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Cap prices or cap revenues? The dilemma of electric utility networks

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ABSTRACT

In this paper I analyse the behaviour of a monopoly electricity provider that serves three distinct markets under a price cap or revenue cap plan. I make comparisons in terms of their effects on price setting, energy conservation, and social welfare.

In addition to contravening the Ramsey pricing rule, I find that under conditions of information asymmetry, when demand becomes more elastic or marginal cost increases, revenue cap price increases are larger relative to price cap regulation. In this specific setting, revenue cap price increases can encourage energy conservation but is less likely to do so when marginal cost is large in a market that is more elastic relative to others. In contrast to a price cap plan, these overall results show that revenue cap schemes are welfare-reducing.

For public policy decision-making purposes, price cap regulation is more desirable especially in developing economies that often experience substantial inflationary pressures from global oil market developments but is less suitable than revenue cap regulation when electricity supply constraints and climate change are major policy concerns.

1. Introduction

Public network industries such as electricity markets were traditionally governed by rate-of-return (ROR) regulation. However, this regulatory approach was often criticised for its lack of incentives in minimising costs and tendency to encourage too much investment in capital (Averch and Johnson, 1962; Laffont and Tirole, 1993; Sappington, 1994). As electricity sectors underwent major market reforms, ROR was eventually replaced with incentive regulation schemes to constrain the market power of privatised utilities and encourage efficiency.

In light of the many incentive schemes that exist, advocates like the Australian Energy Regulator (2013) and the Jamaica Public Service (2014) claim that replacing price caps with revenue cap regulation will provide greater incentives for cost recovery and investment in energy efficiency and promote energy conservation in electricity markets. The ineffectiveness of price cap regulation in encouraging energy conservation from a demand-side perspective is widely discussed in the literature (see, for example, Wirl, 1995; Sappington and Weisman, 2010). However, proponents of price cap regulation argue that in contrast to price cap regimes, revenue cap regulation incentivises price increases that depart from the Ramsey pricing rule, creates output restrictions, and may lead to major reductions in social welfare (Comnes et al., 1995; Crew and Kleindorfer, 1996b; Decker, 2009). Others such as Dutra et al. (2015) find that price cap regulation induces incentives for supply-side energy efficiency by reducing network losses while both schemes can be implemented to achieve the same level of welfare.

The arguments in support of a particular incentive pricing plan have evolved from a theoretical framework without knowledge of behavioural differences in practice. Therefore, I aim to reconcile these arguments by using actual industry parameters to quantitatively assess differences in revenue and price cap schemes in terms of prices, energy conservation, and welfare. This represents the first known attempt at performing a comparative analysis of both schemes using parameters calibrated with industry data. I take a demand-side management focus and use a firm operating under a vertically separated electricity market structure with a monopoly in the downstream (distribution and retail) segment. To capture the regulator's problem of information asymmetries recognised by Laffont and Tirole (1993), I also address cost and demand uncertainties.

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Understanding differences between either scheme has important policy implications. For example, developing countries that generate a substantial portion of their electricity from imported fuels are more prone to price instability, and may show a preference for price cap regulation to ease inflationary pressures on the local economy. This is of particular significance when there is substantial pass-through to domestic inflation. However, if the argument for energy conservation holds for a revenue cap, heightened security of supply and climate change concerns may necessitate the use of revenue cap regulation which favours price increases. This is important since a climate-induced increase in electricity demand can give rise to higher emissions during peak demand hours (Chen et al., 2015). These emissions could be reduced through demand flexibility arising from higher renewable energy penetration, but Kroeze et al. (2004) argue that end-use efficiency also has the potential to create substantial reductions in greenhouse gas emissions in developing countries. In this particular case, caution should be exercised since increased prices could result in the substitution of oil and gas-fired generating units for cheaper and more carbon-intensive technologies such as coal (Xie et al., 2014). In general, choice of a specific scheme will involve trade-offs and is dependent on the goals of government and regulators.

To test the theoretical arguments about price setting, energy conservation, and social welfare for both schemes, I use a constrained optimisation problem similar to Brennan (1989) and De Villemeur et al. (2003), and apply it to the electricity network in Jamaica. I find that under certain conditions, relative to price cap regulation, revenue cap regulation creates conditions for higher and inefficient price setting, encourages energy conservation, and is welfare-reducing. The remainder of the paper is organised as follows: Section 2 provides a brief overview of market reforms and various incentive regulation schemes. Section 3 presents the main electricity pricing models used. In Sections 4 and 5, I calibrate each pricing model with parameter values that approximate the key characteristics of the regulated entity, discuss the data used, perform analyses, and report their results. Section 6 highlights the main conclusions and policy implications of the study.

2. Market reforms and incentive regulation

Policymakers in both developed and developing countries have long believed that it is most efficient for electricity to be supplied by a single firm. It is this thinking that gave rise to the creation of a natural monopoly charactersised by common ownership and sole responsibility for electricity generation, transmission and distribution services. Joskow (1997) postulates that utilities have maintained this vertically integrated structure because of significant operating and investment complementarities that allowed them to benefit from economies of scale and scope. However, this traditional belief is increasingly being challenged. Indeed, many developed and developing countries have implemented major structural and regulatory reforms to promote competition within the electricity sector.

Large-scale reform measures in electricity sectors across developed countries dates back to as early as the 1980s. These reform measures were largely aimed at introducing private sector participation and the promotion of competition through economic deregulation. In contrast, the introduction of substantial reforms in the electricity sectors of developing countries has been a more recent phenomenon. It was not until the early 1990s and 2000s that such reforms were initiated. Bacon and Besant-Jones (2001) theorize that comparatively, introducing electricity reform measures in developing countries is more challenging than in developed countries and every effort should be made to ensure that such measures are both desirable and politically feasible before implementation.

Based on the European Bank for Reconstruction and Development (EBRD) definition of sector transition which has five levels, ranging from extensive government control (Level 1) to large-scale private involvement (Level 4+), electricity reform measures undertaken in many developing countries can be categorised according to Level 4. This involves the separation of the industry into generation, transmission, and distribution; setting up of an independent regulator with rules for cost-effective tariff-setting formulated and implemented; and some degree of liberalisation (The European Bank for Reconstruction and Development, n.d.). This could also include separation of the distribution and retail segments as is the case in many developed countries such as Nordic states.

2.1. Incentive regulation plans

Traditionally, rate of return regulation has been the primary means of regulating utilities, where the utility is allowed to recover its costs and a guaranteed rate of return. This pricing methodology has been criticised on a number of grounds, most notably of which is the incentive it gives to firms to over-invest in capital as was first pointed out by Averch and Johnson (1962). This has led to the development of various incentive regulation schemes. Common forms of these schemes that exist in practice include price cap regulation, revenue cap regulation, sliding-scale regulation, yardstick competition, and menu of contracts regulation. Relative to ROR where consumers bear all the risks, since operating and investment costs are reflected in price increases, differences among incentive schemes are largely explained by risk allocation and incentives.

In the United Kingdom and many Latin American countries, price cap regulation is the preferred form of regulation used to incentivise cost reductions and constrain the market power of privatised utilities. Under a price cap, constraints are placed on the path of prices for services provided by a regulated firm during a fixed period of time. With prices constrained, firms increase profits by reducing cost or increasing sales. Therefore, unexpected cost changes and volumetric risk are borne mostly by the firm. This reduces the moral hazard problem present in managerial effort, but if regulators have limited knowledge of the firm's ability to reduce costs this can potentially allow the firm to extract significant rent from consumers or it can lead to the firm's detriment (Joskow, 2007). Another drawback of price caps is the potential to deter investment and reduce service quality (Sappington, 2002) as effort is expended at minimising cost, though Banerjee (2003) does not find any evidence that price cap causes deterioration in service quality. Despite its shortcomings, Armstrong and Vickers (2012) show that social welfare can increase when regulated firms operate under a price cap by limiting cross-subsidizing pricing behaviour.

In order to overcome volumetric risk, European countries such as Norway and Sweden show a preference for revenue cap regulation (Jarvis, 2011). In its simplest form, constraints are placed on the regulated firm's revenues rather than prices. Hirst et al. (1994) advocated for the use of revenue caps based on the idea that they provide greater incentives for demand-side management compared to price cap regulation. Though both schemes encourage cost reduction, a price cap encourages higher sales while a revenue cap promotes energy savings through flexible price adjustments. Under a binding revenue cap, the firm can increase profit by reducing costs through reductions in output or increasing price. Revenue caps are more suitable in situations where the positive covariance between costs and sales is low. If tariffs are reflective of the utility's costs and demand is inelastic, a price rise will reduce the quantity of electricity demanded and total costs, while increasing revenue. With the revenues of the utility capped, the reduction in costs will translate directly into profits. This incentivises price increases for the least inelastic market segments served by utilities. This idea was advanced by Jamison (2007) and was similarly supported by Lantz (2008) who