from eight to five years going forward – However, companies can be allowed a longer regulatory period if they make a compelling case for this, such as greater efficiencies or innovation
Secondary deliverables (22)	– To encourage companies to focus on the longer term, Ofgem allows for costs in the current period which are related to the delivery of primary outputs in future periods – Secondary deliverables could, for example, be the achievement of milestones related to delivery of a project
Innovation stimulus package (23)	– The innovation stimulus package can provide partial funding for innovation projects that intend to deliver a sustainable energy sector
Proportionate assessment of business plans (24)	– The level of scrutiny of business plans varies according to the quality of business plans submitted, the company's performance in previous periods, and a benchmarking of business plans
Decisions can be appealed to complaints board (25)	– Ofgem's decisions can be appealed to the Competition and Markets Authority

End of table

Table A.4: Explanation of Mechanisms in the Regulation of Scottish Water

Mechanism	Explanation
Negotiation between Customer Forum and Scottish Water (26)	– A Customer Forum has been established to negotiate and reach an agreement with Scottish Water on behalf of the generality of customers
Customer research programme (27)	– To understand the priorities and preferences of the broader customer base, the Customer Forum and Scottish Water must jointly carry out a customer research programme
Financial tramlines (28)	– The financial tramlines are acceptable ranges for three cash-based financial ratios which indicate financial strength of the company
Allowed revenue is linked to deliverables (29)	– Allowed revenue is linked to deliverables agreed between the Customer Forum and Scottish Water assisted by the regulators guidance notes
Guidance notes (30)	– The regulator prepares guidance notes to support the negotiations between the Customer Forum and Scottish Water – For example, the guidance notes can indicate where the regulator agrees with Scottish Water's proposals and where it considers more detail is required
Assessment of efficient costs via benchmarking, etc. (31)	– Benchmarking is one of the tools used by the regulator to assess the company's business plan
Output monitoring group (32)	– The performance of Scottish Water in delivering outputs is monitored quarterly by the Output Monitoring Group
Long term payback initiatives (33)	– The Customer Forum can agree with Scottish Water that the company is allowed to retain cost savings from long-term projects until the accumulated savings have paid the upfront cost of the investment, including the cost of capital
25-year strategic vision (34)	– The strategic vision is prepared by Scottish Water in dialogue and negotiation with the Customer Forum and the quality regulators – The strategic vision provides a long-term outlook of the financial resources needed to carry out required improvements
Decisions can be appealed to complaints board (35)	– The regulator's decisions can be appealed to the Competition and Markets Authority

Chapter 2

Balancing Rent Extraction and Service Differentiation

Anita Eskesen and Peter Bogetoft

Abstract

In the regulation of natural monopolies such as regional utilities, several goals must be balanced. In this paper, we focus on the trade-off between rent extraction and service differentiation. Consumers in different regions may prefer different service levels and service mixes. The services provided should therefore ideally be aligned with the preferences of the regional consumers. The utilities, however, have superior information about the cost of different services. This allows them to extract information rents by claiming high cost on the provided services. Relative performance evaluation in the form of benchmarking is typically used to limit the information rents, but benchmarking is less efficient when service profiles are heterogeneous. Hence, there is a trade-off between minimising the information rents and maximising the adjustment to consumer preferences via service differentiation. In this paper, we study this trade-off in a simple principal-agent model and we discuss how the trade-off may limit the usefulness of recent regulatory frameworks based on dialogue and negotiations with utilities about which services to provide.

2.1 Introduction

Large infrastructure industries such as the networks to distribute electricity, gas, and water, commonly referred to as Distribution System Operators (DSOs), are characterised by considerable fixed costs and relatively low marginal costs. They therefore constitute natural monopolies and they are generally given licenses to operate as legal monopolies. Monopolies have limited incentives to reduce costs, and will tend to under-produce and over-charge the services provided since they are not subject to the disciplining forces of the market. Most countries therefore empower regulators to act as a proxy purchaser of the services, imposing constraints on the prices and the modalities of the production. One of the instruments used in the regulation is benchmarking, i.e. comparison of different utilities with the aim of determining reasonable costs for the services provided.

Modern economic theory views the regulatory problem as a game between a principal (the regulator) and a number of agents (the regulated firms). The regulation problem is basically one of controlling firms that have superior information about their technology and their cost reducing efforts as compared to the regulator. Using relative performance evaluation and benchmarking, the regulator can partially undermine the information asymmetry. The regulatory toolbox contains many alternative regulatory proposals based on more or less formalised relative performance evaluations, including cost-recovery regimes (cost of service, cost-plus, rate of return), fixed price (revenue) regimes (price-cap, revenue-cap, RPI-X), yardstick regimes, and franchise auction regimes, cf. also Agrell and Bogetoft (2018).

In the case of DSO regulation, regulators have mainly focused on providing incentives to lower cost for given services. The trade-off between service levels and information rents has not been much of an issue because the demand for services has largely been considered inelastic and relatively stationary. The aim of the regulation has therefore been to lower the historical cost levels. The most commonly applied regulation is the RPI-X approach based on the simple idea of Littlechild (1983). The RPI-X formula implies that historical costs cannot increase more than the growth rate of a retail price index minus a target productivity growth, X, intended to capture the general productivity growth and possibly minus a specific requirement, X_i, intended to ensure that utility i gradually eliminates its historical inefficiency compared to best practices.

According to Joskow (2014), as incentive regulation has evolved, focus has shifted from

reducing operating costs to investment and various dimensions of service quality. Many countries have indeed introduced some quality incentives, typically by add-on models that, for example, penalise the DSOs for energy not delivered during black-outs. Likewise, many regulators have shifted the cost focus from pure operation costs, Opex, to total expenditures, Totex, which includes also the capital expenditures, Capex.

Recently the infrastructure sectors have also started to discuss the need for new services and the regulatory adjustment needed to support the introduction of such services. A main driver of this has been climate challenges and the need for a green transition. The green transition is for example expected to necessitate reinforcements of the electrical grid due to a growing number of electric vehicles and a more widespread use of decentralised generation. Likewise, the climate challenges are raising the need for investment in water installations to accommodate increased rainfalls and pollution of wells. Such changes could challenge the RPI-X approach. When allowed revenues are largely based on historic costs rather than expected future costs, it may be hard to accommodate the necessary adjustments and changes in focus. To properly compensate firms for the costs associated with service adjustments, the regulator may have to rely more on the firms' private information about future costs. This entails a trade-off between the gains from making service adjustments and the costs of increased rent extraction caused by the asymmetric information.

One way for regulation to become more forward-looking is to rely on yardstick regulation where the allowed revenue is determined ex post based on the actual costs. Yardstick regulation is used in, for example, the Norwegian regulation of DSOs in the electricity sector.

Another approach is to introduce ex ante dialogue of the desired future services and the cost of providing these. Examples of this approach include the Office of Gas and Electricity Markets' (Ofgem's) RIIO framework to regulate British DSOs and the Water Industry Commission for Scotland's (WICS') regulation of Scottish Water. Both frameworks were designed with the aim of encouraging the regulated firms to focus on delivering outputs which are valuable to consumers rather than solely focusing on economic efficiency.[1] Within each framework, the regulated firms are required to consult with their stakeholders and demonstrate how their business plans have been affected by stakeholders' views. The outputs

[1]See for example Ofgem (2010a) and Water Industry Commission for Scotland (2013)

pursued by each firm therefore depend on stakeholders' preferences in each of the geographic areas.

This paper focuses on this trade-off between service differentiation and information rents. More generally, as a contract design problem, it focuses on the trade-off between coordination of production and motivation of the agents, cf. e.g. Milgrom and Roberts (1992) and Bogetoft and Olesen (2004). That is, on ensuring that the right service mix is pursued compared to consumers' preferences while also minimising rent extraction. We study a simplified example of the problem where consumers in one area prefer a combination of services which is different from the preferred combination of services of consumers in another area. The regulator would therefore, in a first best world, like the two monopolies to produce different service combinations. In a second best world, however, this comes at a cost since it complicates the comparison of the two firms in a relative performance evaluation and in turn leads to higher information rents.

Specifically, we consider a principal-agent model where the regulator, as the principal, negotiates with two utilities (the agents) on their production of two different services. Remuneration is based on ex post costs using yardstick competition and the aim of the regulator is to maximise the consumer's net-value, i.e. the consumers' benefits from the services provided minus the costs they have to pay. We show that in some cases, and despite different preferences, it is optimal to let the two utilities produce the same services since the information rents associated with a diversified service mix outweigh the added value to consumers. More generally, the second best service mixes are biased towards each other compared to the first best mixes.

The paper proceeds as follows. Section 2.2 reviews related literature and provides regulatory examples that serve as a background to the problem we study. Section 2.3 presents the model by introducing assumptions about costs and utility functions and by formulating the regulator's contract design problem. In Section 2.4.1, we consider the optimal production plans under perfect information and in Section 2.4.2, we consider the case of asymmetric information. In Section 2.5, we discuss how different assumptions impact information rents. Section 2.6 concludes.

2.2 Background and Literature

Regulation of natural monopolies is an example of the principal-agent problem. Section 2.2.1 therefore reviews the agency literature to which our paper is most closely related. Section 2.2.2 draws on contract theory to describe the concept of coordination as a goal for contract design and Section 2.2.3 reviews some regulatory examples that serve as a background for the problem we study.

2.2.1 Agency Theory

The problem of regulating a monopolist with private information has been studied in the framework of the principal-agent literature since the pioneering contributions by Baron and Myerson (1982) and Loeb and Magat (1979). The application of principal-agent methodology to the contractual relationship between regulators and regulated firms has since been named 'the new economics of regulation' by Laffont (1994).

This paper is closely related to Antle and Bogetoft (2019) who show that the agent's superior information about the relative costs of different products or activities leads to inertia in the mix of products or activities pursued, i.e. a favouring of the status quo which is referred to as 'mix stickiness'. The more the principal varies the production plan, the larger the agent's ability to claim high motivation costs. Therefore, the principal may not want to adapt the production plan fully. In this way, the principal trades off coordination against the goal of reducing information rents. The model framework thus sheds light on the trade-off between coordination and motivation, i.e. the result that optimal coordination is not achieved because of motivational problems. Similarly to Antle and Bogetoft, we study a principal-agent model in which the agents produce two outputs. As an extension to the model considered by Antle and Bogetoft, we consider the problem in the context of utility regulation and in a setting where the principal does not have any historical information. Instead, the principal needs to regulate several agents while balancing the goal of coordination between the produced output mix and consumers' preferences against the goal of minimising information rents.

2.2.2 Coordination as a Goal for Contract Design

Coordination of production as a goal for contract design has been described by Bogetoft and Olesen (2004) as the objective of making sure that the right producers are producing the right quantity of the right products at the right time and place. In the context of utility regulation, coordination of production can be seen as the alignment between the combination of services desired by consumers and the combination of services produced by the regulated firms. Perfect coordination of production would mean that the right combination of services is being produced compared to consumers' preferences, given what is feasible on the production possibilities frontier. Service combinations on the production possibilities frontier that reflect perfect coordination are therefore equivalent to the notion of first-best outcomes in the agency literature and can only be achieved with perfect information about the firms' production possibilities and consumers' preferences.

Coordination of production is also related to the concept of allocative efficiency. In the productivity analysis literature, allocative efficiency requires that the firm is able to select the correct mix of services such that an optimal balance between the benefit and cost sides is achieved.[2] If allocative efficiency is combined with technical efficiency, such that production takes place on the frontier and is optimally balanced with consumers' preferences, the outcome is equivalent to the first-best outcome.

Coordination is one of three main goals for contract design in the framework developed by Bogetoft and Olesen (2004). The other two main goals are motivation and minimisation of transaction costs. Together, the three goals contribute to the overall goal of maximising integrated profit, i.e. the sum of profits of all the contracting parties in a production chain context as analysed by Bogetoft and Olesen. In the context of utility regulation, the overall goal of the regulator would be to maximise social welfare. The three overall goals however need to be balanced since they may conflict in a way where focusing on one objective comes at the cost of assigning a lower priority to another objective. The regulator therefore needs to prioritise between the different objectives and must accept trade-offs between them. When prioritising coordination of production, it may come at the expense of providing incentives for the firm to control its costs (the moral hazard problem) and minimising information rents (the adverse selection problem).

[2]See for example Bogetoft (2012)

2.2.3 Regulatory Examples

Based on the hierarchy of goals for contract design developed by Bogetoft and Olesen (2004), Eskesen (2021) illustrates, by four regulatory examples, how utility regulators have prioritised various goals of contract design in different ways. In the regulation of British electricity and gas networks (RIIO), Scottish Water, and Copenhagen Airport, customers and other stakeholders are involved in the regulatory process thereby creating an opportunity for higher coordination between consumer preferences and production possibilities. In contrast, the regulation of Danish electricity distribution companies is an example of a revenue-cap regulation where the model for calculating allowed revenues is fixed by law so that company or consumer specific circumstances, which are not accounted for in the legislation, cannot be taken into account. Coordination of production therefore seems to be less of a priority in this case.

According to Joskow (2014), as incentive regulation has evolved, focus has shifted from reducing operating costs to investment and various dimensions of service quality. In the UK, this change in focus can be seen in a change away from an RPI-X regulation to the RIIO model in 2010, as the existing RPI-X regulation was not considered robust to future challenges and focused more on economic efficiency than on outputs which are valuable to consumers (Ofgem, 2009). Among other issues, the regulator (Ofgem) was worried that RPI-X might not support the changing nature of energy network services and the associated uncertainty about which investments are necessary in the transition to a low carbon economy. To address these issues, regulation was changed in a way where consumers and other stakeholders are allowed a greater role in the decision making process and where allowed revenues of companies partly depend on their performance on a number of outputs. The companies set out their initiatives for the coming period in business plans and submit these to the regulator for assessment. The business plans must demonstrate how they are influenced by stakeholder engagement and thus provide the basis for a higher coordination of production, where outcomes reflect a higher alignment between stakeholders' preferences and companies' production possibilities. At the same time, it may be challenging to assess the cost-efficiency of proposed initiatives if the associated costs cannot be compared to historical costs or to the costs of other companies' business plans. In this way, prioritising coordination of production may come at the cost of providing companies with better

opportunities for rent extraction.

The regulation of Scottish Water and Copenhagen Airport is based on a direct negotiation between the regulated companies and their customers (or customer representatives). This facilitates coordination of production but private information, for example about costs, may impact negotiations and leave companies with more bargaining power. Therefore, in the regulation of Scottish Water, the regulator supports the Customer Forum in negotiations by issuing guidance on the most material parameters in price setting, e.g. on the scope for future efficiency improvements. However, the regulator's assessment of efficient costs is also challenged by private information, for example if new developments in the sector lead to new initiatives such that costs cannot easily be compared to historical costs. In the regulation of Copenhagen Airport, the regulator can participate as an observer in the negotiations between the airport and airlines or decide to enter into negotiations as a mediator if needed. Moreover, the regulator can order the parties to present whichever documentation and information the authority may find necessary to ensure transparency during negotiations. It has, however, proved difficult to ensure equality and transparency in negotiations which has led to adjustments in the regulation from year 2018 with the aim of increasing equality and transparency (Danish Transport, Construction and Housing Authority, 2017; Ministry of Transport, Building, and Housing, 2017).

In the revenue-cap regulation of Danish electricity distribution companies, allowed revenues are calculated on the basis of historical costs. Within the regulatory period, the revenue-cap is, however, subject to a number of different adjustments that reflect changes in conditions beyond the companies' control. Adjustments can be made either on application from the companies or by an automatic link to a price index or activity-indicators (Danish Ministry of Climate, Energy and Utilities, 2018). Allowed revenue is generally mechanically determined and governed by a legislation that specifies the conditions for all adjustments. Moreover, a benchmarking model determines the relative efficiency of companies which results in efficiency requirements to the least efficient companies. The companies may therefore make operation and investment decisions based on the expected effect on the revenue-cap and their relative efficiency. In this case, costs may be easier to compare, both over time and across companies, which reduces opportunities for rent extraction, but the decisions made by companies may not reflect coordination with consumers and other stakeholders.

2.3 Model

We consider a regulator (the principal) negotiating with two utilities (the agents) on the production of different services and the remuneration for providing these services. Services could, for example, encompass the duration of customer interruptions, grid capacity, time to connect new demand and the establishment of new generation nodes. Here, we limit the scope to the mix of two different services, y_1 and y_2. We let $y^i = (y_1^i, y_2^i) \in \mathbb{R}_+^2$ be the observed service profile produced by agent i.

We might think of the underlying production possibilities as being defined by a cost function $\phi : \mathbb{R}_+^2 \to \mathbb{R}_+$ and let c_i be the underlying minimal costs of producing $y^i = (y_1^i, y_2^i)$, i.e.,

$$c^i = \phi(y_1^i, y_2^i), \;\; i = 1, 2$$

We have here assumed that the agents have the same cost function. It is therefore clear that relative performance evaluation is meaningful. Of course, as is well-known from the literature, relative performance evaluation is relevant more generally where there is some correlation between the costs faced by the two agents, i.e. if they are both affected by a common price index.

We will assume that the principal does not know ϕ. The principal only knows that costs are weakly increasing in the services produced.

The agents are better informed. We assume that they do not know ϕ in all details,[3] but they know costs locally. That is, if the principal asks an agent to produce y, the agent can determine $\phi(y)$. This seems to be a reasonable assumption in applications. We will ignore the possible search costs of finding $\phi(y)$.

To formalise the assumption a little more, we might assume that agent i has private information about his type

$$\psi^i \in \Psi^i$$

When the aim is to produce y^i, we might think of ψ^i as local cost function with $\psi^i(y) \geq \phi(y)$ $\forall y$ and $\psi^i(y^i) = \phi(y^i)$. More specifically, we can think of ψ^i as the cost function of the technology that leads to lowest cost of producing y^i. In this setting, we can think of ϕ as

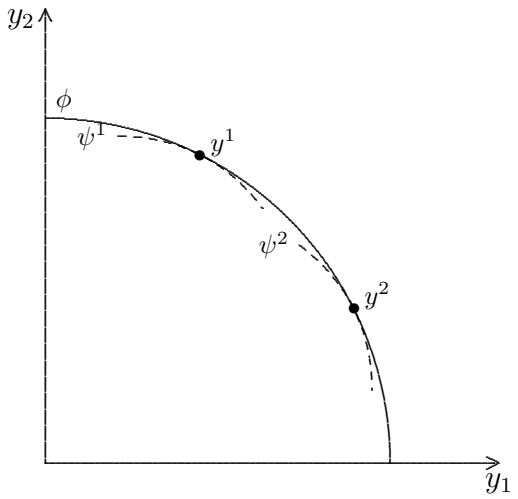
[3] If the agents know ϕ, one can incentivise them to "freely" reveal this information, e.g. by introducing a very harsh punishment should their cost function messages deviate

the lower envelope of the local technologies Ψ, i.e.,

$$\phi(y) = \min_{\psi^i \in \Psi^i} \psi^i(y) \quad \forall y \in \mathbb{R}^2_+, \ \forall i$$

This is similar to the idea of long run cost curves being a lower envelope of short run cost curves. An illustration is given in Figure 2.3.1 below.

Figure 2.3.1: Envelope of Local Cost Functions



We let $x^i \in \mathbb{R}_+$ be the observed cost of agent i. The costs may not necessarily be the minimal costs $\phi(y^i)$ necessary to produce the services y^i since the agent may be inefficient or earn information rents. To model this, we assume that the regulator can observe and verify the output y^i and the incurred costs x^i but the regulator cannot observe the minimal costs of producing y^i.

The actual costs x^i of agent i may include inefficiency or slack, $s^i \geq 0$. That is we assume that

$$x^i = \phi(y^i_1, y^i_2) + s^i, \ \ i = 1, 2.$$

Slack, s^i, makes it easier for agent i to operate. We can model this in the simplest possible way by assuming that slack comes with a monetary equivalent value of $\rho^i s^i, \ \ i = 1, 2$ to agent i. Here $\rho^i \in [0, 1)$ is the marginal value of slack compared to monetary profit. If $\rho = 0.6$, it means that \$1 spent on slack gives the same value to agent i as \$0.6 profit. More generally, we can assume that the agents' utility is increasing in profits and slack and that the marginal utility of profit exceeds the marginal utility of slack. For more on such models, see Bogetoft

(1997) and Bogetoft (2000).

We also assume that the two utilities serve different consumers. The agents may for example operate in separate geographic areas with associated consumers. The consumer groups have different preferences. We let $u^i = u^i(y_1^i, y_2^i),\ \ i = 1, 2$ be the gains (in monetary equivalents) to consumer group i from receiving services (y_1^i, y_2^i).

Lastly, we let the consumers' payments for the services received be denoted as the transfers $t^i,\ \ i = 1, 2$. The transfer will depend on the contractable information. We will first consider a revelation game where the transfers depend on the agents private information, $t^i(\psi^1, \psi^2)$. Next, we turn to a more specific case more in line with traditional regulation. Here, the transfer depends on the contractible information ex post, i.e. the realised costs of both agents and the service profiles they provide, $t^i(x^1, x^2, y^1, y^2)$. The transfer scheme is the core of the regulation. It defines how the agents are rewarded as a function of their observable outcomes.

The objective of the end-consumers is to maximise their net value, i.e. their utility from the services provided minus their payment for those services:

$$V^i = u^i - t^i,\ \ i = 1, 2.$$

Since the regulator aims to serve as a proxy-buyer, the regulator seeks to maximise the sum of these values:

$$V^1 + V^2$$

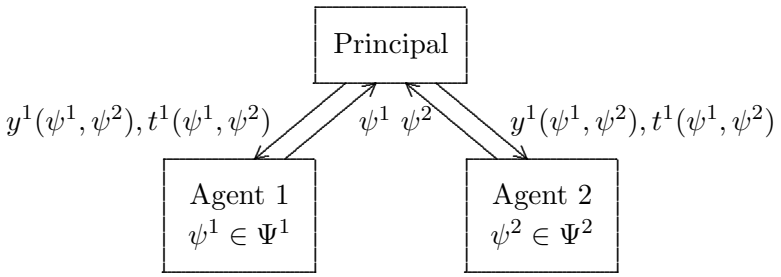
The agents, on the other hand, seek to maximise the transfer received minus the cost of providing the services plus the possible gains from operating with slack:

$$W^i = t^i - x^i + \rho^i s^i \ \ i = 1, 2$$

Now, to summarise the general setting, we can use a revelation game as illustrated in Figure 2.3.2 below.

The idea is that the agents get signals ψ^i, $i = 1, 2$, about their cost types and send this information to the principal. The principal then decides on the production plans to be implemented, y^i, $i = 1, 2$, as well as the transfers $t^i, i = 1, 2$. The production and transfer

Figure 2.3.2: Revelation Game



plans are therefore mappings, $y^i[\cdot] : \Psi^1 \times \Psi^2 \to \mathbb{R}^2_+, i = 1, 2$, and $t^i[\cdot] : \Psi^1 \times \Psi^2 \to \mathbb{R}_+$, $i = 1, 2$.

From the revelation principle, we know that any solution to the principal's problem can also be implemented as a direct revelation game where the agents have incentives to reveal their true types. We can therefore formulate the principal's general problem as a mathematical program,

$$\max_{t^1,t^2,y^1,y^2} \quad E_{\psi^1,\psi^2}\left[\sum_{i=1}^{2} V^i(y^i(\psi), t^i(\psi))\right] = E_{\psi^1,\psi^2}\left[\sum_{i=1}^{2}(u^i(y^i(\psi)) - t^i(\psi))\right]$$

$$\begin{aligned}
\text{s.t.} \quad W^i(y^i(\psi), t^i(\psi)) &\geq 0 && \forall \psi^i \in \Psi^i \ \forall i && (IR)\\
W^i(y^i(\psi), t^i(\psi)) &\geq W^i(y^i(\tilde{\psi}^i, \psi^{-i}), t^i(\tilde{\psi}^i, \psi^{-i})) && \forall \psi^i \in \Psi^i, \tilde{\psi}^i \in \Psi^i \ \forall i && (IC)\\
y^i(\psi) \in \mathbb{R}^2_+, &\quad t^i(\psi) \in \mathbb{R} && \forall \psi^i \in \Psi^i \ \forall i &&
\end{aligned}$$

where we stick to the common notation of ignoring the superscript when covering both agents, e.g. $\psi = (\psi^1, \psi^2)$ and where superscript $-i$ refers to the agent who is not i.

The principal's objective is to choose production plans and transfer schemes that maximise the expected net-utility to the end-consumers subject to incentive compatibility (IC) constraints, ensuring that the agents will reveal their true private information instead of manipulating their private information, ψ^i, and instead send a message, $\tilde{\psi}^i$. Lastly, we include individual rationality (IR) constraints to ensure that the agents will participate. In the regulation of critical infrastructure, the regulator naturally wants to avoid disruption of

services. Another way to express this is to say that the principal cannot reduce information rents by rationing away certain agent types.[4]

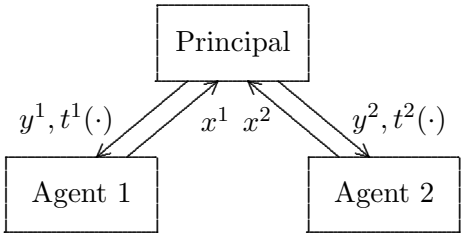
Solving the full revelation game is complicated and requires more specific assumptions about the technology. Antle and Bogetoft (2019) investigate a related problem under the assumption that the underlying cost function is linear but the principal has limited information about the marginal costs of the two outputs. The principal only knows that $cy^0 \leq x^0$. They show that the optimal solutions tend to be biased towards the historical plan, y^0. In the example below, we will also make more specific assumptions about the underlying cost function.

Another complication is the choice of optimal production plans. Antle and Bogetoft (2019) did not fully integrate the choice of production plan – they simply explored the role of the production plan to be implemented and showed that implementation becomes more costly, the more the new plan deviates from the historical plan. In the following, we will also not solve the full problem. Instead, we solve the problem for different values of the production mixes and show how this affects the agents and the end-consumers. In particular, we will illustrate the extra costs of implementing differentiated production plans.

When the production plans are fixed, the principal's problem reduces to the design of transfer schemes that are individually rational and make it optimal for the agents to minimise the costs of producing the outputs. We can illustrate this as the simple relative performance set-up in Figure 2.3.3.

[4]When rationing is possible, the analysis becomes more complicated, but the qualitative insight about information rents increasing in the product differentiation, is not changed. For an analysis with rationing, see Antle and Bogetoft (2019).

Figure 2.3.3: Relative Performance Evaluation Approach



Here, the principal initially instructs the agents what to produce. Next, costs are observed and finally, the transfers are made. The agents know the transfer plans when they select their cost levels. When production plans are fixed, the principal's problem reduces to one of minimising the cost of implementing these plans. The corresponding mathematical program is

$$\min_{t^1,t^2} \quad E_{c^1,c^2}\left[\sum_{i=1}^{2} t^i(y,c^1,c^2)\right]$$

$$\begin{array}{lllll}
\text{s.t.} & W^i(y^i,t^i(y,c)) & \geq & 0 & \forall \psi^i \in \Psi^i \ \forall i \qquad (IR) \\
& W^i(y^i,t^i(y,c)) & \geq & W^i(y^i,t^i(\tilde{c}^i,c^{-i})) & \forall c^i \in C^i, \tilde{c}^i \in C^i \ \forall i \quad (IC) \\
& t^i(c) \in \mathbb{R} & & & \forall c \in C^1 \times C^2 \ \forall i
\end{array}$$

where $C^i\{\psi^i(y^i) \mid \psi^i \in \Psi^i\},\ i = 1,2$, is the set of possible cost levels for agent i when the production plan is fixed at y^i.

2.4 A Numerical Example

To illustrate the principal's challenge of balancing the costs and benefits of adjusting production to end-users' preferences, let us consider some numerical examples.

Specifically, we will assume that the cost of producing (y_1, y_2) is

$$c = \phi(y_1, y_2) = \begin{cases} 100\sqrt{y_1^2 + y_2^2} & \text{if } y_1^2 + y_2^2 \leq 1 \\ \infty & \text{otherwise} \end{cases}$$

We see that the cost function is an increasing, free-disposable function that satisfies constant returns to scale on the positive quadrant of the (closed) unit disk, and that it is not possible to produce outside this area.[5] We see also that the costs is 100 on the production possibility frontier.

Now, as above, we will assume that the principal does not know this function. He only knows that the underlying cost function is an increasing, free-disposable and constant returns to scale cost function on the unit disk and that production is not possible outside the disk. We also assume that the agents have this information. In addition, the agents can determine the costs of a specific production plan they may be asked to implement, corresponding to the relative performance evaluation framework illustrated in Figure 2.3.3.

Consumers' preferences are first assumed to be given by Cobb-Douglas utilities:

$$u_1 = K y_1^{1/5} y_2^{4/5}$$

$$u_2 = K y_1^{4/5} y_2^{1/5}$$

where K is a constant. Consumer group 1 thus values y_2 higher than y_1 while consumer group 2 values y_1 higher than y_2. We let $K = 300$ in our base case, but any $K \geq 100\sqrt{2}$ can be used in our calculations.[6] We will later consider the case where consumers have Leontief preferences.

[5] We could alternatively have assumed that the cost function was quadratic, e.g. $100(y_1^2 + y_2^2)$ but this would make calculations more complicated since we would have to not only find the optimal mix of services, also the optimal length of the service vector. This means that we would have to look not only at the marginal rates of substitution between the products but also the directional derivatives of the utility and cost functions.

[6] The condition $K \geq 100\sqrt{2}$ ensures that the directional distance in the direction of all the points on the unit circle we investigate is at least 100 and hence that it is optimal under perfect information to produce at the unit circle instead of inside the unit circle

2.4.1 First-Best – Perfect Information

As a benchmark, suppose first that the regulator has perfect information about the underlying cost function and consumers' preferences.

In this case, the agents cannot manipulate the description of costs. The IC constraint is therefore not relevant. Leaving any rents to the agents also increases the costs to principal. Hence, the IR constraint must be binding. In the first-best solution, the agents are therefore simply paid the minimal production costs. In particular, the principal shall not allow any slack.

The regulator's optimisation problem in the case of perfect information separates in two sub-problems, one for each of the agents:

$$\max_{y_1,y_2} 300 y_1^{1/5} y_2^{4/5} - 100\sqrt{y_1^2 + y_2^2}$$

$$\max_{y_1,y_2} 300 y_1^{4/5} y_2^{1/5} - 100\sqrt{y_1^2 + y_2^2}$$

The first-order conditions imply for consumer 1 that $2y_1 = y_2$ and for consumer 2 that $y_1 = 2y_2$. Substituting back into the production function, we obtain the following first-best outcomes, which are illustrated in Figure 2.4.1.

$$y_1^1 = \sqrt{1/5}, \quad y_2^1 = \sqrt{4/5}$$
$$y_1^2 = \sqrt{4/5}, \quad y_2^2 = \sqrt{1/5}$$

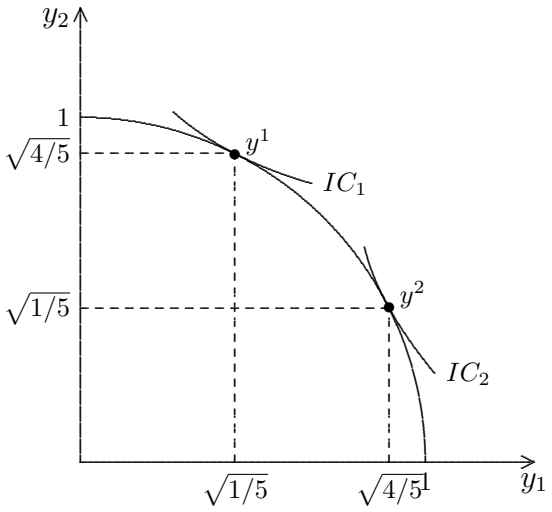
These are the service levels that maximise consumers' utility within the production possibilities set:

$$u_1 = 300 \left(\sqrt{1/5}\right)^{1/5} \left(\sqrt{4/5}\right)^{4/5} \approx 234$$

$$u_2 = 300 \left(\sqrt{4/5}\right)^{4/5} \left(\sqrt{1/5}\right)^{1/5} \approx 234$$

In the first-best solution, the parties coordinate optimally, i.e. the produced services provide each consumer (group) with the highest possible utility, given the available technology.

Figure 2.4.1: The First Best Solution



2.4.2 Second-Best

Since the regulator only knows that the cost function is increasing, freely disposable and has constant returns to scale on the unit disk, the regulator has to rely on relative performance evaluation to determine reasonable transfers.

By the revelation principle we can assume that the agents must have incentives to reveal the true costs. The agents will only do so if they are not penalised for telling the truth. Assume now that agent 2 has produced y^2 as in Figure 2.4.2 below and reported the true costs x^2. In this case, the principal knows with certainty that all production plans to the south west of y^2 are also feasible at a cost of x^2. Besides, he knows that the cost function is increasing and constant returns to scale on the unit disk. A worst case cost function from the point of view of the principal, i.e. the highest cost function consistent with the available information, is therefore a cost function with x^2 isoquant defined by the dashed lines originating from y^2 in Figure 2.4.2. This cost function can be formally defined as:

$$\tilde{\phi}(y) = \max\{\frac{y_1}{y_1^2}, \frac{y_2}{y_2^2}\} \text{ for } (y_1)^2 + (y_2)^2 \leq 1$$

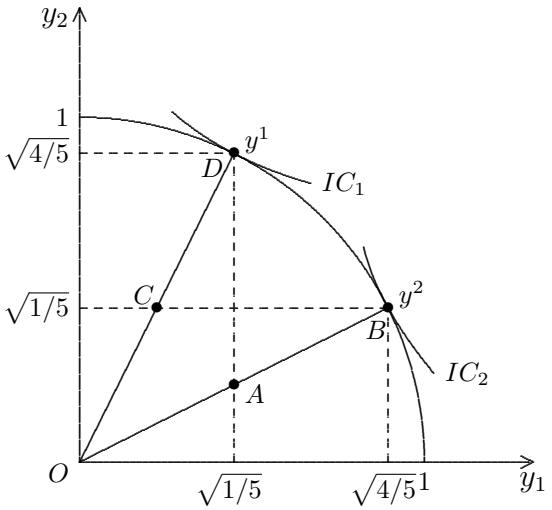
If this was actually the true cost function, the cost of the other production plan, y^1, in Figure 2.4.2 would be $\frac{OD}{OC}x^2$ where OD is the distance between the origin O and the point D, and OC similarly is the distance of O to D. By the no rationing, individual rationality constraint, the principal will therefore have to pay at least $\frac{OD}{OC}x^2$. Also, since this is independent of the

actual cost of agent 1, x^1, it makes it incentive compatible to reveal the cost of y^1, namely $x^1 = \phi(y^1)$. We can of course make similar inference about the worst-case cost function based on (y^1, x^1) information and use this to determine the compensation of agent 2. In summary, we therefore must have:

$$t_1 = \frac{OD}{OC}x^2$$
$$t_2 = \frac{OB}{OA}x^1$$

In the optimal compensation plans, agents are honest since their cost claim does not affect an agent's own payoff. However, as illustrated below, agents earn information rents when their production plans are different from other agents' production plans. This is due to the fact that agent's are compensated on the basis of the worst possible technology from the regulator's point of view. However, the regulator is left with no other option when the efficiency frontier is unknown to the regulator and when the regulator cannot ration.

Figure 2.4.2: Implementation of First-Best Solution in Second-Best World



Solutions with Cobb-Douglas Preferences

Using the same specific values for parameters in the utility function as in Section 2.4.1, the bundles A and C and the distances, OA and OC, can be computed as follows:

$$A = \left(\sqrt{1/5}, \frac{\sqrt{1/5}}{\sqrt{4/5}}\sqrt{1/5}\right) = \left(\sqrt{1/5}, \sqrt{1/20}\right)$$

$$OA = \sqrt{\left(\sqrt{1/5}\right)^2 + \left(\sqrt{1/20}\right)^2} = \sqrt{1/4} = \tfrac{1}{2}$$

$$C = \left(\frac{\sqrt{1/5}}{\sqrt{4/5}}\sqrt{1/5}, \sqrt{1/5}\right) = \left(\sqrt{1/20}, \sqrt{1/5}\right)$$

$$OC = \sqrt{\left(\sqrt{1/20}\right)^2 + \left(\sqrt{1/5}\right)^2} = \sqrt{1/4} = \tfrac{1}{2}$$

When $x^1 = x^2 = 100$, the payments and information rents can be computed as follows:

Payment to agent 1 (t_1):	$\frac{OD}{OC}x^2 = \frac{1}{1/2}100 \quad = 200$
Payment to agent 2 (t_2):	$\frac{OB}{OA}x^1 = \frac{1}{1/2}100 \quad = 200$
Information rents to agent 1 ($t_1 - c$):	$200 - 100 = 100$
Information rents to agent 2 ($t_2 - c$):	$200 - 100 = 100$

In this case, we have perfect coordination, i.e. we maximise consumers' utility, but it comes at the cost of providing the companies with information rents. Alternatively, by choosing service mixes that are closer to each other, we can reduce information rents. For example, as illustrated in Figure 2.4.3, the regulator could ask agent 2 to produce D' instead of D, it could ask agent 1 to produce B' instead of B, or it could ask both agents to produce E. Table 2.4.1 shows the corresponding utilities and information rents of the different service combinations, thereby illustrating the trade-off between service differentiation and rent extraction. Information rents are minimised at point E, where both agents produce the same service mix but coordination with consumers' preferences is lower than at the points (D, B) which is reflected in lower utility levels. However, point E maximises the total value to consumers, i.e. utility adjusted for the transfer to the companies, $V^i = u^i - t^i$. At points D' and B', coordination is improved compared to E at the cost of increasing information rents. When maximising the total value to consumers, the optimal second-best solution is

for both companies to produce the same bundle corresponding to point E in Figure 2.4.3.

Figure 2.4.3: Varying the Output Mixes

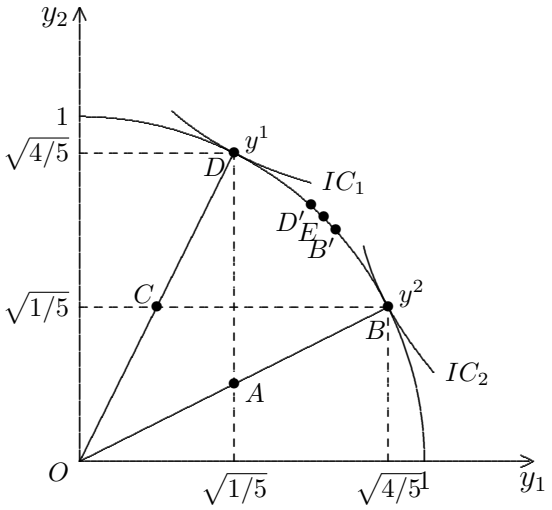


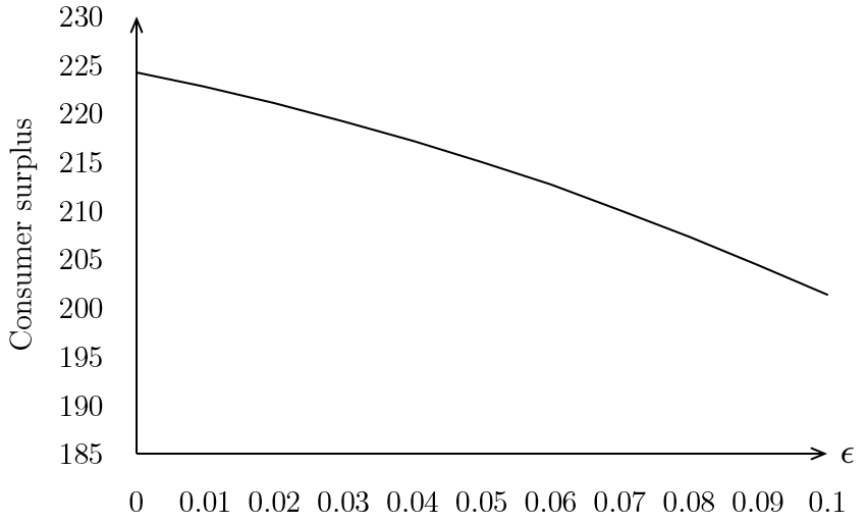
Table 2.4.1: Variation of Output Mix for K=300

		First-Best	Second-Best				
		(D,B)	(D,B)	(E,E)	(B,B)	(D,D)	(D',B')
Payment of agent 1	t^1	100	200	100	100	100	111
Payment of agent 2	t^2	100	200	100	100	100	111
Total payment of agents	$t^1 + t^2$	200	400	200	200	200	221
Profit of agent 1	w^1	0	100	0	0	0	11
Profit of agent 2	w^2	0	100	0	0	0	11
Agents' total profit	$w^1 + w^2$	0	200	0	0	0	21
Consumer 1's utility	u_1	234	234	212	154	234	218
Consumer 2's utility	u_2	234	234	212	234	154	218
Consumers' total utility	$u_1 + u_2$	467	467	424	388	388	436
Net value to consumer 1	V_1	134	34	112	54	134	108
Net value to consumer 2	V_2	134	34	112	134	54	108
Total net value to consumers	$V_1 + V_2$	267	67	224	188	188	215

Notes: *i*) D=$(\sqrt{1/5}, \sqrt{4/5})$, B=$(\sqrt{4/5}, \sqrt{1/5})$, E=$(\sqrt{1/2}, \sqrt{1/2})$, D'=$(\sqrt{4/9}, \sqrt{5/9})$, B'=$(\sqrt{5/9}, \sqrt{4/9})$, $u_1 = Ky_1^{1/5}y_2^{4/5}$ and $u_2 = Ky_1^{4/5}y_2^{1/5}$, where $K = 300$

Furthermore, Figure 2.4.4 illustrates the change in consumer surplus as the production bundles deviate from the symmetric production bundle (E, E). Figure 2.4.4 shows that consumer surplus is strictly decreasing with the distance from (E, E).

Figure 2.4.4: Consumer Surplus as a Function of the Distance From (E, E) for $K = 300$



Note: Figure 2.4.4 illustrates the level of consumer surplus as the production plans diverge from $(E, E) = (\sqrt{1/2}, \sqrt{1/2})$ in the direction of the first-best outcomes: $y^1 = \left(\sqrt{1/2 - \epsilon}, \sqrt{1 - (1/2 - \epsilon)}\right)$ and $y^2 = \left(\sqrt{1/2 + \epsilon}, \sqrt{1 - (1/2 + \epsilon)}\right)$. The first-best outcomes are $y^1 = \left(\sqrt{1/5}, \sqrt{4/5}\right)$ and $y^2 = \left(\sqrt{4/5}, \sqrt{1/5}\right)$, which corresponds to $\epsilon = 0.3$.

Part of the reason why it is not worthwhile to deviate from (E, E) in this particular example is the magnitude of consumers' utility as reflected by $K = 300$. Higher values of K increase the weight on consumers' utility relative to the payment of companies, which can make it worthwhile to deviate from (E, E). For example, $K = 600$ changes the picture in a way where it is optimal to deviate from (E, E) to instead let the companies produce (D', B'). This case is illustrated in Table 2.4.2 below. Likewise, Figure 2.4.5 illustrates how consumers' surplus increases as the production plans deviate from (E, E) towards (D', B') and hereafter decreases.

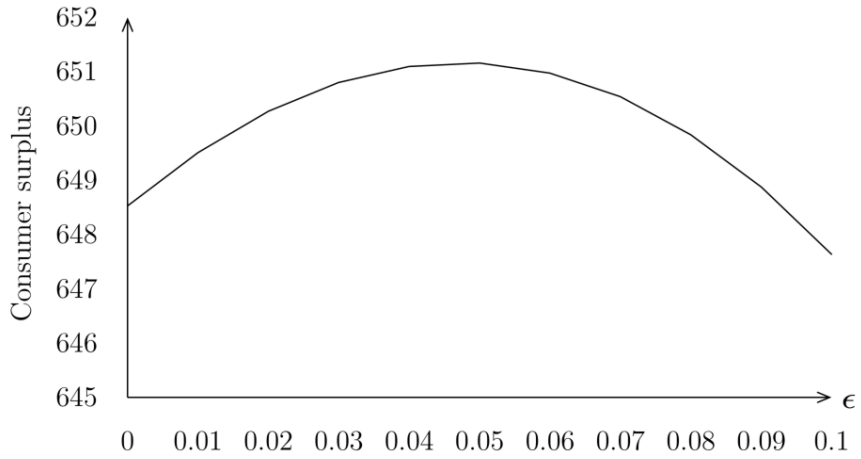
Another factor that affects the solution is the curvature of the indifference curves. More curved indifference curves would lead to a bigger loss of utility when deviating from the first-best outcome (D, B). In the following, we therefore supplement the analysis with an example using the limiting case of Leontief preferences where indifference curves are L-shaped.

Table 2.4.2: Variation of Output Mix for K=600

		First-Best	Second-Best				
		(D,B)	(D,B)	(E,E)	(B,B)	(D,D)	(D',B')
Payment of agent 1	t^1	100	200	100	100	100	111
Payment of agent 2	t^2	100	200	100	100	100	111
Total payment of agents	$t^1 + t^2$	200	400	200	200	200	221
Profit of agent 1	w^1	0	100	0	0	0	11
Profit of agent 2	w^2	0	100	0	0	0	11
Agents' total profit	$w^1 + w^2$	0	200	0	0	0	21
Consumer 1's utility	u_1	467	467	424	308	467	436
Consumer 2's utility	u_2	467	467	424	467	308	436
Consumers' total utility	$u_1 + u_2$	934	934	849	775	775	872
Net value to consumer 1	V_1	367	267	324	208	367	326
Net value to consumer 2	V_2	367	267	324	367	208	326
Total net value to consumers	$V_1 + V_2$	734	534	649	575	575	651

Note: D=$(\sqrt{1/5}, \sqrt{4/5})$, B=$(\sqrt{4/5}, \sqrt{1/5})$, E=$(\sqrt{1/2}, \sqrt{1/2})$, D'=$(\sqrt{4/9}, \sqrt{5/9})$, B'=$(\sqrt{5/9}, \sqrt{4/9})$, $u_1 = Ky_1^{1/5}y_2^{4/5}$ and $u_2 = Ky_1^{4/5}y_2^{1/5}$, where $K = 600$

Figure 2.4.5: Consumer Surplus as a Function of the Distance From (E, E) for $K = 600$



Note: Figure 2.4.5 illustrates the level of consumer surplus as the production plans diverge from $(E, E) = (\sqrt{1/2}, \sqrt{1/2})$ in the direction of the first-best outcomes: $y^1 = \left(\sqrt{1/2 - \epsilon}, \sqrt{1 - (1/2 - \epsilon)}\right)$ and $y^2 = \left(\sqrt{1/2 + \epsilon}, \sqrt{1 - (1/2 + \epsilon)}\right)$. The first-best outcomes are $y^1 = \left(\sqrt{1/5}, \sqrt{4/5}\right)$ and $y^2 = \left(\sqrt{4/5}, \sqrt{1/5}\right)$, which corresponds to $\epsilon = 0.3$.

Solutions with Leontief Preferences

We now assume that consumers' preferences can be represented by Leontief utility functions of the following form:

$$u_1(y_1, y_2) = 300 \min(2y_1, y_2)$$

$$u_2(y_1, y_2) = 300 \min(y_1, 2y_2)$$

The indifference curves for the utility functions are depicted in Figure 2.4.6. The consumers' utility is maximised when the optimal production bundles satisfy $2y_1 = y_2$ for consumer 1 and $y_1 = 2y_2$ for consumer 2. In this case, the first-best production bundles are similar to the previous case of Cobb-Douglas utility functions as illustrated in Figure 2.4.6. Using a second-best incentive scheme similar to that of the previous section, it is no longer optimal for the regulator to let the two agents produce identical production bundles for $K = 300$. As illustrated in Figure 2.4.7, consumer surplus is no longer strictly decreasing as the service mixes move from the symmetrical bundle (E, E) towards the specialised bundles (D, B). Specifically, consumer surplus is maximised[7] when agent 1's production is slightly

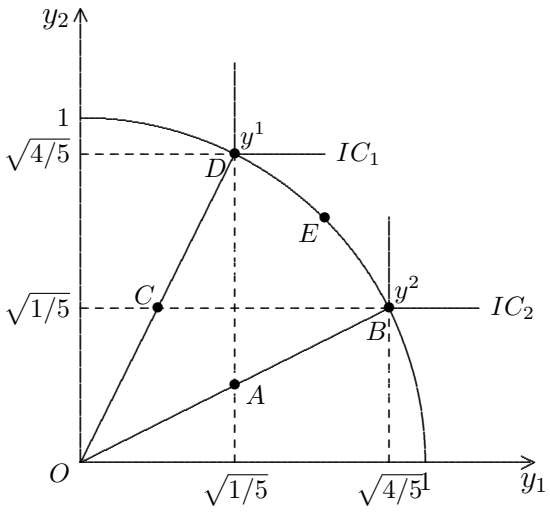
[7]Solved numerically using Excel Solver

biased towards D and agent 2's production is slightly biased towards B:

$$y^1_{SB} = (\sqrt{0.48}, \sqrt{0.52})$$

$$y^2_{SB} = (\sqrt{0.52}, \sqrt{0.48})$$

Figure 2.4.6: Leontief Preferences



Again; increasing K from 300 to 600 makes it more costly to deviate from consumers' preferred bundles. As a result, the optimal production plans are better aligned with consumer preferences:

$$y^1_{SB} = (\sqrt{0.30}, \sqrt{0.70})$$

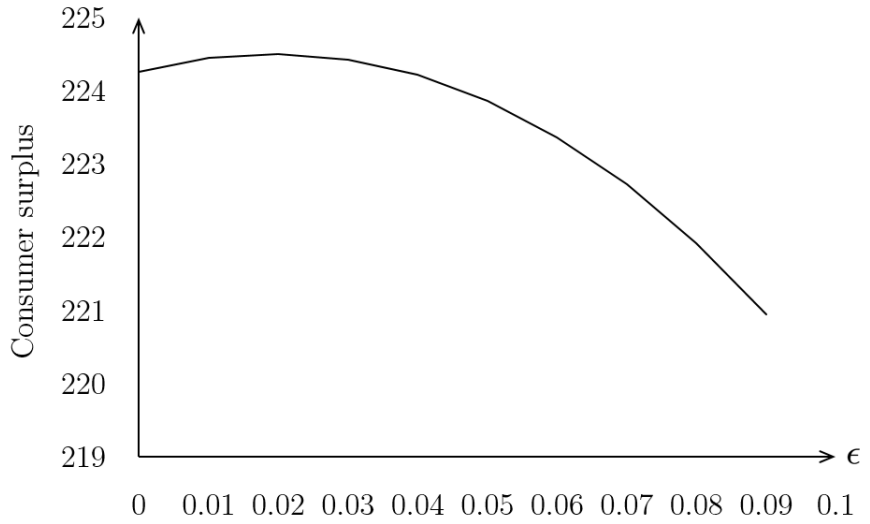
$$y^2_{SB} = (\sqrt{0.70}, \sqrt{0.30})$$

Accordingly, Figure 2.4.8 illustrates that consumer surplus is maximised at a much larger deviation from (E, E).

2.5 Discussion

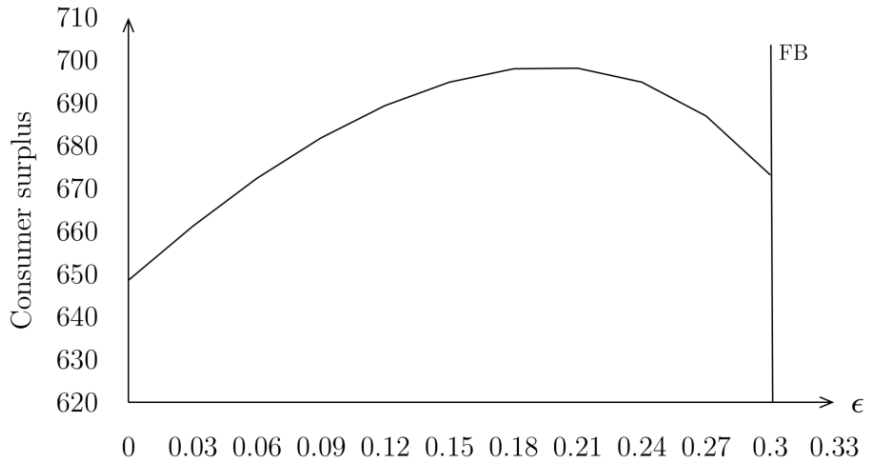
In Sections 2.3-2.4.2, we have considered stylised examples of utility regulation. One of the ways in which regulatory practices differ from our examples is with respect to the role of yardstick competition. This is discussed in Section 2.5.1. In Sections 2.5.2-2.5.5, we discuss other assumptions that affect information rents.

Figure 2.4.7: Consumer Surplus as a Function of the Distance From (E, E) for $K = 300$



Note: Figure 2.4.7 illustrates the level of consumer surplus as the production plans diverge from $(E, E) = (\sqrt{1/2}, \sqrt{1/2})$ in the direction of the first-best outcomes: $y^1 = \left(\sqrt{1/2 - \epsilon}, \sqrt{1 - (1/2 - \epsilon)}\right)$ and $y^2 = \left(\sqrt{1/2 + \epsilon}, \sqrt{1 - (1/2 + \epsilon)}\right)$. The first-best outcomes are $y^1 = \left(\sqrt{1/5}, \sqrt{4/5}\right)$ and $y^2 = \left(\sqrt{4/5}, \sqrt{1/5}\right)$, which corresponds to $\epsilon = 0.3$.

Figure 2.4.8: Consumer Surplus as a Function of the Distance From (E, E) for $K = 600$



Note: Figure 2.4.8 illustrates the level of consumer surplus as the production plans diverge from $(E, E) = (\sqrt{1/2}, \sqrt{1/2})$ in the direction of the first-best outcomes: $y^1 = \left(\sqrt{1/2 - \epsilon}, \sqrt{1 - (1/2 - \epsilon)}\right)$ and $y^2 = \left(\sqrt{1/2 + \epsilon}, \sqrt{1 - (1/2 + \epsilon)}\right)$. The first-best outcomes are $y^1 = \left(\sqrt{1/5}, \sqrt{4/5}\right)$ and $y^2 = \left(\sqrt{4/5}, \sqrt{1/5}\right)$, which corresponds to $\epsilon = 0.3$.

2.5.1 Yardstick Competition

Above we have made a series of assumptions about the class of possible cost functions and the information, which the principal and agents have access to. In this setting, we argued that a version of yardstick competition is optimal. The version we have used is related to the so-called DEA-based yardstick competition studied by Bogetoft (1997). It is the optimal regulation in some situations with considerable initial uncertainty about the class of possible cost functions.

More generally, yardstick competition is recognised for providing strong incentives for cost reduction: allowed revenue does not depend on the firm's own costs so the firms can profit from reducing their costs to beat the average of other firms' costs. In this way, the costs of all firms will converge towards the efficient cost frontier. Shleifer (1985) shows that yardstick competition, as a mechanism to regulate identical firms or heterogeneous firms with observable differences, can deliver the first-best outcomes in some settings. Importantly, accounting data is sufficient to achieve efficiency so the regulator's limited knowledge about true costs does not lead to a distortion of outcomes away from first-best outcomes:

> By relating the utility's price to the costs of firms identical to it, the regulator can force firms serving different markets effectively to compete. If a firm reduces costs when its twin firms do not, it profits; if it fails to reduce costs when other firms do, it incurs a loss. To use this scheme, the regulator does not need to know the cost reduction technology; the accounting data suffice to achieve efficiency. (Shleifer, 1985, p. 320)

However, the result is conditional on the regulator committing to letting firms go bankrupt if they choose inefficient cost levels. In practice, the regulator is usually not prepared to let firms go bankrupt. Many regulators adopt a hybrid of different incentive schemes that includes yardstick competition (Joskow, 2014). For example, the regulation of Danish electricity distribution companies is based on a revenue-cap regulation, where efficiency requirements are determined using a benchmarking model. In this case, allowed revenue depends largely on historical costs and investments as well as the imposed efficiency requirements. Historical costs are permitted to increase with inflation, activity levels, etc., minus efficiency requirements. In contrast to a 'pure' yardstick regulation, allowed revenue

is thus highly dependent on the utility's own historical cost reports. However, benchmarking intends to provide incentives for the utilities far from the efficiency frontier to move towards it and to reward utilities on the frontier. A utility will profit from delivering high efficiency levels and it will suffer from being inefficient relatively to other utilities. Since a yardstick competition would provide even stronger incentives for cost reduction, we use this mechanism to illustrate the trade-off between information rents and service differentiation. Other mechanisms that more accurately reflect current regulatory practices would be associated with higher information rents so yardstick competition provides a conservative estimate of the distortions.

2.5.2 Consumer Preferences

In Section 2.4.2, we found that the curvature of indifference curves does not change the conclusion a lot but it does have some impact. However, the magnitude of consumers' surplus relative to the payment of utilities has a big impact on whether it is worthwhile to differentiate productions plans, cf. Figures 2.4.5 and 2.4.8. The distance between the two groups' preferred output combinations is also important. The more similar the preferred service combinations are to each other, the more comparable are the utilities and the easier it is for the regulator to minimise information rents. If utilities produce exactly the same service mix, we can avoid information rents altogether. On the other hand, if the different consumer groups prefer very different sets of services, it will be more costly to match consumer preferences. Importantly, in the present setting and the base case, it is optimal to let the utilities produce the same service mix.

2.5.3 The Number of Utilities and Service Dimensions

Information rents are also affected by the number of utilities. By having only two utilities in our example, we have illustrated the worst-case scenario with respect to the number of utilities. A higher number of comparable utilities would inevitably reduce information rents as the distance between production plans gets reduced. Utilities that wish to maximise information rents would produce service combinations that are as different from each other as possible. This is related to the conclusions in location models, such as Hotelling's linear city model and Salop's circular city model (Hotelling, 1929; Salop, 1979). These models

study product differentiation where the difference between products is modelled as the difference between the products' location in a product space.

In Hotelling's linear city model, two firms that sell identical products choose their location along a street where consumers are identical, uniformly distributed, and face transportation costs. If consumers' transportation costs are quadratic, the two firms will locate at the opposite extremes of the city, i.e. with maximum differentiation (Aspremont, Jaskold Gabszewicz and Thisse, 1979). There are two underlying effects taking place; on one hand, there is an incentive for firms to reduce the distance to the other firm in order to increase their market share. On the other hand, as a firm get closer to its competitor, price competition intensifies and this will incentivise product differentiation. The second effect dominates the first effect if consumers' transportation costs are quadratic. In Salop's circular city model, consumers are uniformly distributed on a circle and a number of firms simultaneously choose whether or not to enter the market. Entry is associated with a fixed cost. The entering firms locate themselves equidistant from each other on the circle. The model shows that firms will enter as long as they get a positive profit, i.e. until the margin that they can charge above marginal cost will not cover the fixed cost of entry.

With natural monopolies, there is no market share effect as in Hotelling's model, since the utilities operate in separate geographic markets so their market share is fixed. Utilities therefore only face an incentive to differentiate their services as much as possible from the services of other utilities. Despite separate markets, profits will decrease with the number of utilities similarly to the circular city model due to yardstick remuneration. At some point, when the number of utilities is large enough, information rents will be so small that it is no longer optimal for the regulator to prevent a differentiation of production plans. Even with just four utilities, information rents can be avoided as long as the four utilities are pairwise similar. However, whether the problem is still relevant with a large number of utilities also depends on the number of service dimensions. We have considered the case of just two service dimensions but, in practice, we could easily observe a higher number. A higher number of service dimensions would increase information rents, given the number of utilities, as the product space expands. Overall, information rents are therefore highly dependent on the prevailing structure which is characterised by a number of factors including: i) the number of utilities, where a higher number reduces information rents, ii) the spatial location

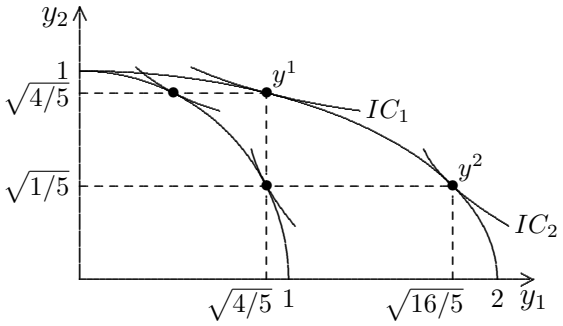
of utilities, where a shorter distance between utilities reduce information rents, and iii) the number of dimensions in the product space, where fewer dimensions reduce information rents.

A final remark on the number of utilities can be made with respect to sectors where there is only a single regulated utility and therefore no comparable firms. The results carry over to this setting if the cost comparison is based on historical data, i.e. longitudinal observations instead of cross-sectional ones, similarly to the situation studied by Antle and Bogetoft (2019).

2.5.4 The Production Possibilities Frontier

In the above examples, we assumed the production possibilities frontier to be represented by the equation for a circle where both services are equally costly to produce. Suppose instead that y_1 is cheaper to produce than y_2. An example is illustrated in Figure 2.5.1, where the production possibilities frontier allows for more of y_1 to be produced without sacrificing y_2, when compared to the old technology.

Figure 2.5.1: A Technological Change



The production possibilities frontier is now represented by the equation for an ellipse centered at the origin, i.e.:

$$P(x) = \left\{ (y_1, y_2) \middle| \left(\frac{y_1}{2}\right)^2 + y_2^2 = 1 \right\}$$

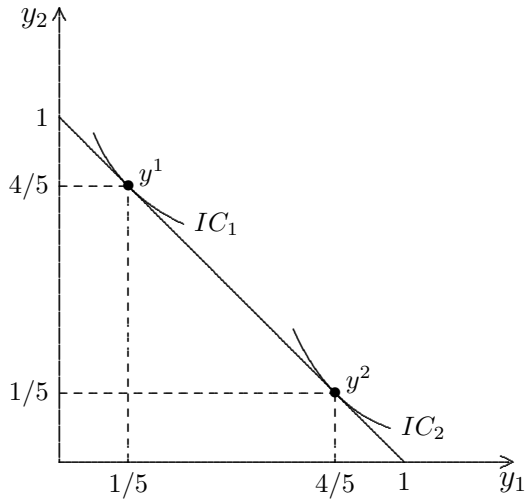
The first-best outcomes are illustrated in Figure 2.5.1:

$$y_1^1 = \sqrt{4/5}, \quad y_2^1 = \sqrt{4/5}$$
$$y_1^2 = \sqrt{16/5}, \quad y_2^2 = \sqrt{1/5}$$

As a result of the new technology, both consumers can enjoy twice as much of y_1 while maintaining the same level of y_2. Consumers' utility increases accordingly. However, in the second-best scenario, payments and information rents associated with perfect coordination are similar to those of the old technology and it is still optimal to let the two utilities produce the same service mix.

If the production function, on the other hand, is linear as illustrated in Figure 2.5.2, the information rents associated with perfect coordination is three times higher than was found with the quadratic cost function in Section 2.4.2. Information rents are thus highly dependent on the specific technology.

Figure 2.5.2: Linear Production Possibilities Frontier



2.5.5 No Rationing

We have assumed 'no rationing', i.e. the regulator cannot deny production from certain utilities. This assumption is reflected in the participation constraint which ensures that all utilities operate with non-negative profits. If we instead allowed rationing, the regulator could ration away utilities with unfavourable cost structures. This would reduce the utilities' bargaining power and limit information rents. The regulator's gain from rationing does not

only come from rationing away inefficient utilities but also from rationing away utilities that may be efficient but where the production plan is markedly different from those of other utilities. In this case, rationing away such utilities may lower the payment to the other utilities. However, a regulator may be reluctant to drive some utilities into bankruptcy to lower payments to other utilities.

2.5.6 Increased Communication and Contract Menus

We have seen above that service differentiation can come at the cost of paying high information rents because the relative performance evaluation becomes less efficient. Therefore, even if consumers in different regions prefer different service mixes, in some cases, it is optimal to prevent service differentiation, as the associated information rents outweigh the added value to consumers.

In the numerical example, we only allowed limited communication between the principal and the agents. The principal can call upon the agents to produce y^1 and y^2 by offering them contracts that pay according the yardstick scheme.

In the general case described in the revelation game in Figure 2.3.2, we might imagine the flow of more detailed information. If agent i knows ψ^i and is able to inform the principal about it, it is possible that better outcomes can be achieved.

Instead of thinking of such situations as starting with the agent sending information to the principal, one can also think of such situations as cases where the principal defines a menu of contracts parameterized by $(\psi^1, \psi^2) \in \Psi^1 \times \Psi^2$. This corresponds to the use of contracts, the terms of which for agent 1 depend in part on the choice of contract by agent 2 and vice versa. The contracts would specify what to produce and what the compensation would look like. If agent 2 has chosen a ψ^2 contract for example, the contract facing agent 1 would be:

> "If you choose contract ψ^1, you will be asked to produce $y^1(\psi^1, \psi^2)$ in exchange for a payment of $t^1(\psi^1, \psi^2)$"

The idea of using menus of contracts is commonly discussed in regulation although usually in the context of a single agent.

The menu of contracts approach was originally developed by Laffont and Tirole (1986, 1993). They show that the regulator is better off by offering companies a menu of contracts rather than a single contract. In particular, by offering a menu of contracts with different cost-sharing provisions, the regulator can incentivise companies to reveal their type. For example, the menu of contracts can be specified as follows (Joskow, 2014, p 298):

$$R = a + (1 - b)C,$$

where allowed revenue, R, is the sum of a fixed component, a, and a cost-contingent component $(1 - b)C$, where C denotes realised costs. In a fixed price contract (price-cap or revenue-cap regulation), $a = C^*$, where C^* is the regulator's assessment of the efficient costs of the low cost firm, and $b = 1$, i.e. $R = C^*$. At the other end of the spectrum, in a pure cost-of-service regulation, $a = 0$ and $b = 0$, such that allowed revenue is set equal to the firm's realised costs, i.e. $R = C$. A range of different options exists between these two extremes, where $0 < b < 1$ and $0 < a < C^*$.

If the menu is well designed, low cost companies will choose a high-powered contract such as a fixed price contract, where b is closer to 1 and a is closer to C^*, which has strong efficiency incentives. High cost companies will choose a low-powered contract, where a and b are closer to zero, such as a cost-of-service contract with weak efficiency incentives. In contrast, if the regulator only offered a single contract, such as a fixed price contract, the fixed price would have to be high to ensure that high cost companies will accept the contract. The low-cost companies can then benefit from claiming to have high costs rather than low costs and earn information rents. Therefore, while a single fixed price contract has the benefit of creating strong efficiency incentives for the high cost companies, it comes at the cost of high information rent to the low cost companies.

However, while the menu of contracts approach has some appealing theoretical properties, it can be difficult to implement in practice. To calculate the optimal menu, the regulator must be able to specify the distribution of the different types of agents, which is not known in practice. However, Rogerson (2003) shows that in some cases, a much simpler menu may be possible to capture a substantial share of the gains that could be achieved with the optimal complex menu. In particular, he considers a menu consisting of two contracts; a cost-reimbursement contract and a fixed price contract, and shows that,

under some circumstances, the menu captures at least three-quarters of the gains that could be achieved using the optimal complex menu.

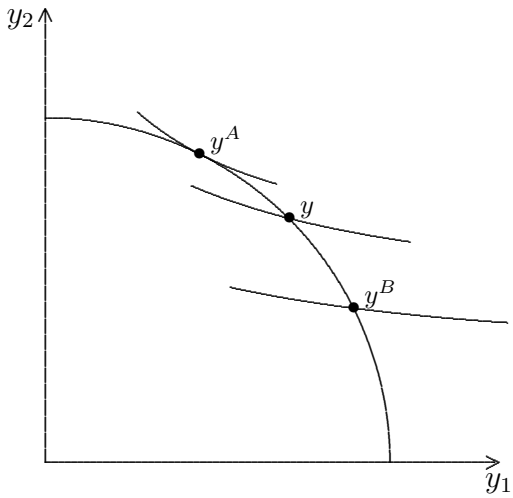
The information quality incentive (IQI) provides an example of the menu of contracts approach used in practice. The IQI mechanism is a mechanism used in the RIIO framework that rewards network companies for submitting expenditure forecasts that are closer to their actual expenditures. However, it also illustrates the difficulties associated with implementing menu of contracts in practice. In particular, Ofgem experienced that network companies systematically forecasted higher expenditures than they subsequently incurred (Ofgem, 2018b).

While there is only limited experience with the explicit use of menu of contracts in practice, Joskow (2014) argues that the regulatory process itself may lead to outcomes that resemble the use of a menu of contracts approach. Specifically, the choice of regulatory framework is often the result of an engagement process involving the regulator, the regulated firm and other stakeholders. In this process, low cost companies will argue in favour of a high-powered contract and high cost companies will argue in favour of a low-powered contract. The process may therefore lead to an outcome similar to the outcome of a formal menu of contracts. Agrell and Bogetoft (2003) study the potential for menu of contracts in the change of the Norwegian regulation of electricity distribution companies. They illustrate how differences in firms' beliefs about the future cost and demand development can be exploited by offering firms the choice between two possible payment schemes, CPI-X regulation or yardstick regulation. The preferred option depends on the firm's historical efficiency, the stipulated efficiency requirement in the CPI-X scheme (X), and the firm's expected productivity gain. The most productive firms will prefer yardstick regulation, while the least productive firms will prefer the CPI-X regulation. Also, Agrell and Bogetoft consider a menu of contracts with two different updating frequencies, i.e. different lengths of the regulatory period, to take account of differences in the age profiles of the different networks and the needs for reinvestment.

Let us close with a discussion of some of the difficulties of designing a menu of contracts in the setting of this paper, where relative performance evaluations are part of the set-up and there are multiple dimensional production plans to consider. To do so, we can consider the idea of cost neutral alternatives. Jamasb (2020) and Tobiasson and Jamasb

(2016) have suggested a menu of contracts approach where the company can propose a menu of cost-neutral options to consumers. The company would be indifferent between the proposed bundles of services but consumers may value some bundles more highly than others. According to Jamasb (2020) and Tobiasson and Jamasb (2016), this approach could lead to higher customer utility at a given cost level and therefore represents a Pareto improvement. This seems obviously to be the case. Imagine a situation in which an agent is offered t to produce y. The agent may then be asked to also make other alternative proposals like y^A and y^B for the same payment. If the agent knows of two alternatives y^A and y^B with the same costs as y, i.e. where $\phi(y) = \phi(y^A) = \phi(y^B)$, the agent is certainly willing to share this information and the consumers may benefit if they have preferences more favourable to at least one of these alternatives as in Figure 2.5.3 below.

Figure 2.5.3: Cost-Neutral Alternatives



Here, the idea of cost neutral alternatives works well and may lead to Pareto improvements. It works however, because payments, t, are fixed.

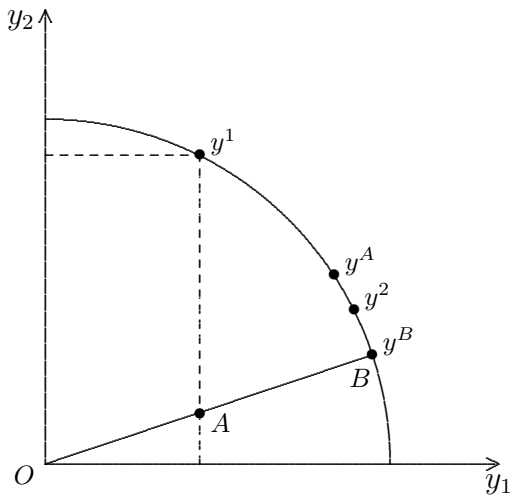
Imagine that we try to reduce the payments using relative performance evaluations as above. In this case, agent 2 will only offer the alternatives if he is always paid according to his most profitable alternative. This is alternative y^B in Figure 2.5.4 below. Hence, the payments must be fixed at

$$t_2 = \frac{OB}{OA} x^1$$

Hence, although the alternatives have equal costs to agent 2, he would have to be also

equally compensated and thereby over-paid. The cost-neutral information is not revealed for free.

Figure 2.5.4: Cost-Neutral Alternatives and Relative Performance Evaluations



This is not to say that the idea cannot be useful in our case. If, for example, the principal signals his interest in y^2 as in our example and promises to pay agent 2 according to our yardstick plan for y^2, he could ask the agent to also propose a cost neutral alternative that is less differentiated, such as y^A. If the agent knows this plan, he should be willing to provide information about it, and this will in turn reduce the payment to agent 1 using our yardstick scheme. Of course, the principal can make similar proposals to agent 1 to further reduce the information rents. In the example he might propose y^C. This situation is illustrated in Figure 2.5.5 below.

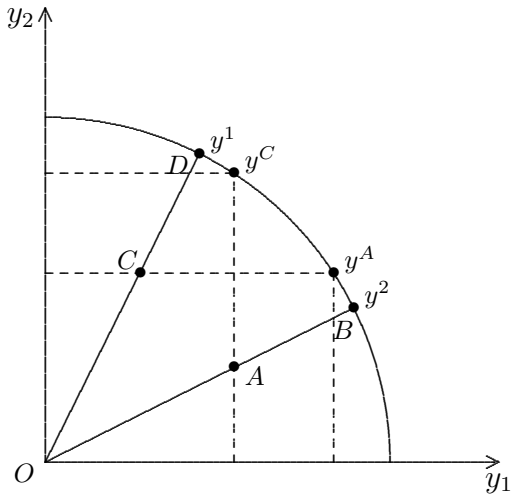
The total payment to the agents will then become

$$t_1 = \frac{OD}{OC}x^2$$

$$t_2 = \frac{OB}{OA}x^1$$

which is less than previously (as in Figure 2.4.2), since the benchmarks are more aligned. To sum up, if the agents have easy access to information about cost-neutral alternatives that are less differentiated, the principal can reduce the information rents even when the original proposals y^1 and y^2 are to be implemented.

Figure 2.5.5: Using Cost-Neutral Alternatives to Reduce Information Rents



2.6 Conclusion

Consumers' preferences may differ across geographic areas in which case their utility is maximised when the utilities adapt their production plans to the specific preferences in their area. However, when the production plans differ across utilities, it complicates the cost comparison, i.e. the power of relative performance evaluation and benchmarking is reduced. Therefore, despite differences in consumer preferences, in some cases, it is optimal to let utilities produce the same set of services since the information rents associated with a diversified service mix outweigh the added value to consumers. We have considered a principal-agent model where the regulator, as the principal, negotiates with two utilities (the agents) on their remuneration and production of two services. The regulator is assumed to maximise the value to consumers of the production plans that are implemented.

In the case of two utilities, two consumers, two services, no rationing, and with a cost function and preferences as specified in the base case, it is optimal for the regulator to trade off service differentiation against rent extraction, i.e. it is optimal for the regulator to let the two utilities produce identical sets of services that falls in between the preferred outcomes of the two consumers. With Leontief preferences, it is optimal to differentiate production plans but not by much; production plans are still distorted when compared to first-best outcomes. However, increasing the magnitude of consumers' utility relative to payment of the companies can make it more worthwhile to adjust to consumers' preferences. The

number of utilities and service dimensions also have an impact on information rents and hence the trade-off. A higher number of utilities would reduce information rents while a higher number of service dimensions would increase information rents. The functional form of the production function can also impact information rents as demonstrated in Section 2.5.4.

The results imply that the regulator should be cautious about allowing for specialised solutions. The conclusion is, however, sensitive to a number of assumptions that describe the context. Further research could try to quantify exactly how sensitive the results are to variations in the number of firms, service dimensions, etc. Furthermore, while this paper has focused on scope, i.e. the question of whether the combination of different services should be allowed to vary according to consumer preferences, a related issue concerns scale. This would address the question of whether the regulator should allow, e.g., quality to vary across geographic areas according to consumer preferences at the cost of higher information rents.

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Chapter 3

Negotiation-Based Regulation: The Next Step in Danish Utility Regulation?

Anita Eskesen

Abstract

This paper evaluates different ways to address issues with the current regulation of Danish electricity distribution networks that have been pointed out by the regulated industry. For example, the industry argues that regulation is too focused on economic efficiency instead of maximising value to customers and that electricity DSOs are not sufficiently incentivised to support the green transition. The evaluation of the different ways in which regulation could be adjusted is based on how the options affect three goals of contract design; coordination, motivation and minimisation of transaction costs. While the option of introducing a negotiation-based regulation, as suggested by the industry, has the advantage of being able to address the issues, it is also associated with a number of disadvantages. For example in terms of higher transaction costs and potentially higher information rents. Therefore, it may be more appropriate to address the issues in a different way. Specifically, the paper considers alternatives in the form of new cost-drivers, application procedures or mandated flexibility tenders as alternatives that address the issues but likely at a smaller increase in transaction costs.

3.1 Introduction

A group of larger Danish utilities suggests negotiation-based regulation as the next step in utility regulation. Their concerns about the current revenue-cap regulation of electricity distribution networks relate to the focus on incentives for economic efficiency as reflected in the efficiency requirements. From the electricity DSO's point of view, regulation does not incentivise utilities to maximise value for their customers by responding to their differentiated needs. They also argue that electricity DSOs are not incentivised to facilitate the transition towards more flexible energy production from renewable sources since investments in innovative solutions, such as Smart Grid solutions, make the DSO look less efficient in the benchmarking of economic efficiency. As a solution to these issues, they propose a negotiation-based regulation, where the utility and the regulator will agree on how the utility can maximise value for their customers and where future investment needs will be part of the dialogue.

Such a regulation would have the advantage of being able to achieve a higher alignment between consumers' preferences and the utilities' production possibilities; an objective of contract design referred to as 'coordination of production' (Bogetoft and Olesen, 2004). However, it also has a number of drawbacks compared to the current regulation, in particular in terms of the extra administrative costs for regulator and utilities but also in the form of information rents, as the utilities' private information would play a larger role in regulation.

As an alternative to the change in regulation suggested by the industry, current regulation may be adjusted in a way that alleviates the issues that has been brought forward while still adhering to the existing prioritisation of regulatory objectives. This paper considers the feasibility of negotiation-based regulation vs. such alternatives by examining the consequences for coordination, motivation, and transaction costs. These can be viewed as the main objectives for contract design, cf. the hierarchy of goals of contract design developed by Bogetoft and Olesen (2004). This hierarchy of goals of contract design is therefore used as a framework for understanding the qualities and drawbacks of different options for changing regulation.

The setup suggested by the Danish utilities has similarities to the RIIO framework, which is used to regulate British electricity and gas networks, in the sense that the utilities envisage a regulation based on business plans that are individually assessed by the regulator.

The resources associated with administering the RIIO framework may therefore give an indication of the transaction costs associated with administering the same type of regulation in a Danish context. On this basis, applying a RIIO type regulation is expected to considerably increase transaction costs compared to the current regulation of Danish electricity and gas networks. However, as an alternative to the framework suggested by the industry, we can consider supplementing current regulation with new elements that target the issues brought forward by the Danish utilities. Such elements may lead to improvements in the same areas but at a lower transaction cost.

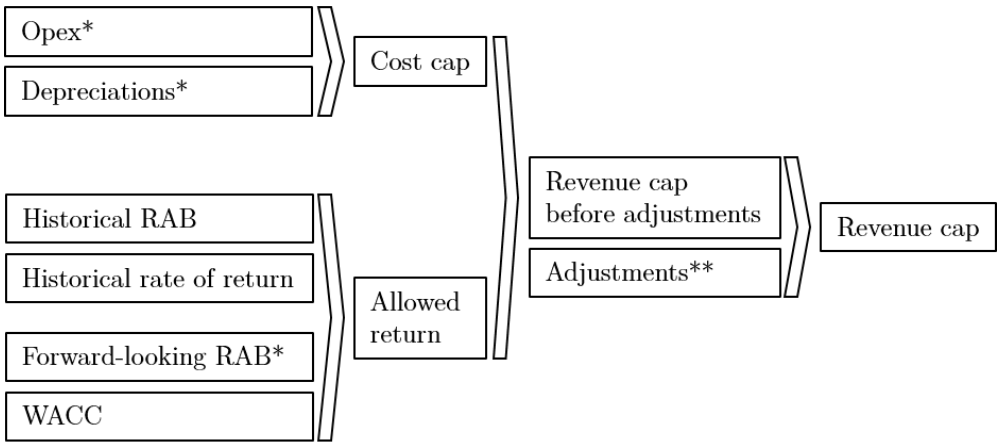
The current paper takes the regulation of Danish electricity distribution networks as a starting point when discussing possible changes in regulation. The paper proceeds as follows: Section 3.2 reviews the current regulation of Danish electricity distribution networks and Section 3.3 describes the issues brought forward by the industry. As a solution to these issues, the industry proposes a negotiation-based regulation as described in Section 3.4. Section 3.5 evaluates the industry's proposal and Section 3.6 considers alternative ways to address the issues. Section 3.7 concludes.

3.2 Current Regulation

Danish electricity distribution companies are regulated by a revenue-cap regulation. The revenue-cap is made up of a cost cap, an allowed return on investment, and a number of adjusting factors, as illustrated in Figure 3.2.1. The cost cap is calculated as the average costs of the previous 5-year period, adjusted with a price index, indicators for changing activity levels, etc. The cost cap is thus independent of actual costs in the period. Likewise, allowed return on investments during the period is independent of actual investments in the period as the asset base is based on average assets of the previous period, adjusted for price developments, activity levels, etc. This means that companies will profit from choosing the most cost-efficient solutions (opex vs. capex) during the period (Udvalg for El-reguleringseftersynet, 2014). When transitioning between regulatory periods, the cost cap and asset base are recalibrated to reflect actual costs and investments during the period.

Within the regulatory period, the revenue-cap is subject to a number of different adjustments that reflect changes in conditions beyond the companies' control. These adjustments

Figure 3.2.1: Main Elements of the Revenue-Cap



*Adjusted from the previous to the current period with several factors, including price index, activity indicators, changing tasks, and external factors
**Adjustments include efficiency requirements, penalties for factors such as insufficient quality of supply and costs of grid losses
Note: Figure 3.2.1 is based on regulations no. 969 of 27/06/2018 (Danish Ministry of Climate, Energy and Utilities, 2018)

protect the companies from cost changes outside of their control by allowing for changes to allowed revenue during the regulatory period. The adjustments intend to encompass all conceivable uncontrollable circumstances that could lead to changing levels of costs and investment. Adjustments can be made either on application from the companies or by an automatic link to a price index or activity-indicators (Danish Ministry of Climate, Energy and Utilities, 2018). The application-based adjustments to the revenue-cap can be applied for in response to considerable cost increases resulting from a specified list of changing conditions, including the connection of new supply areas, replacement of overhead lines with underground cables, changes in tasks, etc.

The companies are subject to both general and individual efficiency requirements. The general requirements are based on measures for labour productivity development in relevant Danish sectors. The individual requirements are determined by a totex benchmarking which addresses the former bias towards capex solutions. While totex serves as the basis for the new benchmarking approach, certain types of costs, including uncontrollable costs, are excluded. The regulator employs a 'best-of-two' approach to determine individual efficiency requirements. According to this approach, the results from a Data Envelopment Analysis (DEA) are compared to the results from a Stochastic Frontier Analysis (SFA). The efficiency of every company is assessed in both models and the most favourable assessment from the

company's perspective will be used to determine the efficiency requirement. This is a precautionary measure that ensures a conservative determination of efficiency requirements. Aside from efficiency requirements, the revenue-cap is reduced annually for insufficient quality of supply, cost of grid losses, etc.

3.3 Issues Brought Forward by the Industry

The industry has brought forward a number of issues concerning the current regulation of electricity distribution companies. For example, that regulation is backward-looking and therefore not appropriate for regulating a transitioning energy system, that benchmarking is being used too mechanically, and that the legal framework for tariff structures needs updating.[1] This paper restricts attention to the following two issues brought forward by the industry: i) current regulation does not maximise value to consumers since and focuses too much on economic efficiency, and ii) current regulation does not incentivise DSOs to support the green transition (Copenhagen Economics, 2018). The publication was made on behalf of four Danish utilities, representing electricity and gas transmission (Energinet), electricity distribution (Radius), a multi-utility (HOFOR), and wastewater (BIOFOS). The focus of this paper is on electricity distribution so the views of the industry, as presented below, therefore effectively refer to the views of the largest Danish electricity distribution network, Radius, and may not represent all Danish electricity distribution networks.

Current Regulation does not Maximise Value to Consumers

The first issue concerns the focus on economic efficiency. According to the Danish electricity distribution network, Radius, the economic regulation only incentivises efficiency improvements and does not incentivise the DSO to maximise value for their customers by responding to their differentiated needs (Copenhagen Economics, 2018). For example, different customers may demand different levels of services from their distribution network such as different levels of security of supply compared to standard levels. Moreover, the focus on economic efficiency means that the DSO is not incentivised to improve personnel safety or seek out more environmentally friendly grid components when there are cheaper alternatives. As another example of how regulation hinders socially efficient investments,

[1] See for example Copenhagen Economics (2018) and Danish Energy (2018)

the DSO explains that even in cases, where a consumer is willing to pay for an inquiry, for example to move a transformer station, the associated revenue would crowd out other revenues under the revenue cap. As a result, the DSO would incur higher costs but is left with unchanged revenues, i.e. a lower profit and worse efficiency as measured by the economic benchmarking.

Current Regulation does not Incentivise DSOs to Support the Green Transition

The second issue concerns flexibility services. Flexible production from renewable energy sources creates a need for flexibility in the system. According to Copenhagen Economics (2018), DSOs need to play a more active role, for example in facilitating flexible demand in a Smart Grid, and current regulation does not incentivise DSOs to support this process. The reason, according to Radius, is that regulation incentivises DSOs to invest in grid expansions since the benchmarking of economic efficiency compares costs relative to grid capacity. Investments in innovative solutions (e.g. Smart Grid solutions) will increase costs but not grid capacity and make the DSO look less efficient. The DSO instead suggests that future investment needs are part of a dialogue between the DSO and the regulator, cf. Section 3.4.

3.4 The Industry's Proposal

Representatives of the Danish utility sector suggest that regulation distinguishes between utilities in a way where the largest utilities are regulated by a negotiation-based regulation, where the regulator and the utility come to an agreement on the size of the revenue-cap, service levels, efficiency requirements, etc. (Copenhagen Economics, 2018). They envisage a regulation that relies on investment plans and stakeholder engagement and where benchmarking is used as an informative tool that supports dialogue in the negotiation rather than to directly determine efficiency requirements.

For electricity distribution networks, they envisage negotiation-based regulation as an add-on to the existing revenue-cap regulation. They explain the add-on as a possibility for DSOs to enter into a dialogue with the regulator, prior to the regulator's determination of revenue-caps, with the purpose of adjusting elements of the decision. Such elements include price, security of supply, reinvestments, new investments, quality, service, efficiency

requirements, return on assets, innovation projects, and personnel safety. The dialogue between the DSO and the regulator should be based on investment plans and analyses of customers' needs and willingness to pay.

They recognise that extra interactions between DSO and regulator can lead to higher administrative costs which should measure up to the benefits. Therefore, they propose that only the largest utilities in each sector are regulated using negotiation-based regulation. They argue that the largest utilities in each sector are more similar to each other than to their within-sector peers. Moreover, they explain that the larger utilities would have the competencies and resources to operate in a negotiation-based regulation that would incorporate elements such as asset management programmes and consumer engagement. In case the regulator and the utility cannot come to an agreement, they suggest a fall-back option; for example that a third party, such as a competition authority, determines an appropriate compromise.

3.5 Evaluation of the Industry's Proposal

The evaluation of the industry's proposal relies on a framework for contract analysis which is presented in Section 3.5.1. Sections 3.5.2-3.5.3 present advantages and disadvantages compared to current regulation.

3.5.1 Framework for Evaluating Regulation

The overall goal for the regulator is to maximise social welfare. Based on contract theory,[2] Bogetoft and Olesen (2004) have developed a theoretical framework for contract analysis that rests on the concepts of coordination, motivation and minimisation of transaction costs. These are the three main objectives against which alternatives will be measured. Bogetoft and Olesen organise the various aspects to consider, when designing a contract, in a hierarchy that contains the objectives and sub-objectives listed in Table 3.5.1.

Coordination of production refers to the alignment between utilities' production possibilities and consumers' preferences. Coordination of production will ensure that the right combination of goods is being produced compared to what consumers would prefer, given

[2]See for example Milgrom and Roberts (1992) and Williamson (1996)

Table 3.5.1: Goals of Contract Design

Objectives	Sub-objectives
Coordination	Coordination of production
	Coordination of risk
Motivation	Participation
	Effort
	Investment
Minimisation of transaction costs	Entering a contract
	Conflict resolution
	Monitoring
	Influence costs

Reference: Bogetoft and Olesen (2004), Figure 3.1

what is feasible on the production frontier. For example, responding to customers' differentiated needs, a concern raised by the industry, is a matter of coordinating production. Coordination of risk is about minimising the level of risk and sharing risk between utilities and consumers in a way that makes the total cost of risk bearing as low as possible. Participation, as a goal for contract design, is about making the contracting parties willing to participate, i.e. providing them with a utility at least equal to what they could obtain outside the contract. Effort is about ensuring that the regulated utilities are incentivised to follow actions which maximise social welfare and preventing moral hazard problems caused by unobservable actions. Incentivising investments to ensure future profits is the third aspect of the motivational objective. Finally, utility regulation is associated with transaction costs that should be minimised. Transaction costs include costs of entering a contract, costs of conflict resolution, monitoring costs, and influence costs.

3.5.2 Advantages

The main advantages of the suggested regulation are its potential to improve service coordination and its flexibility in responding to utility-specific circumstances and changes in future operating conditions, as outlined below.

Service Coordination

An obvious advantage of the industry's proposal is its potential to create higher value for consumers by taking into account their preferences for different service combinations and aligning these with the utility-specific production possibilities. For example, consumers in one area may prefer a combination of services which is different from consumers in another area or geographic differences may affects the utilities' cost of producing different services. The type of regulation proposed by the industry can take such differences into account, and through that, improve value for consumers. The realisation of this advantage however depends on the success of the consumer engagement initiatives that are required to translate any differences in consumers' preferences into differences in regulatory outcomes.

The industry's suggestion is somewhat in line with a new trend in utility regulation; the practice of involving consumers and other stakeholders more explicitly in the regulatory process (Hahn, Metcalfe and Rundhammer, 2020). The regulation of Scottish Water and RIIO can be seen as examples of this development in utility regulation, which has been described as a shift from regulator-focused to a more customer-focused regulation (Hahn, Metcalfe and Rundhammer, 2020, p. 124):

> "The novelty of this paradigm is not the consideration of customer needs per se – a goal that has been important for decades – but rather the direct engagement with customers. If successful, this process can help resolve some of the information asymmetries involving regulators, firms and end customers."

The potential to resolve information asymmetries has also been emphasised by Littlechild (2012a,b). It implies that utilities and consumers have better information about the cost structure and consumer preferences than the regulator. This may apply to varying degrees depending on the setting. For example, in airport regulation, both the airport and airlines, as professional players in the market for airport services, are likely to be better informed than the regulator and have strong financial incentives to negotiate a mutual beneficial outcome. In this case, negotiations between airport and airlines can likely resolve some of the information asymmetries that would prevail, if the outcome was centrally determined by the regulator. In such cases, direct customer engagement can improve regulatory outcomes. However, individual customers of electricity networks, such as households, may display a

wide range of preferences and have weak incentives to negotiate, compared to airlines. This makes it less obvious that direct customer engagement can improve outcomes.

Improving Regulatory Processes

However, direct customer engagement may also be considered for the sake of improving processes. Both Ofgem and the Water Industry Commission for Scotland have stated legitimacy as one of the reasons for introducing direct customer engagement in RIIO and the regulation of Scottish Water; when stakeholders are involved in the regulatory process, outcomes may be seen as more legitimate.

Customer engagement can be said to originate from the US, where it was introduced in the form of negotiated settlements between consumer advocates and utilities in 1970s and 80s (Krieger, 1995; Littlechild, 2009b). Here, it was also introduced to improve processes, particularly with an aim of expediting a large number of rate reviews. In the US, customer engagement is thus seen as a way to speed up the regulatory process, i.e. reduce transaction costs, whereas in the cases of RIIO and Scottish Water, customer engagement is introduced as additional elements in the regulatory framework that may increase transaction costs but still with the aim of improving processes.

Taking Account of Utility-Specific Circumstances

The revenue-cap under current regulation is based on historical costs and investments and therefore does not automatically leave room for increasing levels of costs or investments, which may be caused by changing conditions such as the green transition. However, in such cases, the Danish electricity distribution companies can apply for increases in the revenue-cap. The suggested regulation on the other hand would be based on business plans, reflecting future costs and investments, where the effects of such changing conditions can be reflected from the outset. This allows company-specific circumstances to influence the regulatory contract to a larger extent than current regulation, which may reduce the participation problem and improve incentives to provide effort. For example, in RIIO, output levels, rewards, and penalties can vary across companies.

Securing Sufficient Investments

The suggested regulation is also assumed to support sufficient investments to a greater extent than current regulation. However, while current regulation has specified the type of investments that can lead to increases in the revenue-cap, the suggested regulation appears to leave investments as a subject of negotiation. On the one hand, this can be seen as a more flexible approach but on the other hand, it may create hold-up problems. Likewise, the industry has suggested to reduce the influence of a benchmarking model in determining efficiency requirements on the basis that the current model is not believed to take account of all relevant conditions that affect efficiency. However, in addition to incentivising efficiency improvements, a benchmarking model may also reduce the uncertainty related to the determination of future efficiency requirements and thereby improve incentives to invest. The effect on incentives to invest is therefore unclear.

3.5.3 Disadvantages

A main disadvantage of the industry's proposal is increased transaction costs compared to current regulation as discussed below. The suggested setup also has implications for the the role of the regulator and other concerns, as reviewed in the following.

Transaction Costs

The transaction costs of entering a contract include the costs of determining and writing the contract under the difficulty of foreseeing all possible outcomes and formulating a contract which, with sufficient clarity, describes the different contingencies and the actions that each party has to take (Milgrom and Roberts, 1992). Furthermore, the contract must be enforceable. The costs of entering a contract can be reduced, for example, by using a standard contract with all companies as is the case under the current regulation of Danish electricity distribution companies. The model suggested by the Danish utility sector is highly dependent on utility-specific circumstances and therefore more demanding.

While it is clear that the direct costs of regulation would be higher, it is difficult, in advance, to estimate by how much. The suggested regulatory process bears some similarity to the RIIO framework by which Ofgem regulates in total 14 different network owners,

covering 26 license areas, across the electricity and gas distribution and transmission sectors in Great Britain. Like the industry's proposal, business plans and stakeholder engagement plays a fundamental role in the RIIO framework. To administer RIIO, Ofgem employs 851 full-time equivalent people and had consultancy expenditures of £18.04m for the year 2018-2019 (Ofgem, 2019a, 2020a). In comparison, the Danish Utility Regulator regulates approximately 40 gas and electricity networks and 400 district heating networks with a staff of about 100 people. However, there are significant differences between the roles and duties of the two regulators, which complicates a comparison of resources.

One of the differences is that in Denmark, the regulatory duties are divided between the Danish Energy Agency and the Danish Utility Regulator. The Energy Agency is part of the Ministry of Climate, Energy and Utilities whereas the Utility Regulator is politically independent. While Ofgem is responsible for both designing and administering the regulation of electricity and gas networks, the Danish Utility Regulator shares this responsibility with the Danish Energy Agency. Another difference between the two countries' setups lies in the fact that Ofgem enforces competition law in the energy sector and consumer protection law (Ofgem, 2020c). In Denmark, these areas of responsibility reside with the Danish Competition and Consumer Authority. In addition to its regulatory, competition and consumer functions, Ofgem manages various environmental programmes on behalf of the government in fields such as renewable heat and electricity, energy efficiency, and fuel poverty (Ofgem, 2020b). In Denmark, equivalent programmes are typically managed by the Danish Energy Agency.

Despite the regulatory duties being shared between the Energy Agency and Utility Regulator, the joint resources of the two Danish regulatory bodies are not directly comparable to Ofgem's resources, since the Danish Energy Agency is responsible for a number of areas other than the electricity and gas sectors, including telecom, water, and waste. The Danish Utility Regulator also regulates a large number of district heating companies, which is not the case for Ofgem. Furthermore, there may be differences in the governance framework within which the two countries' regulatory bodies operate. For example, the Danish Ministry of Climate, Energy and Utilities may have delegated more or less of the responsibility for the regulatory framework to the regulatory bodies compared to the British equivalent; the Department for Business, Energy & Industrial Strategy.

Table 3.5.2 provides an overview of the regulatory staff and number of regulated firms in Denmark and Great Britain. Applying Ofgem's ratio between regulatory staff and number of regulated networks (851/26) to the number of Danish electricity and gas networks implies a regulatory staff of 1.571 across the Danish Utility Regulator and the Danish Energy Agency for the regulation of electricity and gas networks. If instead, this type of regulation is only applied to, for example, the three largest networks, the corresponding regulatory staff is 98. However, this number reflects *extra* employees compared to the status quo, as the situation implies a continuation of the existing regulation for the remaining networks. Therefore, the suggestion of only enrolling the larger networks in this type of regulation does not necessarily imply that the increase in transaction costs would be insignificant. It may be more realistic to assume that only a part of the regulatory staff increases proportionally with the number of regulated networks. On the other hand, administering two different regulatory schemes will, in itself, increase transaction costs. Overall, despite the difficulties associated with any direct comparison of resources, the numbers indicate that the RIIO framework is associated with substantially higher costs for the regulator compared to the current Danish revenue cap model.

From the point of view of the firms, the reporting and documentation requirements are also more demanding in a RIIO-type regulation compared to current regulation as firms would need to justify and document their investment choices to the regulator, which is not required under the current regulation. As illustrated by the industry's proposal, asset management programmes may be required to facilitate analyses of the implications of different investment scenarios. Moreover, the industry suggests a process where the dialogue between the regulator and the utility will typically require several iterations to reach consensus. This is costly compared to the consultation procedure in the current regulation. If the regulator and the utility cannot come to an agreement, it will furthermore inflict transactions costs on the authority responsible for the fall-back option. Finally, consumer engagement contributes to increasing transaction costs, both in terms of the utilities' resources associated with planning and carrying out the engagement, documenting the findings to the regulator and for consumers in terms of the time spent engaging with their utility.

The suggested regulation is also likely to be associated with an increase in influence activities, as utilities are more involved in the decision-making process. Influence activities

Table 3.5.2: Regulatory staff and number of regulated firms in Denmark and GB

Number of employees	
Danish Utility Regulator (excluding district heating)[1]	76
Danish Energy Agency[2]	500
Ofgem[3]	851
Number of regulated gas and electricity networks (licenses)	
By the Danish Utility Regulator[4]	48
By Ofgem[5]	26
Ratio between staff and regulated firms (electricity and gas)	
Danish Utility Regulator & Danish Energy Agency	12
Great Britain	33
Corresponding regulatory staff in Denmark	
Applying Ofgem's ratio to the Danish electricity and gas networks	1.571
Applying Ofgem's ratio to 3 networks	98

[1] As of April 2020 according to the Danish Utility Regulator (*Vores medarbejdere*)
[2] Total employees in the Danish Energy Agency, i.e. including areas such as telecom, water, waste, and district heating (*Karriere — Energistyrelsen*)
[3] As of the accounting year 2018/2019 according to Ofgem (2019a)
[4] 44 electricity distribution networks, 3 gas distribution networks, and 1 electricity and gas transmission network as of 2020
[5] 14 electricity distribution networks (owned by 6 ownership groups), 8 gas distribution networks (owned by 4 ownership groups), 3 electricity transmission networks, and 1 gas transmission network (Ofgem, 2020a)

may include activities aimed at suppressing unfavourable information or otherwise biasing information used in decision-making. Influence activities are costly both because they reduce the quality of decision-making but also in terms of the resources spent on influence activities, and dealing with them, instead of productive activities. Milgrom and Roberts (1988) show that, in some circumstances, it may be efficient to discourage influence activities, for example by limiting the access to decision-makers and participation in the decision-making process or by limiting the decision-maker's use of discretion in contracting. However, such measures are also costly since they prevent potentially valuable information from being made available as inputs in the decision-making process.

The Role of the Regulator

The four utilities envisage a regulation where the regulator negotiates with the largest utilities to reach an agreement on their future deliverables with a fall-back option in place, if an agreement cannot be reached, whereby another authority determines the outcome. The use of a fall-back option is known, for example, from the regulation of Copenhagen Airport, where the airport negotiates with airlines to reach an agreement on the level and structure of charges that airlines pay to use the airport as well as service and capacity levels. If the parties cannot come to an agreement, a fall-back model determined by the Danish Transport, Construction and Housing Authority is used to determine the allowed revenue of Copenhagen Airport. The authority can participate as an observer in the negotiations or decide to enter into negotiations as a mediator if needed. Moreover, the authority can order the parties to present whichever documentation and information the authority may find necessary to ensure transparency during the negotiations. In this way, the regulator has a role of supporting negotiations while still holding the ultimate responsibility for the regulatory review as the authority must approve the charges proposal prepared by the airport on the basis of the negotiated outcome.

The negotiation-based regulation of Scottish Water also provides experience concerning the role of the regulator. The regulation is based on negotiations between Scottish Water and a Customer Forum that represents the interest of consumers in general. The regulator supports the negotiations but holds the ultimate responsibility for the price control which is manifested by its final determination that sets out the regulator's conclusions on the level

of customer charges for the regulatory period. The powers and duties of the regulator vis-a-vis the Customer Forum is discussed by Littlechild (2014). He argues that, compared to previous processes, the new approach was more effective at taking customer interests into account without delegating any of the regulator's statutory powers or duties. The Customer Forum itself believed that "the fact that the Customer Forum was independent of all the key stakeholders and has no statutory powers in relation to Scottish Water, considerably facilitated the ability of both parties to share emerging thinking" (Littlechild, 2014; Water Industry Commission for Scotland, 2014). Littlechild concludes that legitimising the Customer Forum, for example by making it a sub-committee of the regulator, would undermine its appeal and effectiveness. He further notes that, in other jurisdictions where negotiated settlements are used, the ultimate responsibility for setting a price control rests with the regulatory body.

It appears that the setup suggested by the four Danish utilities would imply that the Danish Utility Regulator takes a role that resembles the role of a consumer representative such as the Customer Forum in the Scottish Water case. The suggested fall-back option entails that the current regulator's decision-making powers would effectively be delegated to the authority responsible for determining the fall-back. In effect, this introduces a second regulatory body that would need competencies similar to those of a regulator to ensure the best possible outcome in the fall-back scenario. Compared to the Scottish Water example, where the role and competencies of the Customer Forum and the regulator complement each other, the suggested setup appears to introduce overlapping and conflicting roles for the two regulatory bodies.

An alternative setup, where the Danish Utility Regulator maintains responsibility over the final decision, can be established by appointing a different party to negotiate with DSOs, similarly to the setups in place for the regulation of Scottish Water and Copenhagen Airport. However, in the context of Danish electricity distribution, there is currently not any natural negotiating party that represents customers collectively. After a reform of the electricity retail market in 2016, retailers have replaced end-consumers as the direct customers of DSOs. DSOs now act as wholesale suppliers of network and system services with retailers as their direct customers, which may point to retailers as a negotiating party. However, many retailers are part of the same corporate group as DSOs and therefore are not in a natural

position to negotiate with the DSOs. Moreover, retailers cannot be expected to correctly represent end-consumers' preferences. Potentially an association of end-consumers, such as FSE[3] would be in a better position to negotiate with some DSOs. This organisation, however, is not representative of all consumers, in particular not smaller end-consumers. On the other hand, an authority, such as the Danish Energy Agency[4] is representative of all consumers by virtue of being a governmental agency. However, the agency's role is to balance the interests of consumers and DSOs in order to maximise social welfare, which contradicts with the role of a suitable negotiating party. Alternatively, establishing a new organisation, like the Customer Forum in Scotland, may be the most viable option if negotiations must play a significant role in regulation.

The Risk of Regulatory Capture

Furthermore, the risk of regulatory capture may provide a rationale for rejecting the industry's suggestion of introducing negotiations between the regulator and the industry. In particular, Agrell and Gautier (2012) argue that a firm may voluntarily disclose information to the regulator in order to avoid the regulator producing the information itself, which could be worse for the firm. The firm will only produce information to the regulator, if the regulator's use of this information benefits the firm. Therefore, unverifiable information provided by the industry must be systematically biased.[5] The regulator can choose to either produce its own information or save time and resources by relying on the information provided by the industry. This could lead to regulation being based on information controlled by the firm, which increases information rents to the firms and reduces welfare. Agrell and Gautier (2012) refer to this problem as 'soft capture' and conjecture that this form of regulatory capture is common in regulated industries. For example, soft capture can occur in the form of a regulator adopting a position made by an industry-financed consultancy or a regulator endorsing a regulation drafted by the industry.[6]

In a formal model of soft capture, Agrell and Gautier (2017) show that soft capture may

[3]FSE is a Danish interest organisation whose members are large industrial and public companies

[4]The Danish Energy Agency is a governmental agency which, among other areas of responsibility, develops the legal framework that applies to Danish electricity DSOs

[5]If information, on the other hand, is verifiable, any bias can be immediately detected

[6]Agrell and Gautier (2012) point to a real-life example of this form of soft capture: in 2001, the Swedish energy regulator endorsed a detailed voluntary service regulation for the quality of electricity distribution prepared by the sector association

be the equilibrium outcome if the quality of the biased information produced by the firm is high relative to the quality of information (potentially) produced by the regulator. A regulator with limited resources and consequently limited abilities for producing high-quality information is therefore likely to receive more biased information from the industry than a regulator with the abilities to produce high-quality information. Ensuring highly skilled regulators compels the firm to produce less biased information and can therefore mitigate the soft capture problem. Another way to prevent soft capture is to rely on multiple sources of biased information, such as information provided by advocates of different interest groups, which reduces the dependency on information provided by the industry (Agrell and Gautier, 2012). The authors draw a parallel to the regulation of US electricity distributors, where interested parties can file testimony to the regulator. In some cases, negotiated settlements reached between utilities and consumer advocates, independently of the regulatory authority, can even replace the formal process.[7] The US rate reviews therefore rely less on the regulator's ability to collect information from the industry, which reduces the problem of soft capture.

In contrast, the regulation suggested by the Danish industry is based on negotiations between the utility and the regulator and therefore relies heavily on the regulator's ability to collect information from the industry. Moreover, since negotiations would concern future costs and investments, the information is likely unverifiable to a larger extent than information used in the current regulation, which relies heavily on verifiable data, such as accounting information. The suggested regulation therefore appears more prone to soft capture than current regulation. The same, in principle, applies to RIIO and the regulation of Scottish Water, which rely more on expected future costs and investments than the previous frameworks used to regulate the sectors. The soft capture problem in these cases is mitigated by several measures, including a well-resourced regulator and by relying on information provided by advocates of different interest groups. However, the regulators in both cases have maintained their decision-making power. While negotiations may be an element of the regulatory framework, the distinctive feature of RIIO and the Scottish Water regulation is not that utilities negotiate with the regulator but rather that consumers and other stakeholders are directly involved in the regulatory process.

[7] See for example Littlechild (2012a)

The problem of biased information in business plans may also be comparable with the practice of using budget-based compensation plans in companies, where managers are rewarded for reaching their targets for the period and penalised when failing to meet them. Such schemes have been criticised for providing incentives to build slack into the budget so the performance target is below the true expected performance.[8] To counteract the tendency to understate expected performance in budgets, "truth-inducing" compensation schemes have been suggested, which reward agents for their truthful revelation of their private information. For example, Weitzman (1976) discusses a scheme that, under certain assumptions, incentivises the agent to suggest a target equal to the agent's expected performance. In addition, the scheme incentivises the agent to maximise performance regardless of the target. The scheme is entirely explicit and can therefore be verified and enforced by a third party. An alternative way to incentivise agents towards a target performance level is via implicit incentive schemes, such as discretionary bonus pools. The Environmental Discretionary Reward Scheme, administered by Ofgem, provides an example of a discretionary bonus pool used in practice, which is studied in Chapter 4.

Other Concerns

One of the purposes for changing the regulation, according to the industry's publication, is to find an optimal combination of price, quality, and other services through an active involvement of consumers' preferences. Compared to current regulation, where the allowed revenue of electricity distribution companies is, for the most part, mechanically determined and based on a totex benchmarking, general negotiations between the regulator and the company would rely more on the companies' private information about costs and technology. Therefore, there is a risk that information asymmetry problems place the regulator at a serious disadvantage and leave companies with higher information rents. In practice, when there is asymmetric information about the utilities' production possibilities, improved coordination may then come at the cost of higher information rents as the utilities' costs become less comparable. In some cases, it may therefore be optimal to disregard coordination and instead ask utilities to produce similar output combinations. This aspect is studied further by Bogetoft and Eskesen (2021).

[8] See for example Jensen (2003)

Another concern is how to decide which utilities should be subject to a negotiation-based regulation if not all. This gives rise to a number of issues: is it fair that only the largest utilities get the opportunity to negotiate? Should negotiation-based regulation be voluntary or based on a size requirement? Is it size neutral? To give all utilities the same opportunities, the choice of regulation could be made voluntary. However, smaller utilities may still claim that they, in practice, have no choice because of the extra resources required for negotiation-based regulation. Utilities may also have different beliefs about the expected development in costs that would make them more prone to choosing one type of regulation over another. Likewise, different levels of risk aversion could influence the preferred type of regulation. It is therefore unclear whether regulation would be size neutral.

3.6 Alternative Ways to Address the Issues

For the reasons outlined in Section 3.5, instead of considering a fundamental change of the regulatory model, it may be more feasible, to assess whether current regulation can be adjusted in a way that addresses the issues put forward by the industry. Section 3.6.1 presents adjustments to current regulation that target the issue of improving value to consumers and evaluates how they each prioritise goals of contract design. Section 3.6.2 follows suit by addressing the issue of incentivising DSOs to support the green transition in a similar way. Finally, Section 3.6.3 considers next steps in order to further clarify the issues and evaluate the suitability of possible solutions.

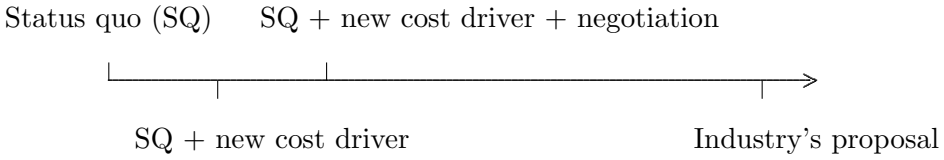
While the paper discusses the industry's proposal and points to alternatives, it does not recommend any specific alternative. Instead, the paper sheds light on how the choice of regulation reflects the prioritisation of different objectives.

3.6.1 Increasing Value to Consumers

When considering alternatives to current regulation that would improve coordination of production and possibly increase value to consumers, the set of regulatory alternatives can be viewed on a spectrum of transaction costs with current regulation at one end and the industry's proposal at the other end, as illustrated in Figure 3.6.1. The following paragraphs describe two adjustments to current regulation that can be seen as steps in a new

direction; i) adding output measures or additional cost drivers and ii) supplementing current regulation with a revenue-cap adjustment based on agreements between the utility and its customers. These alternatives directly target the issues pointed out by the industry without fundamentally changing the regulatory framework. However, the two approaches each target different aspects of the issue described by the industry and could be combined. Additional output measures or cost drivers target the issue of consumers preferring different output levels than currently incentivised while the revenue-cap adjustment, based on negotiations between the utility and its customers, can facilitate more specialised solutions to customers that demand these and choose to engage with their utility.

Figure 3.6.1: Spectrum of Regulatory Transaction Costs



Including Additional Cost-Drivers

Introducing new cost drivers or output measures can incentivise companies to direct their efforts towards meeting consumers' preferences for certain outputs such as safety and environmental standards that were emphasised by the industry. Ideally, output measures are implemented as additional cost-drivers in the benchmarking model. In this way, utilities are automatically rewarded for delivering higher quantities of outputs within the benchmarking framework. In principle, this allows utilities to choose output levels that appropriately balance the benefits for consumers against the impact on their costs. Alternatively, output measures can be considered separately from benchmarking as an add-on to allowed revenue as in the RIIO model, where allowed revenue depends on the DSOs' performance on a number of aspects, such as safety, environment, reliability and availability. In this case, the choice of output levels depends on the associated rewards and penalties which may not appropriately reflect the costs and benefits of a given output level in each supply area.

Revenue-Cap Adjustments Based on Utility-Customer Agreements

The industry points out that, in cases where a customer is willing to cover the expenses

associated with, for example, an extra connection or with moving a transformer station, responding to such needs makes the DSO worse off. The reason is that the customer's payment increases the DSO's revenue and, given the revenue-cap, crowds out other revenue so total revenue remains unchanged. As a result, the DSO is left with higher costs but without a corresponding increase in revenue. This lowers profit and makes the DSO look less efficient in the benchmarking. As a solution, Radius proposes a negotiation-based regulation, where the DSO and the regulator agrees on how the DSO will maximise value to its customers. However, as reviewed in Section 3.5.3, the setup has a certain disadvantages, especially in terms of high transaction costs and potential problems of soft capture and higher information rents. To address these issues, while still targeting the issue pointed out by the industry, we can instead consider negotiations on a smaller scale, but without appointing the regulator as a party in the negotiations. For example, we can consider a procedure for increasing revenue-caps based on agreements between the DSO and its customers about requests that the DSO is not legally obligated to meet. However, such arrangements would require measures to prevent making some customers better off at the expense of other customers and to avoid free-riding problems, which could occur when service differentiation is not separable. The most informed customer may refuse to pay but still benefit from a service, which is paid for by other customers.

Assessment of Alternatives

The performance of current regulation and the above-mentioned two alternatives, when measured against the objectives of coordination, motivation and minimisation of transaction costs, is summarised in Table 3.6.1 and elaborated below.

Table 3.6.1: Assessment of Alternatives

	Coordination	Motivation	Minimisation of Transaction Costs
Status quo	−	+	+
Cost-drivers/outputs	+	+/−	−
Negotiation	+	−	−

Coordination Status quo is the preferred alternative if consumers do not value higher coordination in the form of outputs being more aligned with their preferences. The other

alternatives improve coordination at the cost of higher transaction costs. These alternatives are therefore only justified if the value to consumers outweighs the added transaction costs. New cost-drivers or output measures prioritise coordination to the extent that the cost-drivers/outputs generate value to consumers. Negotiations prioritise the objective by allowing for direct negotiations between consumers and the DSOs. Negotiations require consumers to play an active role to obtain the value of improved coordination whereas cost-drivers/outputs would generate value to all consumers regardless of whether they actively engage in the process. Introducing new cost-drivers/output measures can therefore provide a more generalised solution to all consumers, whereas negotiations can facilitate specialised solutions to the consumers that actively choose to engage with their DSO. Therefore, if lack of coordination is mainly a problem for commercial consumers, introducing negotiations likely targets the problem better than outputs. On the other hand, introducing new cost-drivers/outputs is more appropriate if consumers in general prefer their DSO to deliver a broader range of outputs than those incentivised in current regulation, i.e. other than economic efficiency and security of supply. When it comes to coordination of risk, new outputs can potentially increase the cost of risk, depending on controllability and the precision with which outputs are measured.

Motivation Compared to current regulation, introducing new cost-drivers or output measures can reveal new information about the effort of DSOs as they can be used as a signal of effort levels. On the other hand, if the output measures or performance levels differ across DSOs, it can complicate the cost comparison and provide DSOs with information rents. The negotiation alternative does not provide new information about the effort of DSOs and may provide DSOs with information rents as DSOs have private information about their costs which they can use to their advantage when negotiating a price to be paid by the involved customers. If the DSO's actual costs are lower than the costs announced to its customers, the DSO benefits in terms of higher profits or by increasing other costs. However, consumers will be at least as well off as a status quo where the solution in question would not be carried out.

Transaction Costs Out of the three alternatives in Table 3.6.1, current regulation is the alternative that minimises transaction costs. Introducing new outputs with associated

rewards and penalties entails higher transaction costs in the form of identifying outputs that generate value to consumers and determining target performance levels, rewards and penalties while taking into account controllability, the precision with which outputs can be measured, the agents' risk tolerance and the value generated to consumers of incremental effort.[9] Moreover, new cost-drivers/outputs increase the amount of monitoring. The negotiation alternative is associated with transaction costs in the form of time spent in negotiations for customers and DSOs and the time spent processing applications for the regulator. The extent depends on the number of applications.

3.6.2 Supporting the Green Transition

There are potentially several possible ways to ensure that the benchmarking of electricity DSOs does not discriminate against the use of flexibility services. A simple alternative to current regulation is to exclude the costs associated with flexibility services from the cost base. However, this would entail that the costs are not subject to the same efficiency pressure as other costs and could create a bias towards flexibility services even when these are not the most cost-efficient solution. Another option is to exclude the norm-grid (aggregate of grid components) from the output side of the benchmarking model. Then the costs associated with physical investments in upgrading or replacing electricity capacity would not result in a higher output level and thereby create more neutral incentives between opex and capex. However, the norm-grid has been shown to be cost driving by explaining a large part of the variation in costs across companies. The use of norm-grid as an output also reflects the fact that the DSOs may need to adapt their networks to the different geographic areas they operate in. Including flexibility on the output-side in the benchmarking model is another way to balance the incentives between physical investments and the procurement of flexibility services. This option is discussed below along with the option of using flexibility tenders as a way to incentivise flexible solutions.

Flexibility Indicators

As an alternative to the status quo, adding an extra output to the benchmarking model can be considered as a way to take account of flexibility services. In this way, a higher cost on

[9] C.f. the incentive intensity principle formulated by Milgrom and Roberts (1992)

the input-side of the model is offset by a higher output level. A new output could reflect grid utilisation or energy on flexible contracts. However, the specific choice of output needs further examination. The Swedish regulation of electricity DSOs provides an example of how grid utilisation can be incentivised. In this case, the incentive is designed as an add-on to the revenue-cap rather than an output in the benchmarking model. The Swedish Energy Markets Inspectorate (Ei), uses a load indicator, indicating the relationship between load and capacity, to reward DSOs if the load is close to capacity. Ei determines a revenue-cap for each DSO for a regulatory period of four years at a time. The revenue-cap is adjusted based on a number of factors, including performance regarding efficient grid utilisation (Swedish Energy Markets Inspectorate, 2019). The efficient grid utilisation incentive consists of two parts: i) reduction of network losses and ii) reduction of load flow peaks in connections to other grids. The incentive to reduce network losses is designed so that a change in network losses as a percentage of distributed energy, compared to the DSO's historical level, leads to change in the revenue-cap (positive or negative). The incentive to reduce load flow peaks in connection to other grids rewards DSOs for reducing the difference between peak and average load, i.e. utilities are rewarded for increasing utilisation.

Flexibility Tenders

DSOs can use flexibility tenders to offer contracts to the distributed energy market, e.g. electricity generators, renewable energy, storage, major consumption users and aggregators, for flexible capacity that can benefit customers by offering lower costs in comparison to traditional grid investments.[10] In RIIO, the distribution network operators' business plans for the coming regulatory period form the basis for determining allowed revenue. In the business plans, network operators must clearly justify their forecast costs and volumes associated with the outputs they set out to deliver which may include comprehensive cost-benefit analyses. Ofgem expect network operators to evaluate flexible solutions against the option of traditional network reinforcements in their business plans by including the option-value of flexibility in cost-benefit analyses (Ofgem, 2019c). A challenge in the approach, experienced by Ofgem, is that flexible solutions are not yet consistently valued. However, Ofgem expects them to converge over time and enable more effective pricing signals. To facilitate

[10]For example, UK Power Networks (2019) has announced the results of its competitive tender to procure flexible energy services

this development Ofgem requires network operators to publish their results of flexibility tenders.

Assessment of Alternatives

The performance of current regulation and each of the above-mentioned alternatives is summarised in Table 3.6.2 and reviewed below.

Table 3.6.2: Assessment of Alternatives

	Coordination	Motivation	Minimisation of Transaction Costs
Status quo	−	+/−	+
Flexibility indicator	+	+/−	−
Flexibility tenders	+	+/−	−

Coordination The output-side of the current benchmarking model does not register the benefits of flexibility services. Flexibility can benefit consumers by lowering electricity distribution costs and tariffs, as flexibility is seen as a less expensive way to maintain security of supply levels compared to the costs of building new infrastructure. Furthermore, the DSOs' use of flexible solutions may offer major consumers, electricity generators, aggregators, and other providers of flexibility a new way to provide their energy resource and create new income. For example, the alignment between consumer preferences and supplied levels of security of supply can improve by giving consumers the option to participate in demand-side flexibility schemes that affects their level of security of supply. In this way, adapting regulation to promote flexible solutions can potentially improve coordination of production. Each of the alternatives to current regulation promotes flexibility in different ways and prioritises coordination of production to similar extents. With respect to coordination of risk; if allowed revenue depends on indicators, such as a load indicator or indicator for capacity on flexibility contracts, the cost of risk may increase, depending on the controllability and the precision with which the new outputs are measured.

Motivation The alternatives to the status quo address the firms' private information about the cost-efficiency of flexibility vs. physical investments. The indicators directly incentivise flexible solutions while the flexibility tender alternative mandates a consideration

of flexible solutions. The trade-off between network utilisation and security of supply calls for balanced incentives in order to avoid that firms focus too much on one aspect at the expense of the other aspect.[11] I.e., directly incentivising flexible solutions, without considering the incentives for investment and long-term planning, may compromise security of supply. The use of flexibility tenders appears to prioritise long-term planning to a higher extent than the use of flexibility indicators as it obliges firms to consider the costs and benefits of flexible solutions compared to network investments. This increases transparency about the choice of solution. However, the use of flexibility tenders may be more susceptible to the adverse selection problem as firms' private information may allow them to misrepresent the value of flexibility.

Transaction Costs All alternatives to the status quo increase transaction costs. Similar to the transaction costs associated with cost-drivers or output measures, as reviewed in Section 3.6.1, the use of indicators is associated with transaction costs in the form of specifying the indicator and determining the associated rewards and penalties while taking into account controllability, the precision with which indicators can be measured, agents' risk tolerance and the value generated to consumers. Indicators also increase the amount of monitoring. Flexibility tenders are associated with transaction costs in the form of the tender process itself and the regulator's scrutiny of the cost-benefit analyses presented by DSOs.

3.6.3 Next Steps

When it comes to improving coordination for the purpose of increasing value to consumers, the least radical way to change regulation is to add extra cost-drivers to the benchmarking model that reflect outputs of value to consumers. This alternative addresses the issue of incentivising DSOs to deliver a broader range of outputs that would better match consumers' preferences. The other alternative, where agreements reached between DSOs and consumers can lead to adjustments of the revenue-cap, addresses the issue of sub-optimisation, i.e. situations where DSOs optimise their decisions without taking the consequences for consumers into account. If both issues play a role, a combination of the two alternatives can be con-

[11] According to the equal compensation principle formulated by Milgrom and Roberts (1992)

sidered. However, to justify the increase in transaction costs, the value to consumers of increased coordination needs to be clarified, for example by seeking answers to the following questions:

- Does the problem of responding to different needs, for example with regard to the number of connections or the location of transformer stations, mainly concern commercial consumers and to what extent?
- To what extent do preferred security-of-supply levels differ across consumers?
- To what extent do consumers prefer environmental and safety standards that are higher than legal requirements?

Various consumer research methods can be used to answer such questions. Likewise, the barriers for the utilisation of flexibility are worth examining further. If the perceived capex bias is not the only barrier, additional tools may be needed to address the issue. For example, a survey of the extent to which DSOs currently offer programmes for demand-side flexibility or procure flexibility can provide a starting point for examining the problem. In addition, an examination of the maturity of the flexibility market can help identify the potential and perceived barriers for DSOs in utilising flexibility.

With respect to the use of an extra output representing the benefits of flexibility services, the specific choice of output needs further examination. An output could be energy (kWh or kW) on flexible contracts or a measure for grid utilisation where DSOs are compensated for load levelling. However, in practice, choosing an appropriate output may turn out to be difficult since DSOs operate under different conditions and consumption patterns. Another concern, that complicates the decision, is to find an output that can both be considered a cost-driver and as representing the benefits of flexibility services. For example, peak load is considered a central cost-driver but peak load as an output does not incentivise the load levelling that can be provided by flexibility services (Benchmarking Expert Group, 2017). One way forward is to attempt identifying the value of flexibility services, i.e. the value of postponing or avoiding network investments, and on this basis, to identify an output that correlates with this value. For example, while a given indicator, such as kWh on flexible contracts, does not consider whether flexibility is available at the right time and place in the network, the indicator may be a sufficient proxy for the value of flexibility services.

Network engineers in the industry may be well-placed to contribute towards identifying more appropriate flexibility indicators.

3.7 Conclusion

Representatives of the Danish utility sector have criticised current regulation for being too focused on economic efficiency and for not incentivising DSOs to support the green transition. As a way to address these issues, they point to negotiation-based regulation, where the regulator and the utility enter into a dialogue and reach an agreement on outputs, investments, prices, etc. This type of regulation does have the advantage of being able to address the issues brought forward by the industry. However, it also has a number of disadvantages when compared to current regulation. Therefore, the paper has considered alternatives, in the form of adjustments to current regulation, that address the issues pointed out by the industry while reducing the disadvantages.

The industry's proposal and the alternatives are evaluated using the hierarchy of goals of contract design developed by Bogetoft and Olesen (2004). On this basis, the industry's proposal can be said to prioritise coordination of production at the expense of higher transaction costs. Asymmetric information may also play a bigger role, which could lead to higher information rents. Moreover, the proposal appears to introduce ambiguity about the statutory role of the regulator. Alternatively, the issues brought forward by the industry could be addressed by introducing new cost-drivers, application procedures or mandated flexibility tenders as part of the current regulation. The different alternatives have different implications for the goals of contract design but they have in common that the increase in transaction costs is likely considerably lower than the industry's proposal.

However, a final remark can be made with respect to the complexities involved in comparing different regulatory policies. The costs and benefits of different regulatory policies are often difficult or impossible to quantify and therefore also difficult to compare. For example, it may be that the transaction costs associated with a regulation, such as RIIO, are not that high considering the value generated by the framework. The potential gains may even be so high that the increase in transaction is negligible in comparison. The comparison of regulatory frameworks is also complicated by specific circumstances, which affects

the relative importance of different objectives in a given context. In some circumstances, improving service coordination may be seen as the most important objective of regulation, which justifies high transaction costs. In other circumstances, the regulatory framework may face different challenges, which warrants a different prioritisation of objectives. The evaluation of a regulatory framework is therefore not only dependent on the costs and benefits, which are hard to quantify, but also on the relative importance placed on different regulatory objectives in a given context.

In addition to future research on these aspects, more work is required to further investigate the issues brought forward by the industry and determine the suitability of the possible adjustments to the regulation. This may entail both market research to determine the extent of the issues and understand consumers' needs, but also for example, work in the form of identifying cost-drivers that appropriately reflect the desired outputs.

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Chapter 4

Use of Subjective Information in Utility Regulation: Comparing Theory and Practice

Anita Eskesen

Abstract

Utility regulators may wish to supplement objective information about the performance of regulated companies with subjective information in order to take more aspects of performance into account. This paper investigates the value and costs of subjective information in utility regulation and the implications it may have for the structure of an optimal incentive scheme. Specifically, the paper compares findings from the literature on managerial bonus pools to a regulatory example, the Environmental Discretionary Reward Scheme, which illustrates the applied use of a bonus pool that incorporates subjective information about companies' focus on environmental issues. The comparison shows that the costs of relying on subjective information in utility regulation are likely lower than in principal-agent relationships where the principal faces incentives to renege on compensation promises. Nevertheless, the regulatory example bears some similarities to the incentive schemes that are found to be optimal under the assumption that the principal faces an incentive problem. Such characteristics may however reflect pragmatic considerations associated with the use of bonus pools in practice.

4.1 Introduction

Widespread types of utility regulation, such as cost-plus and price-cap regulation, rely mainly or solely on objective information, such as accounting information, price indices, delivered kWh, number of connections, etc. Since such objective information can be observed by both the principal and the agent and is verifiable to third parties, compensation can be explicitly conditioned on its realisation. In recent years, some utility regulators have modified regulation to address issues such as stakeholder engagement, innovation, and environmental concerns.[1] However, it may be difficult to describe, with sufficient precision, an indicator of a company's effort when it comes to, for example, environmental considerations, which may not be reflected in verifiable facts, such as accounting information. The principal may, nevertheless, benefit from incorporating subjective information as part of the contract. One advantage is that more aspects of performance can be taken into account to provide a more balanced view of performance.

However, contracts based on unverifiable information become vulnerable to the so-called double moral hazard problem; the agents' actions are unobservable and the principal observes unverifiable information about the agent's actions that can be used to misrepresent the agent's performance level in order to minimise compensation payments. One way to solve the principal's incentive problem is for the principal to commit to paying out a fixed bonus pool, which can be distributed between the participating agent(s) and an outside party, depending on the subjective outcomes, as suggested by the literature on discretionary bonus pools.[2] This arrangement, however, is more costly to the principal compared to a situation where the information had been objective and verifiable. Nevertheless, in some circumstances, the cost of bonus pools based on subjective information approaches the cost of optimal incentive schemes based on objective information. The literature on discretionary bonus pools has provided a number of other findings regarding the use of both objective and subjective information in a range of different settings, which can be of relevance to the design of incentive schemes in utility regulation.

A practical example of a bonus pool used in utility regulation is the Environmental Discretionary Reward (EDR) Scheme administered by Ofgem, the regulator for gas and

[1] This includes Ofgem and the Water Industry Commission for Scotland

[2] See for example Ederhof, Rajan and Reichelstein (2011)

electricity markets in Great Britain. This example offers a basis for comparing the theory on bonus pools to the practice of using a bonus pool in the context of utility regulation. Accordingly, this paper investigates the similarities and differences between the theoretical predictions from the bonus pool literature and the EDR scheme. The comparison provides insights into how the specific context may justify departures from the bonus pool arrangements presented in the literature, under which conditions subjective information is valuable, and how the cost of relying on subjective information may vary in different settings, among other issues.

A central assumption in the literature on discretionary bonus pools is that the principal faces an incentive to underreport the agents' performance in order to minimise bonus payments. However, in the context of utility regulation, the more critical problems of subjective performance evaluations may be concerned with influence costs, uncertainty about measurement criteria, and perceived fairness. The comparison therefore also touches on how the EDR scheme affects these issues. While the EDR scheme serves as an illustrative example, the aim is not to evaluate this specific arrangement but rather to illustrate issues associated with the use of subjective information that could be relevant for utility regulators in general.

The paper proceeds as follows; Section 4.2 reviews the EDR scheme and Section 4.3 provides a brief overview of the benefits and drawbacks of subjective performance evaluation. Based on the bonus pool literature, Section 4.4 outlines the principal-agent problem and Section 4.5 compares theoretical predictions to elements of the EDR scheme. Section 4.6 concludes.

4.2 Regulatory Example: The EDR Scheme

The Environmental Discretionary Reward Scheme (EDR scheme) is a reputational and financial incentive available to the electricity transmission licensees in Great Britain.[3] Ofgem (2019b) describes the purpose of the EDR scheme as follows:

> "The purpose of the EDR scheme is to sharpen the focus of the companies on strategic environmental considerations and organisational and cultural

[3]Currently, three electricity transmission network owners operate the high voltage network carrying electricity across Great Britain; Scottish Hydro Electric Transmission Plc, SP Transmission Ltd, and National Grid Electricity Transmission Plc (Ofgem, 2019b)

changes to facilitate growth in low carbon energy, for example encouraging a more systematic approach to whole system planning."

Applications to the EDR scheme take the form of annual, non-compulsory, submissions by the transmission companies. The scheme has two main components: an executive-level annual statement and a scorecard. The executive level annual statement identifies the strategic activities related to the EDR scheme which the company will undertake over the next three years. The scorecard assesses the evidence provided by the company against each of the seven categories in the scorecard, cf. Table 4.2.1 below. Each category in the scorecard is associated with a number of sub-categories for which Ofgem has outlined the respective requirements of an 'engaged', 'proactive' and 'leadership' company. For example, scorecard category 1 has two sub-categories, for which Ofgem has specified a list of evidence criteria for the companies to meet in order to earn points in the category.[4] While some of the evidence criteria are objective in nature, such as '*Is there evidence that the company's GHG* [greenhouse gas] *footprint is publicly communicated*' (Ofgem, 2015, question E7.8), others are more subjective in nature and may be hard to verify for outside parties. For example; '*Is there evidence that the company is proactive in implementing solutions that optimise whole system performance and savings for users and consumers?*' (Ofgem, 2015, question E2.2). Therefore, the scorecard appears to combine subjective and objective performance measures.

The performance on each of the categories is weighted together to get an overall percentage score. Depending on this score, companies are grouped into one of three performance levels; 'engaged' ($< 50\%$), 'proactive' ($50 - 70\%$), or 'leadership' ($\geq 70\%$). Only companies with a satisfactory executive annual statement and a 'leadership' score on the balanced scorecard are eligible for a financial reward. Furthermore, the higher an applicant's score, the more of its potential maximum payment it will receive. Only companies with a score of 90% or higher will be recommended all of the potential maximum payment, while companies scoring 80-89% are eligible for 2/3 of the potential maximum payment and companies scoring 70-79% are eligible for 1/3 of the potential maximum payment.

Up to £32 million is available to electricity transmission licensees over the 8-year price control period, from 2013-2021. The EDR incentive thus has an annual value of £4 million,

[4]See Ofgem's "Environmental Discretionary Reward Scheme: Guidance (Revision 3)" and the associated "RIIO-T1 Environmental Discretionary Reward - Scoring Spreadsheet (revision 3)" (Ofgem, 2015, 2016)

Table 4.2.1: Scorecard Categories and Weights

Scorecard category	Weighting
1. Strategic understanding of and commitment to low carbon objectives and the role of the applicant company in their facilitation	10
2. Involvement in whole electricity system planning for low carbon future, including integration with distribution network operators (DNOs) and involvement in development of demand side interventions	10
3. Approach taken to connections for low carbon generators	10
4. Collaborative working to remove barriers to low carbon and wider environmental benefits through innovation	5
5. Approach to network development (for example outage planning) that considers alternatives to building/reinforcing, e.g. smarter network use, demand-side response and energy storage	5
6. Direct environmental impact of activities and associated reporting	5
7. Business greenhouse gas emissions management	2

Source: Ofgem (2016)

plus any rolled-over funding from previous years. Ofgem may award all, some, or none of the incentive each scheme year. If the full amount is not awarded in a given year, up to half of the total available annual funding can be rolled over to the next year. For example, the total financial reward available for the 2018-2019 scheme year was £6 million, as £2 million had been rolled over from the previous year. For the 2018-19 scheme year, all three transmission licensees applied to the scheme. They all provided a satisfactory annual statement but differed in terms of points achieved on the balanced scorecard, where two companies earned a score of 78%, making them eligible for 1/3 of the £6 million. The two companies therefore each received a £1 million financial reward while the third company, with a score of 63%, received no reward. As the previous year, £4 million was left as unallocated funds of which half was rolled over to the following year. The maximum available reward for the 2019-2020 scheme year is therefore £6 million.

4.3 Contracting with Subjective Information

Introducing subjectivity in contracting can mitigate a range of problems associated with solely relying on objective performance measures.[5] Subjective information may, for example,

[5]See, for example, the reviews by Bol (2008), Gibbs et al. (2004) and Prendergast (1999)

potentially contribute towards:

Mitigating the multi-tasking problem By introducing subjective performance measures, more aspects of performance can be taken into account which facilitates a more balanced view of performance and mitigates the multi-tasking problem.

Reducing risk Objective performance measures may be affected by uncontrollable events that increase risk to the agent. Unverifiable information about uncontrollable events may reduce such risk, for example via discretionary adjustments of the agent's compensation. However, it is not given that the use of unverifiable information always reduces risk. For example, while discretionary adjustments may be a suitable way for the principal to take account of uncontrollable events in order to reduce risk, at the same time, it allows the principal to consider factors other than those specified ex ante, which can create uncertainty about the measurement criteria used to evaluate the agent's performance.

Encouraging a long-term focus Objective indicators, such as accounting figures, often reflect past performance whereas it may be possible to construct subjective performance measures that reflect the effects of agents' actions on future value that are not easily quantified.

Reducing the vulnerability to manipulation Objective performance measures are often specified in numerical terms and may therefore be vulnerable to manipulation by the agent. For example, by changing accounting policies, a firm may be able to affect a performance measure positively without improving firm value. An ex post subjective performance evaluation however provides the principal with the possibility of penalising any detected manipulation. This benefit may materialise if the principal can directly observe an agent's behaviour or receives reports about the agent's misconduct, for example from other agents in the organisation, but does not apply to subjective information produced by the agent.

The vulnerability to manipulation can also be reduced by reducing the certainty about measurement criteria used in the principal's evaluation. However, at the same time, increased uncertainty about measurement criteria can negatively affect agents' incentives as the effect of increased effort on compensation becomes unclear.

Taking account of information not foreseen ex ante A purely explicit contract, based only on objective information, requires renegotiating if relevant new information becomes available. If the principal can rely on subjective information, new information can instead be taken into account during the period, for example via discretionary adjustments. This can lead to a quicker adaptation of the agent's behaviour and reduce the costs associated with renegotiation.

Reducing perceived unfairness If the agents perceive the contract to be unfair, the principal may benefit from making adjustments based on subjective information, i.e. use discretion when compensating agents. A reduction of perceived unfairness benefits the principal as agents trust that higher performance will lead to higher rewards and in this way improve the agents' motivation for exerting effort. However, this benefit only materialises if the principal makes unbiased performance evaluations and if the agents trust this to be the case. Also, allowing subjectivity in performance evaluations may lead to costly conflicts between the agent and the principal, when the two parties' performance evaluations are uncorrelated.

A fundamental problem with the use of subjective information in contracts is that such information cannot be verified by outside parties and therefore cannot be enforced by a court. Therefore, a contract based on subjective information becomes vulnerable to incentive problems for both the agent and the principal: the agent's actions are unobservable and the principal receives unverifiable information about the agent's actions that can be used to misrepresent the agent's performance level in order to minimise bonus payments.[6] The principal's incentive problem is referred to as reneging which describes a situation where the agent's performance is not rewarded. One strand of literature assumes that the principal will not renege because of reputational concerns[7] while another strand assumes that the principal will not renege because the principal commits to a fixed payment scheme or bonus pool.[8]

[6]See for example Demski and Sappington (1993) for a treatment of the two-sided or double moral hazard problem

[7]Studies of self-enforcing relational contracts, where the contracting parties can rely only on subjective information and are not legally obligated to fulfil the agreement, include for example Baker, Gibbons and Murphy (1994) and Levin (2003)

[8]See for example Baiman and Rajan (1995) and MacLeod (2003)

However, even when the principal is not the residual claimant and therefore has no financial incentive to renege, the principal may still benefit from misrepresenting an agent's performance evaluation. For example, supervisors may bias the performance evaluation of their subordinates because communicating a poor evaluation is unpleasant or because supervisors may have preferences for equity in outcomes. This can lead to compressed and more lenient compensation levels, which can result in reduced incentives for effort. Subjectivity in contracting can also lead to favouritism, which reduces incentives for employees that feel discriminated against and possibly for unduly favoured employees as well.[9] However, a principal may also bias the performance evaluation with the intention of improving perceived fairness and reducing costly conflicts (Bol, 2011). Specifically, a more lenient evaluation may be more in line with the agent's own perception of performance.

Since Ofgem has specified a bonus pool, in the form of the EDR scheme, as opposed to individual relational contracts with each of the companies, the theoretical findings from the bonus pool literature are used as a starting point when comparing the EDR scheme with theory.

4.4 The Principal-Agent Problem

As a reference point for studying Ofgem's practice, this section outlines the theoretical framework used in the literature on bonus pools to characterise the optimal contract when relying on subjective performance indicators.[10] After outlining a simple version of the theoretical framework, Section 4.5 summarises the ways in which Ofgem's setting varies from this framework. For simplicity, the starting point in this section is a principal offering a contract to a single agent who will choose between two actions, a^h and a^l, representing different levels of effort.[11] The principal cannot directly observe the outcome of the agent's actions but can rely on a subjective performance indicator when incentivising the agent to choose a given action a^h, which is more costly to the agent than the less productive action

[9] See for example Prendergast and Topel (1993) for an outline of these and related issues associated with subjective performance evaluation

[10] This and the following sections are based on MacLeod (2003) and Rajan and Reichelstein (2009) and in particular Ederhof, Rajan and Reichelstein (2011) who provide an overview of the existing research on managerial bonus pools

[11] While MacLeod (2003) models effort levels on a continuous scale, this outline follows Ederhof, Rajan and Reichelstein (2011) and Rajan and Reichelstein (2009), where actions are binary

a^l.

The subjective indicator of the agent's performance is denoted y and is assumed to have n different outcomes; $y = y^1, ..., y^n$. The indicator may not perfectly reflect the agent's actions, which is captured by the probability distribution q, referred to as the 'informativeness measure' by Ederhof, Rajan and Reichelstein (2011), where;

$$q^j(a) \equiv Prob[y = y^j|a] > 0$$

The density $q^j(a)$ is assumed to satisfy the monotone likelihood ratio property (MLRP): $q^j(a^l)/q^j(a^h)$ is monotone decreasing in j, i.e. the higher j, the more we believe a^h. Therefore, when the MLRP is satisfied, higher outcomes of the subjective indicator imply that the outcome is more likely to be drawn from the $q^j(a^h)$ distribution. The principal can credibly make use of such subjective performance information by setting up a fixed payment scheme and promising the agent a compensation that depends on the subjective information. Following the notation used by Ederhof, Rajan and Reichelstein (2011), the fixed payment or 'bonus pool' is denoted w. For a given subjective outcome, y^j, the principal promises the agent a corresponding compensation payment, s^j. We let $\mathbf{s} \equiv (s_1, ..., s_n)$ denote the vector of possible payments, where the maximum payment cannot exceed the size of the bonus pool; $w \geq \max\{s^j\}$. The principal is assumed to be risk neutral while the agent is assumed to be risk averse and to have additively separable preferences over wealth and the cost of effort. The agent's utility from compensation is denoted $U(.)$ and the cost of effort by $e(.)$. The principal's optimisation problem is then:

$$\min_{w,\mathbf{s}} \quad w$$

subject to:

$$i) \qquad \sum_{j=1}^{n} U(s^j) * q^j(a^h) - e(a^h) \geq \bar{U} \qquad (IR)$$

$$ii) \qquad \sum_{j=1}^{n} U(s^j) * q^j(a^h) - e(a^h) \geq \sum_{j=1}^{n} U(s^j) * q^j(a^l) - e(a^l) \qquad (IC)$$

$$iii) \quad w - s^j \geq 0, \text{ for all } j, \text{ where } 1 \leq j \leq n.$$

Constraint i) is the agent's participation constraint; the agent's expected utility must be higher than the agent's reservation utility, denoted $\bar{U}$. Constraint ii) ensures that the agent is better off choosing the productive action a^h over the less productive action a^l. MacLeod (2003) finds the striking result that, even though the agent can choose between a range of different actions and the performance indicator can take n different values, the solution to the principal's problem is a contract that entails only two different levels of compensation:[12]

$$s^j = \begin{cases} w, & \text{if } j > 1 \\ w - \Delta, & \text{if } j = 1. \end{cases}$$

In particular, the agent is paid the full bonus pool unless the subjective indicator takes the lowest possible value in which case some or all of the bonus pool, $\Delta = w - s^j$, is paid to a third party. The agent therefore receives the same compensation for a range of different values of the subjective indicator. This result is referred to as compression of payments. Ederhof, Rajan and Reichelstein (2011) provide intuition for the result by considering a scenario where the subjective indicator can take three different values, ($n = 3$). If the compensation level was strictly increasing with subjective outcomes, where the highest level of compensation equals the bonus pool ($w = s^3$), the principal would be diverting money to a third party whenever $j < 3$. However, the principal can reduce costs by instead lowering the size of the bonus pool and at the same time pay the agent more when $j = 2$ and less when $j = 1$. Given MLRP, it can be shown that, in this case, agents are still better off choosing a^h over a^l and the participation constraint is still satisfied. Therefore, the principal prefers to compress payments when $j > 1$ and punish the agent only when $j = 1$.

In contrast, for the case of objective performance indicators, Holmström (1979) has shown that the agent's compensation generally depends on the different realisations of the performance indicator. In this case, for n different signals realisations, the optimal contract generally specifies n different compensation levels that are strictly increasing in the signal realisation (Grossman and Hart, 1983).

The mechanisms considered by MacLeod (2003) differ from those considered by Ederhof, Rajan and Reichelstein (2011) and Rajan and Reichelstein (2006). MacLeod studies

[12]The following statement of MacLeod result follows the representation by Ederhof, Rajan and Reichelstein (2011, proposition 2.1)

mechanisms that specify compensation as a function of reports by both the principal and the agent regarding the agent's performance. Prior to the reports, both the principal and the agent observe a signal of the agent's performance. These signals may be correlated. The agent will impose a cost on the principal when the principal's evaluation is believed to be unfair. This threat ensures that the principal has an incentive to acknowledge good signal realisations that result in a higher compensation of the agent. MacLeod finds that if the principal's and agent's subjective evaluations are perfectly correlated, then the optimal contract with subjective evaluation is the same as the optimal contract with verifiable information (MacLeod, 2003, Proposition 4). In contrast, when the principal's and agent's signals are uncorrelated, the optimal contract exhibits compression, as illustrated above. In this case, the optimal contract is a fixed payment scheme, involving the use of a third party, since the principal's payoffs must be constant for all signal realisation in order to induce truthful reporting, which characterises the equilibrium according to the revelation principle. As reasoning for his result, MacLeod (2003) explains that, since the principal incurs a cost whenever the agent's compensation is smaller than the maximum possible level, and since the lowest signal realisation is the strongest indicator of low effort, it is optimal to punish the agent only when observing the lowest signal.

Ederhof, Rajan and Reichelstein (2011) and Rajan and Reichelstein (2006, 2009) argue that the message-based mechanisms considered by MacLeod (2003), when both parties observe the same signal, suffer from multiple equilibria problems; any pair of messages that form an equilibrium in one state also form an equilibrium in any other state. The authors therefore restrict attention to fixed payment schemes, i.e. bonus pool arrangements, which corresponds to the case where information observed by the principal is not available to the agents. In these settings, message-based mechanisms cannot achieve outcomes beyond those that can be achieved with bonus pools. Another justification for disregarding message-based mechanisms is that it may be too costly to write a contract that specifies compensation as a function of both parties' reports about their observed signals.

4.4.1 Multi-Agent Bonus Pools

Rajan and Reichelstein (2006) show that, when contracting with multiple agents, it becomes less likely that the principal needs to divert money to third parties. If an agent's performance

indicator suggests low effort, the principal can now divert money to the other agents instead of third parties. The following account of the model setup, when extending to two agents, follows the exposition by Ederhof, Rajan and Reichelstein (2011) and Rajan and Reichelstein (2006).

We consider a principal that seeks to motivate two agents, $i = 1, 2$, to choose high effort, a_i^h, as opposed to low effort, a_i^l. The agents are assumed to make their action choices simultaneously. The principal can observe a subjective indicator for each of the agents, y_i, which again can take n different outcomes; $y_i = y_i^1, ..., y_i^n$. Given the agents' action choices, the two performance indicators are assumed to be stochastically independent across agents. If all signals had been objective and verifiable, the agents' compensation schemes would then be independent of each other. Again, the indicators may not perfectly reflect the agents' actions as reflected by the density $q_1^j(a_1)$ for agent 1 and $q_1^k(a_2)$ for agent 2, where $a_i \in \{a_i^l, a_i^h\}$. Both densities are assumed to satisfy the MLRP.

Similarly to the single-agent scenario described above, the two agents are assumed to be risk averse with additively separable preferences over utility from compensation, $U_i(.)$, and the cost of effort, $e_i(.)$. The bonus pool is again denoted w and the vector of compensation payments by $\mathbf{s} = (\mathbf{s}_1, \mathbf{s}_2)$. The principal "promises" to pay the agents s_1^{jk} and s_2^{jk} respectively when the subjective outcomes are $\{y_1^j, y_2^k\}$. Each agent's expected utility, given both agents' actions, is then:

$$E(U_i(s_i^{jk})|a_i, a_{-i}) \equiv \sum_{j=1}^{n} \sum_{k=1}^{n} U_i(s_i^{jk}) q_i^j(a_i) q_{-i}^k(a_{-i}) - e_i(a_i)$$

The principal's optimisation problem then becomes:

$$\min_{w, s_1^{jk}, s_2^{jk}} \quad w$$

subject to:

$$i) \qquad E(U_i(s_i^{jk})|a_i^h, a_{-i}^h) \geq \bar{U}_i \qquad \text{for } 1 \leq i \leq 2, \qquad (IR)$$

$$ii) \qquad E(U_i(s_i^{jk})|a_i^h, a_{-i}^h) \geq E(U_i(s_i^{jk})|a_i^l, a_{-i}^h) \qquad \text{for } 1 \leq i \leq 2, \qquad (IC)$$

$$iii) \qquad w - s_1^{jk} - s_2^{jk} \geq 0 \qquad \text{for all } 1 \leq j, k \leq n.$$

Rajan and Reichelstein (2006) prove that it is always efficient for the principal to pay out the entire pool to the agents for all outcomes of the subjective indicator, i.e. it is no longer necessary to divert money to third parties. In other words, it is cheaper for the principal to pass on a bonus withheld from one agent to the other agent rather than diverting it to a third party. Provided the MLRP holds, they find that, holding the other agent's outcome fixed, each agents' compensation is an increasing function of the agent's own performance. At the same time, since the bonus pool is fixed, each agent's compensation is a decreasing function of the other agent's performance. Even though the agents are exposed to additional risk, as their compensation depends on the other agent's performance, they are better off, compared to repeating the third-party scheme for each agent, since their compensation will never decrease.

The incentive compatibility constraint in this problem requires the agents to choose high effort as a Nash equilibrium. However, as illustrated by Ederhof, Rajan and Reichelstein (2011), with binary outcomes and two symmetric agents, a second Nash equilibrium exists, where both agents shirk, which Pareto-dominates the obedient equilibrium. However, the authors point out that the existence of an undesirable equilibrium does not always hold. For example, it does not extend to three symmetric agents or to two non-symmetric agents.

In situations where the multiple equilibria problem does exist, the principal can overcome it by tightening the incentive compatibility constraint such that obedience becomes a dominant strategy for both agents. In this case, the optimal bonus pool arrangement

may involve diverting money to third parties when both agents' subjective performance indicators suggest low effort, thereby eliminating the equilibrium where both agents shirk. However, dominant strategy implementation requires an increase of the bonus pool and is therefore more expensive than Nash implementation.

4.5 Comparison of Theory and Practice

This section compares the EDR scheme to the theoretical predictions regarding discretionary bonus pools. As discussed in Section 4.5.1, a fundamental difference between the EDR scheme and the bonus pool literature is the extent to which the pool is fixed and paid out in full. Section 4.5.2 reviews the cost of using subjective as opposed to objective information and relates the issue to the EDR scheme. The dependency between companies' compensation levels in the EDR scheme is discussed in Section 4.5.3. Section 4.5.4 further reviews the conditions under which it is valuable to supplement objective information with subjective information and investigates the extent to which these conditions apply to the EDR scheme. However, even if subjective information is valuable, payments are not always fully differentiated with respect to the subjective outcomes, as reviewed in Section 4.5.5. Another issue, given that the subjective information is valuable, is the relative weight placed on the subjective measure, i.e. the aggregation of performance metrics, which is the topic of Section 4.5.6. Section 4.5.7 reviews how the use of discretion may affect influence costs, uncertainty about measurement criteria, perceived fairness of the contract, and the ways in which the EDR scheme addresses these issues. Finally, Section 4.5.8 discusses the problem of balancing incentives across the overall framework when introducing a targeted incentive scheme, such as the EDR scheme.

4.5.1 The Credibility Problem

An underlying assumption in the literature on bonus pools is that the principal will not renege because the principal commits to a fixed payment scheme or bonus pool. The principal's commitment to paying out the entire bonus pool reduces the principal's incentive problem and thereby overcomes a fundamental problem with the use of subjective information in contracting. As reviewed in Section 4.4, when contracting with a single agent, the

principal is assumed to commit to paying out the entire pool, while diverting some or all of the pool to a third party for unfavourable outcomes of the subjective indicator (Ederhof, Rajan and Reichelstein, 2011; MacLeod, 2003). With multiple agents, the principal has the option of punishing unfavourable outcomes by one agent by diverting money to the other agent(s).

Ederhof, Rajan and Reichelstein (2011) use the term 'proper bonus pools' to refer to bonus pools, where the principal ex ante commits to paying out the entire pool to the agents, regardless of the subjective information that later becomes available, i.e. bonus pool arrangements that do not involve payment of a third party. An advantage of proper bonus pools is that the money saved from not paying a third party can instead be used to make agents better off. A disadvantage, however, is that when the entire bonus pool is distributed between agents, the agents' compensation depends on the realisation of the other agents' performance indicator, which they cannot influence. Proper bonus pools therefore expose the agents to additional risk, which is further discussed in Section 4.5.2.

Baiman and Rajan (1995) show that proper bonus pools can lead to a strict Pareto improvement in a two-agent setting when the principal can rely on subjective as well as objective information, compared to the optimal contract that relies only on objective information. Rajan and Reichelstein (2006) show that, under certain conditions, proper bonus pools are optimal mechanisms when a principal must rely only on subjective information when contracting with multiple agents. I.e., it is cheaper for the principal to balance the bonus pool between agents than to divert money to a third party.

A possible implication of the principal's commitment to paying out the entire pool, when contracting with multiple agents, is that it prevents the principal from punishing both agents for choosing low effort collectively. However, as mentioned in Section 4.4.1, the multiple equilibrium problem does not always exist and, in contrast to the literature on bonus pools, Ofgem does not commit to paying out the entire scheme and therefore avoids this potential problem. Ofgem has announced that £32 million is available to the electricity transmission licensees over the 8-year price control period from 2013-2021 but the actual total compensation is left to Ofgem's discretion. In fact, nothing may be paid out in a given year if none of the three networks achieves a leadership score and produces a satisfactory executive-level annual statement (Ofgem, 2016).

It appears plausible that a multi-period bonus pool, such as the EDR scheme, provides the principal with additional flexibility compared to a one-period bonus pool. In response to unfavourable outcomes in one period, the principal can roll over to the next period a share of the compensation that would have been paid if the agents had performed better. However, Ederhof, Rajan and Reichelstein (2011) shows that the principal does not necessarily have anything to gain from a multi-period bonus pool with a roll-over provision, when the principal is assumed to commit to the size of the pool. Specifically; in a single-agent setting, where the agent's preferences are assumed to be separable across periods and where both the principal and the agent are assumed not to discount their future payoffs, the authors find that the optimal two-period bonus pool with a roll-over provision is equivalent to repeating the one period bonus pool arrangement.

For the EDR scheme, since Ofgem does not commit to paying out the entire pool over the course of the 8-year period nor in any single year of the period, the regulator already has the advantage of avoiding compensation of poor performance. The roll-over provision gives Ofgem the opportunity to provide stronger incentives in the following period but can give rise to random fluctuations in compensation levels for the individual company. The companies are, however, never worse off from the roll-over provision.

Since Ofgem does not commit to paying out the entire pool, the credibility of the EDR scheme hinges on the agents to trust that Ofgem will not act opportunistically when deciding on their compensation, which may be justified by the fact that Ofgem is not the residual claimant of the funds not paid out as compensation to the network companies and so has no financial incentive to renege. Suppose instead that a multi-level principal agent relationship exists, where a principal, such as the national government, directs the regulator, as an agent. In this case, the potential for political intervention could deter long-term commitments, such as outside investments in the industry. However, in practice, the independence of utility regulators from governments and other stakeholders, as mandated by the Third Energy Package adopted in 2009 for EU member countries, counteracts the fear that governments will renege on their promises. The independence of regulators increases regulatory stability by dampening the effect of short-term changes in political priorities on regulatory decisions. However, regulators' budgetary and staffing resources may need to be agreed upon and approved by national ministries of finance, which, in theory, could provide a means of

rewarding regulators, e.g., for reducing prices to consumers. Therefore, hypothetically, it is possible that even independent regulators face incentives to renege. As for the EDR scheme specifically, with the size of the pool specified ex ante, it appears improbable that the regulator has more to gain from reneging than from honouring its promise to the reward the companies.

4.5.2 The Costs Associated with Discretionary Bonus Pools

Bonus pools based on subjective information are more costly to the principal than the benchmark of optimal contracts based on objective and verifiable information. The costs arise as the principal must commit to paying out the entire pool in order to create credible incentives. In contrast, when information is objective and verifiable, the principal can credibly withhold parts of the pool.

When contracting with a single agent, it is costly to divert money to third parties for unfavourable outcomes. When contracting with multiple agents, the principal can balance the pool among agents and thereby avoid "wasting" money on third parties. However, multi-agent bonus pools based on subjective information still entail additional costs to the principal compared to optimal contracts based on objective and verifiable information. The costs arise as agents are exposed to additional risk as their compensation depends on the realisation of the other agents' performance indicators. Unless the subjective performance indicator perfectly reflects an agent's actions, the risk associated with the measurement error of a given agent's indicator is borne by the other agents as the bonus pool is balanced across agents. The principal therefore has to pay an additional risk premium. Rajan and Reichelstein (2006) find that the additional cost of discretionary bonus pools declines as the number of agents in a bonus pool arrangement increases and as the informativeness of the subjective indicator increases. In the limiting case, where subjective indicators reflect the agents' efforts precisely, bonus pools perform as well as the benchmark case of verifiable information. When the subjective indicator imperfectly reflects the agents' efforts, the cost declines with the number of agents.

As the number of agents in the bonus pool arrangement increases, the variation of any agent's compensation can be spread among a larger number of agents. Each agent's compensation then entails less risk, which reduces each agent's risk premium and allows the

size of the pool to be reduced. If the bonus pool must be balanced between two agents, all of the variance associated with an agent's compensation is imposed on the other agent. However, if the number of agents increases to three, the variation in agent $i's$ compensation can be spread among two agents so they are each imposed half of the variation in agent $i's$ compensation. Rajan and Reichelstein (2006) show that as n becomes large, the principal's cost per agent converges to the cost per agent of the optimal contract when information is verifiable, given an assumption of constant absolute risk aversion for n identical agents with stochastically independent performance signals.[13] For a large number of agents, bonus pool arrangements based on subjective information can thus be as cost-efficient as contracts based solely on objective and verifiable information.

Rajan and Reichelstein's findings are also relevant in situations where the information available to the principal may be contractible but is associated with high verification costs or where the costs of writing and enforcing the contract are particularly high. In such cases, for a large number of agents, bonus pool arrangements may be an attractive alternative to entering into explicit contracts with the agents. Conversely, for a small number of agents, the costs associated with bonus pool arrangements may be higher than the costs of verifying information to be used in explicit contracts.

In the EDR scheme, the compensation of each of the companies is determined via a two step procedure. First, the number of eligible companies is determined. In turn, this determines the size of the bonus pool available to each of the eligible companies, namely as the total pool divided by the number of eligible companies. For example, if only two out of the three companies are eligible, the maximum available reward to each company is £4m/2=£2 million, assuming that nothing has been rolled over from the previous year, as opposed to £1.33 million if all three companies are eligible. Secondly, given eligibility, how big a share (1/3, 2/3 or the whole) of the individual pool is paid out to a company depends on the company's performance on the balanced scorecard. Both steps require a subjective performance evaluation by the regulator, but only the first step causes additional risk, unless the subjective indicators perfectly reflect the agents' actions, since the available compensation of a given company depends on the realisation of the other companies' indicators.

[13]Proposition 5 by Rajan and Reichelstein (2006)

4.5.3 Interdependent Compensation Levels

A characteristic of the EDR scheme is that the size of the bonus pool available to a company in any given year depends on the number of companies eligible for a reward, i.e. the number of companies with a satisfactory executive-level annual statement and a score above 70% on the balanced scorecard. Given eligibility, the fraction of the maximum available reward paid to each of the companies depends on the company's score on the balanced scorecard, independently of the other companies' score as illustrated in Table 4.5.1. The structure encourages competition between the companies and at the same time discourages cooperation such as knowledge sharing on best practices, etc. Moreover, the compensation scheme provides a given company with higher rewards, when it performs well and other companies perform poorly, compared to a situation where the other companies also perform well. In this way, a company may receive a higher reward, potentially £4m instead of £1.33m. Compared to having three independent bonus pool of £1.33m each, the maximum potential reward to a given company is therefore higher when balancing the £4m bonus pool across eligible agents, which strengthens incentives.

Alternatively, we can consider a variation of the scheme, where the companies instead are encouraged to cooperate with each other to generate a larger bonus pool, for example a bonus pool that increases with the number of eligible companies. However, such a variation implies either an increase of the total bonus pool, if the different compensation levels must be held constant (as illustrated in Table 4.5.2), or a reduction of the compensation levels associated with each of the three scorecard performance bands, if the annual bonus pool cannot exceed £4m. Whether it is worthwhile for the regulator to change the compensation scheme therefore depends on the potential gains from cooperation.

Another alternative is three separate bonus pools, one for each company. The individual bonus pools need not be equal in size but could instead be made proportional to the size of each company, for example as measured by their revenues. If the companies differ considerably in size, such a variation could help align incentives so that larger companies have as strong incentives to provide effort as smaller companies. The advantage of multi-agent pools is that the principal no longer needs to "waste" money on third parties to make the incentive scheme credible, as the agents can then act as each other's budget balancers. However, if Ofgem can credibly withhold parts of the pool, then single-agent pools do not entail higher

Table 4.5.1: Compensation in the EDR Scheme (£m)

		Company 2, Company 3		
		NE,NE	NE,E	E, E
Company 1	Not eligible	0	0	0
	Eligible with score of 70-79%	1.33	0.66	0.44
	Eligible with score of 80-89%	2.66	1.33	0.89
	Eligible with score of 90+%	4	2	1.33
	Bonus pool size	4	4	4

Note: Table 4.5.1 states the compensation (£m) to a given network company, company 1, given its score and the eligibility of the other two companies, company 2 and 3, where E is "eligible" and NE is "not eligible"

Table 4.5.2: Alternative Compensation Scheme (£m)

		Company 2, Company 3		
		NE,NE	NE,E	E, E
Company 1	Not eligible	0	0	0
	Eligible with score of 70-79%	0.44	0.66	1.33
	Eligible with score of 80-89%	0.89	1.33	2.66
	Eligible with score of 90+%	1.33	2	4
	Bonus pool size	1.33	4	12

Note: Table 4.5.2 states the compensation (£m) to a given network company, company 1, given its score and the eligibility of the other two companies, company 2 and 3, where E is "eligible" and NE is "not eligible"

costs for the regulator.

4.5.4 The Value of Subjective Information

The assessment of applications to the EDR scheme is based on two overall criteria; the executive level annual statement and the balanced scorecard. The scorecard is a weighted sum of multiple performance measures of which some are objective while others are more subjective in nature. Rajan and Reichelstein (2009) study the question of whether it is always valuable to include a subjective performance indicator when the principal has access to both an objective and a subjective indicator. While Holmström (1979) shows that it is always valuable to include an additional objective performance indicator as long as it is informative relative to an existing indicator, this is not always the case when the performance indicator is subjective and used in combination with objective indicators.

Rajan and Reichelstein (2009) study both a single- and multi-agent setting, where the principal has access to both an objective indicator, x, and a subjective indicator, y. The two indicators are binary and independently distributed conditional on the agent's choice of action. The principal specifies a bonus pool for each of the two objective outcomes. If the subjective information indicates shirking when contracting with a single agent, the principal threatens to divert some or all of the bonus pool to a third party. If y in this case was objective and verifiable, it would clearly be valuable because the two signals are stochastically independent, but the authors show that this is not guaranteed when y is subjective and thus non-verifiable. Rajan and Reichelstein consider a subjective indicator to be valuable in a contract, if the solution to the principal's problem is such that the agent's compensation level depends on the realisation of the subjective indicator, when conditioning on the objective indicator.

The authors show that the subjective indicator is valuable when contracting with a single agent if it is sufficiently informative. In the extreme case, where the subjective indicator is a strong indicator of the agent's action choice such that the informativeness measure, q^h, approaches 1, the principal can pay the entire bonus pool to the agent for high outcomes of the subjective indicator and divert a fraction to a third party otherwise. The authors further derive a condition (Proposition 1) under which the subjective indicator is valuable. They find that:

- When q^h is close to q^l, i.e. for less extreme values of q^h, the subjective signal is of low quality and the principal is better off ignoring the subjective signal
- Subjective information is of no value when the moral hazard problem is not significant, i.e. when $e(a^h)$ approaches $e(a^l)$
- A less informative objective measure makes it easier for the condition to hold while a 'strong' objective indicator makes the subjective indicator dispensable even if it is marginally informative

When extending their analysis to the case of multiple-agents, Rajan and Reichelstein (2009) find that the subjective indicator is always valuable, regardless of the objective outcome, provided that the subjective indicator is incrementally informative about the agents' effort. The reason is that the cost of using subjective information, when contracting with multiple agents, is smaller than the single-agent case, since the principal can now avoid diverting money to a third party. When contracting with multiple agents, the principal therefore never benefits from ignoring the subjective indicator. The fact that the EDR scheme applies to multiple agents and relies on both subjective and objective information is therefore consistent with Rajan and Reichelstein's finding that the principal is better off using subjective information as opposed to ignoring it.

However, the finding is based on the assumption that the principal needs to commit to paying out the entire pool for the incentive scheme to be credible. In contrast, if a regulator can credibly commit to withhold parts of the pool when contracting with both single- and multiple agents, then single-agent bonus pools are not more costly than multi-agent pools. This would extend the result from the multi-agent scenario to the single-agent scenario, i.e. increase the cases for which a subjective indicator is valuable when used in combination with an objective indicator when contracting with a single agent.

4.5.5 Compression of Payments

Compression of payments refers to the finding that even though a subjective performance indicator can take a range of different values, the solution to the principal's problem, entails that the agent(s) receives the same compensation for a range of subjective outcomes. The agent's compensation is thus considerably less variable than the agent's actual performance.

As reviewed in Section 4.4, MacLeod (2003) finds that when contracting with a single agent, the optimal bonus pool based on subjective information is an extremely compressed incentive scheme, where the agent is paid the full bonus pool unless the subjective performance indicator takes the lowest possible value. The compression result does not extend to multi-agent bonus pools; Rajan and Reichelstein (2009) find that optimal multi-agent compensation schemes are generally fully differentiated with respect to the performance indicators in the presence of both objective and subjective indicators.[14]

The EDR scheme compresses compensation since the companies' performance is grouped into four levels according to their percentage score on the balanced scorecard. Given an acceptable executive level annual statement, the following compensation levels apply:

- 0-69%: No compensation
- 70-79%: 1/3 of the potential maximum compensation
- 80-89%: 2/3 of the potential maximum compensation
- 90-100%: All of the potential maximum compensation

Since the EDR scheme applies to multiple agents, it appears to exhibit compression to a greater extent than suggested by theory. This lack of variation in the compensation scheme can reduce the companies' incentives and aggregate productivity compared to a scheme with a greater degree of differentiation between performance levels. Therefore, it may be beneficial to increase the sensitivity between compensation and performance evaluation on the balanced scorecard.

On the other hand, a compressed compensation scheme may be seen as a more fair solution than a fully differentiated scheme if the agent does not agree with the principal's evaluation of the agent's performance. In particular, MacLeod (2003) finds that the degree to which the principal is able to compensate the agent as a function of a subjective performance evaluation depends on the extent to which the agent agrees with the principal's evaluation. Only when the principal and agent's evaluations are perfectly correlated, is it optimal for

[14]Partial compression can arise under dominant strategy implementation if the bonus pool corresponding to the lowest possible outcome is not paid out in full (Rajan and Reichelstein, 2009, Proposition 6)

the principal to fully differentiate compensation with respect to the subjective evaluation.[15] In MacLeod's model, compression arises due to the threat of costly conflicts when the agent does not agree with the principal's evaluation. Likewise, Ofgem may prefer a compressed compensation scheme in order to avoid costly conflicts, such as complaints or appeals of the regulator's decisions. Furthermore, compression may arise as a result of the principal's aim to minimise time and effort associated with the process of evaluating performance (Bol, 2011).[16]

4.5.6 Aggregation of Performance Measures

In the EDR scheme, the actual aggregation (balancing) of the scorecard categories is published ex ante in the form of a scoring spreadsheet (Ofgem, 2015), which lists the questions and evidence required by Ofgem to assess applications to the scheme. Each overall scorecard category is associated with a number of underlying performance metrics. The first category, for example, covers 14 questions related to the category. The companies earn points for each satisfactory response to the questions. The sum of points within each category is then weighted according to the weights specified in Table 4.2.1. This reduces uncertainty about evaluation criteria. In contrast, if the weights placed on the different performance measures are not contractually specified, the use of subjective performance evaluations in a balanced scorecard can lead to complaints about favouritism and uncertainty about evaluation criteria (Ittner, Larcker and Meyer, 2003).

Rajan and Reichelstein (2006) study the aggregation of subjective and objective performance metrics in a multi-agent setting where the principal observes both an objective and a subjective performance indicator. They use the so-called LEN-model, which assumes Linear compensation, Exponential utility, and Normally distributed performance indicators. They find that subjective performance indicators receive less weight in optimal contracts compared to objective indicators, since bonus pools based on subjective information entail a cost in the form of increased risk. For the case of two agents, the weight on the subjective

[15] However, as mentioned in Section 4.4, Ederhof, Rajan and Reichelstein (2011) and Rajan and Reichelstein (2006, 2009) point out that the mechanism considered by MacLeod (2003) suffers from multiple equilibria problems

[16] Bol (2011) further points to managers' incentive to prevent damage to the employee-manager relationship as a driver of both centrality bias, i.e. compression, and leniency bias, i.e. inflation of performance ratings

indicator is only half of what it would have been if the indicator was verifiable. As the number of agents increases and each agent's compensation entails less risk, the weights on performance indicators approach the scenario where all indicators are objective and verifiable.

The finding is not directly applicable to the EDR scheme, since Ofgem does not commit to paying out the entire pool. The EDR scheme still specifies compensation of a given company to depend on the other companies' performance but this characteristic is not the result of a balancing requirement. Since the companies are never worse off from being evaluated against the other companies, no additional risk premium is needed to compensate the companies. Therefore, Ofgem does not benefit in this way from placing less weight on subjective metrics compared to objective metrics.

The balanced scorecard has been studied extensively[17] since Kaplan and Norton (1992) developed the concept, but relatively few papers have studied balanced scorecards using agency theory. The papers by Budde (2007) and Kvaløy and Olsen (2020) are exceptions. Both papers fall into the literature on self-enforcing relational contracts, which assumes that a contract is sustained through the value of future relationships. Budde (2007) studies the incentive effects of a balanced scorecard both when information is verifiable and when unverifiable measures are included. For both settings, the paper investigates the conditions under which a balanced scorecard contract can obtain the first-best solution.

While Budde takes the balanced scorecard contract as given, Kvaløy and Olsen show that a balanced scorecard is the optimal contract between a principal and a multi-tasking agent, where the agent gets a bonus if the weighted sum of performance outcomes exceeds a hurdle. They also show that the inclusion of verifiable measures in the scorecard can reduce the variance of the performance index, which strengthens incentives. The papers provide a theoretic rationale for the use of balanced scorecard contracts in practice. However, the conditions underlying the EDR scheme may differ from those assumed in these papers, for example regarding risk-neutral agents and unlimited liability. Whether balanced scorecard contracts continue to be optimal under such conditions is a question for future research, as noted by Kvaløy and Olsen.

[17] See for example Hoque (2014) for a review of the research on balanced scorecards

4.5.7 Downsides of Discretion

The literature on discretionary bonus pool is of particular relevance to principal-agent relationships, where the principal is the residual claimant of the compensation not paid out to the agents. In these cases, the principal may face a financial incentive to underreport performance when using discretion in the performance evaluation since the evaluation is unverifiable to third parties. However, utility regulators are not generally the residual claimant of the funds not paid out as compensation to the utilities and so have no financial incentives to renege. In this case, the more critical problems of using discretion may include influence costs, uncertainty associated with measurement criteria, and the effect on perceived fairness.[18]

Influence Costs

Influence costs have been defined by Milgrom and Roberts (1990, p 58) as "the losses that arise from individuals within an organization seeking to influence its decision for their private benefit (and from their perhaps succeeding in doing so) and from the organization's responding to control this behavior." The use of discretion in performance evaluation may induce agents to increase their influence activities since it increases the principal's ability to respond to information supplied by agents, compared to a performance evaluation based solely on objective measures. Influence activities are costly both in terms of the time spent influencing, instead of productive activities, and the time spent limiting influence activities or their effects. Influence costs can thus be reduced by limiting the use of discretion, and instead committing to fixed rules, or by limiting communication prior to decision-making (Milgrom and Roberts, 1988). However, these measures may themselves be costly. For example, limiting the use of discretion may prevent the principal from adjusting for uncontrollable events and limiting communication prior to decision-making may involve not obtaining information that could improve decisions.

The EDR scheme discourages influence activities by ex ante publishing the weighting of the scorecard categories and the measurement criteria that utilities will be evaluated against ex post. This commitment limits the regulator's use of discretion so it only concerns the ex post evaluation of whether the measurement criteria have been met and not the

[18] See Bol (2008) for a review of benefits and drawbacks of subjectivity in compensation contracting

criteria themselves. This likely limits influence activities, compared to a situation, where the measurement criteria had not been defined ex ante. However, the ex ante commitment to measurement criteria may prevent Ofgem from adjusting for factors, for example by expanding the measurement criteria, to take into account factors that were not foreseen ex ante.

Uncertainty About Measurement Criteria

Objective indicators have the advantage of setting clear measurement criteria, which provide a clear signal to the agent of which actions are expected to increase compensation. However, objective indicators may not be able to deal with uncontrollable events or information that could not be foreseen ex ante. The use of subjectivity in contracting, such as discretionary adjustments, can be used to mitigate this problem but may at the same time generate uncertainty about measurement criteria (Bol, 2008). This uncertainty in turn has a negative effect on incentives to provide effort. It is therefore not clear whether the use of subjectivity increases or reduces uncertainty. However, the amount of uncertainty depends on the specific implementation. Ofgem has implemented its performance evaluation by publishing guidance to the applicants of the EDR scheme, which both explains the assessment process and procedures and the basis for allocating rewards. This reduces the uncertainty about what type of behaviour is expected by the agents in order to perform well and thereby improves incentives. In contrast, if there was no clear guidance, the use of discretion can lead to increased uncertainty about measurement criteria.

Perceived Fairness

The use of subjectivity in performance evaluations may lead to a low goal clarity, undermine the agents' trust in the principal and reduce their perception of fairness, which can significantly affect motivational incentives.[19] While subjectivity can improve fairness of a purely objective compensation plan, for example by taking account of uncontrollable events, it may also have the opposite effect. For example, in a study of bonuses rewarded on the basis of a subjective balanced scorecard in a financial services firm, Ittner, Larcker and Meyer (2003) show that high levels of discretion can lead to uncertainty about measurement

[19] See for example Hartmann and Slapničar (2009)

criteria and favouritism, which reduce perceived fairness. In contrast, Bol (2011) shows that the use of subjectivity can lead to evaluation biases, which can improve perceived fairness and positively affect future performance. This contrasts with the prediction from agency theory that evaluation biases will reduce motivational incentives, since they blur the relationship between pay and performance. Specifically, Bol examines the effect of centrality and leniency bias on employees' performance incentives in a financial services firm. While she finds centrality bias (compression of payments) to negatively affect performance improvements, leniency bias is found to positively affect performance. She finds the results to be consistent with the behavioural argument that employees have a tendency to overestimate their own relative performance, and therefore non-inflated (unbiased) ratings are likely to be perceived as unfair.[20] A leniency bias, which inflates performance ratings, can therefore positively affect perceived fairness and improve motivational incentives as well as reduce costly influence activities such as complaints.

Voußem, Kramer and Schäffer (2016) aim to provide an explanation to some of the conflicting empirical findings regarding the effect of subjectivity on perceived fairness by suggesting that perceived fairness depends on how much emphasis is put on subjective measures. In an empirical study of annual bonus contracts in the finance sector of German-speaking countries, Voußem, Kramer and Schäffer (2016) examine how perceived fairness varies with the weight put on subjective performance measures. They find that perceived fairness initially increases but eventually declines as more weight is put on subjective measures in the performance evaluation, consistent with an inverse U-shape relationship. Their results suggest that the marginal benefits, in terms of adjusting for uncontrollable factors, are high at low levels of subjectivity, while the marginal costs in terms of evaluation biases, influence activities, and low goal clarity, increase with the degree of subjectivity. Low to moderate levels of subjectivity in performance evaluation thus seem to increase perceived fairness, while extensive use of subjectivity can have the opposite effect.

Some of the ways Ofgem's EDR scheme addresses perceived fairness include:

- relying on a combination of objective and subjective measures, which restricts the weight on subjective performance measures

[20]See Bol (2011) for an account of behavioural research concerning employees' perception of fairness of performance-based compensation plans

- ex ante publishing of assessment criteria and performance targets, which improves goal clarity and communicates that the evaluation is performed consistently across companies

- convening an expert panel to act as advisors, which conveys that the evaluation is free of bias and based on specialist knowledge

4.5.8 Balancing the Strength of Incentives Across Activities

The EDR scheme has an annual bonus pool of £4m annually, which amounts to £32m over the course of the 8-year regulatory period. Regarding the strength of the incentive, Ofgem has estimated that "... a figure of £4 million is an appropriate incentive to recover the cost of additional resources required to meet the criteria well as well as make a reasonable return." (Ofgem, 2012a, p 24) Given that the three electricity transmission networks differ in size, the size of the bonus pool relative to allowed revenue ranges from 0.2 percent for the largest network, National Grid Electricity Transmission, to 1.4 percent for the smallest network in terms of allowed revenue, SP Transmission Ltd.[21]

The financial incentive encourages utilities to spend more time on the activities covered by the EDR scheme but at the same time may divert attention away from other tasks. This is known as the multi-task problem. In their seminal article, Holmström and Milgrom (1991) study a principal-agent model, where the agent performs several different tasks, and illustrate the problem of balancing incentives across tasks. They show that it can be optimal to use low-powered incentive schemes if the principal does not want tasks to be neglected. The observation that incentivising effort on one activity can crowd out effort on another activity is also reflected in the equal compensation principle by Milgrom and Roberts (1992, p 228):

> "If an employee's allocation of time or attention between two different activities cannot be monitored by the employer, then either the marginal rate of return to the employee from time or attention spent in each of the two activities must be equal, or the activity with the lower marginal rate of return receives no time or attention."

[21] Based on allowed revenue of £13,118m and £2,352m respectively for RIIO-T1 in "best view" scenario, i.e. actual allowed revenue may be higher or lower (Ofgem, 2012b,c)

Consequently, the size of the EDR bonus pool should ideally reflect a balance between the incentives to provide effort across all the different activities performed by utilities such that no activities are neglected because they are less rewarded. However, different utilities will exhibit different costs of effort of different activities and each select a level of effort across different activities that maximises profit. Moreover, utilities may be motivated by reputational incentives or there may be synergies with other incentive schemes in the overall framework, which makes it difficult to assess whether the financial incentive of the EDR scheme is balanced in comparison to the incentives for other activities. However, the fact that the EDR scheme is discretionary may enable Ofgem to prevent possible pitfalls, such as consumers paying twice for the same output or rewarding utilities based on results that are outside their control, which may be harder to avoid when using an automatic output measure.[22]

Other targeted incentive schemes in the RIIO framework include the financial incentives to deliver 'primary outputs', which span areas such as customer satisfaction, reliability and availability, and environmental impact. In a review of the RIIO-1 framework, Jamasb (2020) points to the inefficiencies of using targeted incentive schemes compared to a global incentive scheme, such as a Totex-based cost benchmarking. When an aspect of performance is included as a cost-driver in a Totex-based benchmarking model, the utilities are incentivised to balance their marginal costs and benefits of delivering the output. The utilities will therefore balance the costs of providing different outputs in a way that minimises their total costs. In contrast, targeted incentive schemes, such as the EDR scheme, induce utilities to pursue several partial cost minimisations, which is less efficient than a global cost minimisation. However, practical issues and considerations other than economic efficiency may justify the use of targeted incentive schemes. Nevertheless, Jamasb (2020) advises regulators to use targeted incentive schemes sparingly in order to promote overall economic efficiency.

In a regulatory framework, such as a conventional revenue-cap regulation that relies heavily on the benchmarking model, a potential downside of including extra dimensions in the benchmarking model is that they may have an undue influence on a firm's efficiency. It is well known that an extra dimension may have the effect that the firms become less

[22] An automatic measure of low carbon generation was also considered but rejected by Ofgem because of concerns regarding double rewards and controllability (Ofgem, 2012a)

comparable, which in turn can lead to increased information rents. In such cases, it may therefore be beneficial to include the performance dimension as an add-on to the revenue-cap, similar to the EDR scheme, rather than including it as a cost-driver in the benchmarking model.

4.6 Conclusion

Subjective information can be valuable to a regulator seeking to motivate utility companies to deliver outputs that are not immediately reflected in verifiable information such as the company's financial accounts. This could be companies' efforts in meeting environmental objectives or targets for stakeholder engagement. In such cases, the compensation of companies may require a subjective performance evaluation by the regulator. Generally, a problem with subjective performance evaluation is that it cannot be verified by outside parties and therefore cannot be enforced by a court. This can give rise to incentive problems, both on the part of the agent and the principal.

The literature on discretionary bonus pools employs a principal-agent framework to study the structure and efficiency of incentive schemes that incorporate subjective information, such as a manager's subjective evaluation of their subordinates' performance. With a starting point in this line of literature, the paper has compared the theoretical findings to an example of a bonus pool used in utility regulation; the EDR scheme administered by Ofgem. A fundamental difference between theory and practice is that utility regulators may not face incentives to renege as assumed in the bonus pool literature. This has a number of implications for the transferability of the theoretical predictions to the context of utility regulation. If the regulator can credibly withhold parts of a bonus pool, as practiced by Ofgem, then the use of a subjective performance evaluation is not more costly than a situation where compensation can be explicitly tied to objective and verifiable performance indicators. The EDR scheme, however, still exhibits some of the same characteristics as bonus pool arrangements that have been found to be optimal in situations where the principal commits to paying out the entire pool. This includes compression of payments and dependencies between the payment levels of different companies. Table 4.6.1 provides a summary of the key characteristics of the EDR scheme along with the associated advantages

and disadvantages identified in Sections 4.5.1-4.5.8.

Table 4.6.1: Overall evaluation of the EDR Scheme

Characteristic	Pros	Cons
No commitment to paying out the entire pool in any single period (Section 4.5.1)	Avoids compensating companies for poor performance	If the companies perceive a risk of reneging, then 'no commitment' can lead to reduced effort incentives
Ofgem can roll over funds from one period to the next (Section 4.5.1)	Ofgem can provide stronger incentives in the next period	Random fluctuations in compensation levels (but the companies are never worse off)
The bonus pool available to each company negatively depends on the number of eligible companies (Section 4.5.3)	Encourages competition between companies and provides stronger incentives	Discourages cooperation between companies
Performance is compressed into four levels (Section 4.5.5)	The evaluation may be seen as more acceptable by companies and therefore reduce costly conflicts. Compression may also reduce the time and effort spent by Ofgem on evaluating performance	Compression can reduce incentives compared to higher differentiation between performance levels
Ex ante commitment to measurement criteria (Section 4.5.7)	Discourages influence activities and reduces uncertainty about measurement criteria	Prevents Ofgem from taking account of unforeseen factors that require an ex post adjusting the measurement criteria

While compression of payments dampens effort incentives, compared to a more differentiated scheme, it may be viewed as a more pragmatic solution. Compressed performance evaluations can potentially save the principal time and effort and may be regarded as a more acceptable compensation scheme by the agents, which in turn can reduce costly conflicts. The fact that the companies' payments are interdependent may have been introduced in the interest of encouraging competition and increasing the potential maximum payment, thereby providing stronger incentives compared to three independent bonus pools of £1.33m each.

As regulators strive towards taking more aspects of performance into account, which may not be reflected in objective information, it becomes important to understand the

implications of using subjective information in utility regulation. For example, the use of discretion may give rise to higher influence costs and information rents, uncertainty about measurement criteria, and could affect the perceived fairness of regulation. Recognising the value and associated costs of subjective information is relevant for clarifying whether it is beneficial for a regulator to rely on subjective information in a given context and how it can be done efficiently. This article has attempted to shed light on some of these issues by relating the existing literature on subjective performance evaluation to the context of utility regulation.

A possible opportunity for future research is to explore whether the information used in a performance evaluation, in effect, can be regarded as "less subjective" if it is assessed by several independent evaluators or if other such measures can reduce the disadvantages of relying on subjective information. Finally, while this paper has focused on the principal's discretion in performance evaluation, another issue that would be relevant to study further, is how to incentivise correct information production by the regulated companies. For example, how to provide incentives for companies to invest the time and effort necessary to produce accurate forecasts of demand and supply in order to establish the need for future network capacity and ultimately, allowed revenue.

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Conclusion

This thesis has studied aspects related to a particular type of utility regulation that has been termed "negotiation-based" or "forward-looking" regulation. Several stakeholders in the Danish utility sector has shown an increased interest in this type of regulation, perhaps inspired by developments in Great Britain where the existing RPI-X framework has been replaced by the RIIO framework, which relies on stakeholder engagement and business plans reflecting expected future developments. While some Danish utilities view a regulation along these lines as the next step in Danish utility regulation, not much formal theory has been used to inform the considerations. The thesis contributes in this regard by exploring which theory can be used to study the topic and which insights can be gained from coupling theory and practice.

Chapter 1 investigates the different mechanisms that make up different types of regulation, including RIIO and other more forward-looking and negotiation-based types of regulation, and examines how these mechanisms contribute to different goals of contract design. Chapter 2 focuses on a particular concern; how the adaptation of production plans to consumers' preferences may lead to higher information rents. Chapter 3 studies advantages and disadvantages of different mechanisms that address issues with the current regulation brought forward by the industry. Finally, Chapter 4 is concerned with the use of subjective information in utility regulation, specifically the regulator's use of discretion in performance evaluation.

In this way, each chapter in the thesis contributes to an understanding of different aspects related to a more forward-looking or negotiation-based regulation. Overall, the thesis clarifies potential advantages and disadvantages associated with this type of regulation, which can be of relevance to utility regulators considering such changes in regulation. Incorporating negotiations or stakeholder engagement into regulation may facilitate a higher

alignment between consumers' preferences for different outputs and the utilities' provision of such outputs. Furthermore, relying on subjective, unverifiable information may allow the regulator to take more aspects of performance into account and reduce uncertainty, for example by using discretionary adjustments to account for uncontrollable factors or unforeseen events.

Disadvantages of the approach may include higher transaction costs and information rents. Higher transaction costs may occur in the form of higher administrative costs of regulation and higher influence costs caused by relying more on unverifiable information produced by the utilities. Higher information rents may occur because of both influence activities and service differentiation. Moreover, the use of discretion may affect the perceived fairness of regulation and generate uncertainty about measurement criteria. However, the magnitude and importance of the different advantages and disadvantages are hard to quantify and depends on specific circumstances.

In carrying out this study, several issues have been left for further research. For example, as a continuation of Chapter 1, further work could illustrate how different regulators try to minimise the drawbacks of different mechanisms, for example by including more details about the level of regulators' administrative discretion and ways in which they compensate for possible limitations of different mechanisms. This could provide a more nuanced picture of the trade-offs portrayed in Chapter 1. In relation to Chapter 2, further work could attempt to quantify exactly how sensitive the results are to variations in the number of firms, service dimensions, etc. Furthermore, while Chapter 2 has focused on scope, i.e. the question of whether the service mix should be allowed to vary according to consumer preferences, a related issue concerns scale. This addresses the question of whether the regulator should allow, e.g., quality to vary across geographic areas according to consumer preferences at the cost of higher information rents. In addition, more work is required to further investigate the issues brought forward by the Danish industry, as presented in Chapter 3, and determine the suitability of possible adjustments to regulation. This includes determining the extent of the issues, understanding consumers' needs, and identifying cost-drivers that appropriately reflect the desired outputs. Finally, while Chapter 4 has focused on the principal's discretion in performance evaluation, another relevant and related issue is how to incentivise correct information production by the regulated companies.

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