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Incentive regulation and utility benchmarking for electricity network security

Rabindra Nepal[a,*], Tooraj Jamasb[b,1]

[a] CDU Business School, Charles Darwin University, Australia

[b] Durham University Business School, Mill Hill Lane, Durham, DH1 3LB, United Kingdom

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ABSTRACT

The incentive regulation of costs related to physical and cyber security in electricity networks is an important but relatively unexplored and ambiguous issue. These costs can be part of cost efficiency benchmarking or, alternatively, dealt with separately. This paper discusses the issues and proposes options for incorporating network security costs within incentive regulation in a benchmarking framework. The relevant concerns and limitations associated with the accounting and classification of network security costs, choice of cost drivers, data adequacy and quality and the relevant benchmarking methodologies are discussed. The analysis suggests that the present regulatory treatment of network security costs using benchmarking is limited to being an informative regulatory tool rather than being deterministic. We discuss how alternative approaches outside the benchmarking framework, such as the use of stochastic cost-benefit analysis and cost-effectiveness analysis of network security investments can complement the results obtained from benchmarking.

1. Introduction

The introduction of incentive-based regulation since market liberalisation has coincided with a gradual adoption of cost and efficiency benchmarking as a regulatory instrument by many European energy regulators. For example, Norway introduced incentive regulation and efficiency benchmarking in 1997 while Germany followed suit in 2009. Benchmarking can be broadly defined as a comparison of some measure of actual efficiency and productivity performance against a reference or benchmark performance (Jamasb and Pollitt, 2000). The primary role of benchmarking under incentive regulation is to decouple the allowed revenues of a network utility from its own underlying costs by determining the regulated revenue cap based on the cost of efficient networks.

Benchmarking allows *comparative regulation* and uses *outside information* beyond what is revealed by the regulated network itself. Hence, benchmarking serves as a regulatory tool to eliminate or reduce the firm's asymmetric information (moral hazard and adverse selection) advantage with its operational and capital costs (*inputs*) and demand.[2] The use of

* Corresponding author. Tel.: +61 0 8 89468856.
E-mail addresses: rabindra.nepal@cdu.edu.au (R. Nepal), tooraj.jamasb@durham.ac.uk (T. Jamasb).

1 Tel.: +44 0 191 3345463.

2 This is a common information asymmetry problem arising in a principal–agent relationship where the regulated agent holds superior information on its own cost and demand structures than the principal (or the regulator in our case). See Laffont and Tirole (1993) for more details.

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available outside information in network regulation that is retrieved independently of the network companies implies that benchmarking, in effect, aims to mimic the incentive mechanisms of a competitive market in a monopoly environment. This resembles a yardstick competition in its extreme form where the outcomes of perfect competition are replicated in a regulated natural monopoly context (Shleifer, 1985).

However, the European electricity supply industry (ESI) is undergoing fundamental technical changes in the drive towards sustainability and ensuring the security of supply signalling changes in energy policy priorities from the overriding economic efficiency goals. Competitiveness, energy security and decarbonisation have become the main energy policy priorities post liberalisation (Pollitt and Haney, 2013). These changes have also sparked debate on how incentive regulation and the application of benchmarking within incentive regulation should evolve (Cambini et al., 2014). For example, it is estimated that the required costs of the transmission grid expansions in Europe will be in the region of 104 billion euros (ENTSOE, 2012). Similarly, the investment needs in Europe's distribution grid is estimated to be around 520 billion euros by 2035 in the transition towards a low-carbon economy (EURELECTRIC, 2012). These investments are driven by the need to accommodate rapid technological advances in distributed energy resources such as solar, energy storage, electric vehicles, micro-grids, intelligent home energy management, demand aggregation, and demand response, all leading to a complex future with a differing role for electricity networks (Sioshansi, 2016). Large-scale investment requirements can alter the cost structure and the use of inputs (operational and capital expenditures) by network companies. Network investments are also 'lumpy', implying increased uncertainty in benchmarking analysis. This is because investments are mostly irreversible and the future is uncertain (Dixit and Pindyck, 1994; Brunekreeft, 2013).

Addressing the concerns of inadequate supply security would also imply that incentive regulation is evolving from an *input-oriented* to an *output-oriented* approach. An *output-based* incentive regulation approach evaluates the monopoly's performance in terms of the quantity and quality of delivered outputs, such as energy and connection services as well as service quality and provides incentives to improve quality (Vogelsang, 2006). However, the probable inclusion of additional output measures of performance such as network security is unexplored by regulators and scarcely discussed among academics and policymakers.

The aim of the paper is to illustrate how output measures of supply security performance such as 'network security' can be utilised using benchmarking analysis within an incentive regulation framework. We conceptualise 'network security' as encompassing the conventional elements of supply security, such as short-run operational reliability, commercial reliability, and long-run resource adequacy (see e.g. Joskow, 2007), along with security threats arising from natural, accidental and malicious (or exceptional) events facing the electricity network (see Nepal and Jamasb, 2013).[3] The paper defines and designs a suitable output metrics of network security to be incorporated in an output-oriented incentive regulation framework. The paper also stimulates policy discussion on conceptual and technical aspects of incorporating network security in an incentive regulation framework using a benchmarking analysis.

The remainder of the paper is organised in four sections. Section 2 discusses the literature on the theoretical and empirical linkages between incentive regulation and network security by focussing on the regulation of quality of service in the European context. Quality of service is an integral but not the only component of network security (Nepal and Jamasb, 2013). Section 3 focuses on general approaches to benchmarking analysis of network security with different benchmarking options, such as network security costs, network security cost drivers, data (or sample) size and quality, and the mathematical techniques. Section 4 proposes an output metrics for network security, critically reflects on the findings from the previous sections, and offers policy recommendations. Section 5 concludes the paper.

2. Relevant literature review

Electricity networks exhibit natural monopoly characteristics, such as economies of scale, scope and density due to high sunk costs and low marginal operating costs (Kahn, 1971). In the absence of regulatory interventions, network companies face low incentives for internal efficiency and greater incentives for rent-seeking, leading to distortions in allocative efficiency. Hence, incentive-based regulation (such as price cap or revenue cap regimes) of network entry, access and charges has been implemented in many European countries since the liberalisation of the electricity sector. Utility benchmarking under incentive regulation aims to promote economic efficiency (cost, allocative, and dynamic efficiencies) by reducing the regulated firm's information advantage with its inputs and demand. It can thus be viewed as a second best solution to competitive markets (Newbery, 2002; Joskow, 2013).

Benchmarking can be a useful tool in assessing the efficiency and performance of the regulated company in meeting the productivity objectives defined by the regulator ex-ante (Ajodhia et al., 2004). The results from statistical benchmarking methods help to determine the relative efficiency of an individual company's operating costs and service quality relative to their peers. This information can then be used as input for setting the initial price 'P_o' and the 'X' factors, reflecting the cost reduction path during a given regulatory period (Jamasb et al., 2004; Joskow, 2008). A robust benchmarking can aid the regulator in determining the relative efficiency of different network companies and in setting their reasonable targets in terms of cost efficiency (Coelli et al., 2008). Hence, benchmarking of network companies can play a key role in sharing the

3 According to CEER (2012), exceptional events include exceptional weather conditions and other exceptional circumstances that can significantly affect the continuity of supply. We share the same understanding of exceptional events in the remainder of the paper.

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