The Quarterly Review of Economics and Finance 54 (2014) 61–69

Contents lists available at ScienceDirect

The Quarterly Review of Economics and Finance

journal homepage: www.elsevier.com/locate/qref

Behavior of the firm under rate-of-return regulation with two capital inputs

Adrienne M. Ohler*

Illinois State University, Campus Box 4200, Normal, IL 61790-4200, United States

ARTICLE INFO

Article history:
Received 3 January 2013
Received in revised form 4 June 2013
Accepted 16 July 2013
Available online 31 July 2013

JEL classification:
L2
L51
L94
Q2
Q4

Keywords:
Renewable energy
Rate-of-return regulation
Deregulation

ABSTRACT

Traditional electric utility companies face a trade-off between building generation facilities that utilize renewable energy (RE) and non-renewable energy (non-RE). The firm's input decision to build capacity for either source depends on several constraining factors, including input prices, policies that promote or discourage RE use, and the type of regulation faced by the firm. This paper models the utility company's decision between RE and non-RE capital inputs. From the model, we derive the result that rate-of-return (ROR) regulation decreases the investment in RE capital relative to the unregulated firm. These findings suggest restructuring electricity generation markets, which removes the ROR on generating assets, can increase the relative use of RE. A second result of the model shows that the renewable portfolio standard (RPS) increases the investment in capital that requires RE as a source of electricity, as expected. This paper contributes to the literature on the substitution between renewable and non-renewable resources, by examining the policies that affect the investment in the two types of technologies. The model can also be applied to other regulated utilities, such as water or natural gas companies, with outputs that are produced from different types of capital.

1. Introduction

Rate-of-return (ROR) regulation is well-known in the electricity industry and in the regulation literature as causing market distortions on production inputs as well as electricity prices. Several articles have demonstrated that ROR regulation affects the firm's input decision between capital and labor (Averch & Johnson, 1962; Hsu & Chen, 1990; Petersen, 1975; Sherman, 1992; Spann, 1974). Sherman and Visscher (1982) also show that ROR regulation impacts the decision of the firm in determining rate structures. Typically under ROR, an electric utility is given the right to be the sole generator, and distributor of electricity in a region. In exchange, the utility is regulated by a public commission that determines the rate for selling electricity. The rate includes a fair return on capital investments.

However, different types of capital can generate electricity. For example, renewable energy (RE) and non-renewable energy (non-RE) differ in their generation turbines, environmental abatement technologies, and the requirements for land development and heat-waste water. Moreover, RE sources are typically more costly to build, provide intermittent output, and have an uncertain capacity to generate revenue. The EIA estimates biomass, hydro, geothermal, solar, and wind have a greater total levelized cost than conventional coal, advanced coal, and natural gas fired plants (EIA, 2010). The inexperience and uncertain revenues from RE technologies also makes them a riskier investment (Wiser & Pickle, 1998). Thus, the cost of capital is higher for RE sources.

Several states in the US still operate under traditional ROR regulation, and the regulation affects the decision to invest in different types of capital. Specifically, ROR regulation acts as a subsidy for capital, lowering the price of capital compared to labor and lowering the price of cheaper capital relative to expensive capital. Since RE is typically more expensive and riskier, the ROR increases the relative price of RE, and the regulated firm utilizes less RE capital than an unregulated firm. Thus, the regulated firm is capital intensive compared to the unregulated firm, and the regulated firm is also capital intensive in cheaper non-RE capital.

This paper theoretically examines how ROR regulation affects the utility company's decision to generate electricity from RE sources and non-RE sources. Following Averch and Johnson (1962), we extend the ROR model to account for two different types of output: electricity generated from RE and electricity generated from non-RE. The results show that ROR decreases the firm's incentive to invest in relatively expensive capital for RE

* Tel.: +1 309 438 7892.
E-mail address: aohler@ilstu.edu

1062-9769/$ – see front matter
http://dx.doi.org/10.1016/j.qref.2013.07.003

sources of electricity. ROR regulation causes the firm to over-invest in capital, and over-invest in capital that utilizes non-RE sources. As a result, more capacity utilizing non-RE sources will be built than compared with an unregulated firm.

One policy consideration is the restructuring of the electricity markets from a monopoly to allowing retail competition in the generation sector. Restructuring, ideally, removes the allowable return on capital assets used for generation. Several papers have suggested mixed results for the impact of restructuring on RE technologies. Wiser, Porter, and Clemmer (2000) argue that restructuring may help RE because of the new attention given to RE policies. Madlener and Stagl (2005) suggest that such electricity market liberalization can allow for the differentiation of products and increase the potential for 'green' markets. On the other hand, Kumbaroğlu, Madlener, and Demirel (2008) suggest that liberalization decreases the incentive to invest in renewable technologies. Empirically, Carley (2009) finds that deregulation decreases the share of renewable electricity generated, and increases the total amount of renewable energy generation. This paper contributes to the literature on deregulation by presenting a theoretical model that illustrates that restructuring that removes or decreases the allowed ROR can also promote the relative use of RE.

The model also allows us to examine the impact of a second regulatory constraint of a renewable portfolio standard (RPS). For several years, advocates for renewable energy (RE) have sought to create a national RPS (Darmstadter, 2004). In the last decade alone, Congress has rejected fourteen proposals to establish a national standard. In April 2009, the US House of Representative's subcommittee on Energy held hearings on a bill to implement a national RPS. The policy requires that generation from renewable resources fulfill a certain percentage of electricity sold. One bill required utility companies to generate 6% of their retail sales from RE by 2012, and 25% by 2025. RPSs have increased in popularity at the state level with over half the U.S. population living in states with an RPS. By 2012 twenty-nine states had enacted legislation that mandated utility companies to provide consumers with electricity generated from RE.

Fischer (2010) models the impact of the RPS as a tax on non-RE sources and a subsidy on RE sources; however, the RPS is actually a proportional constraint requiring the utility to produce electricity using at least a minimum ratio of RE to non-RE sources. This paper contributes to the RPS literature by presenting an alternative approach to modeling the RPS that is more consistent with the incentives faced by the firm, and accounts for ROR regulation. We examine the utility company's input decision with a proportional constraint on RE and non-RE sources for electricity generation. By modeling the decision of the firm to choose between two different sources of electricity, we can examine the change in inputs caused by a change in the RPS policy. The results for the RPS are similar to that of a tax/subsidy approach, but the model of the firm accounts for the impact of ROR regulation. The results suggest that an RPS will have varying impacts that depend on ROR regulation. A national RPS will then have differing impacts on regulated and restructured states.

In regulated industries, policymakers are often cautious of firms attempting to implement new and expensive technologies, and have consumers bear the burden of the cost with uncertain improvements in output. For example, regulators and policymakers often think that the cost of smart grid technologies in the electricity industry are difficult to recover because their benefits to consumers are often unknown or unmeasurable. Additionally, solar technologies are often thought to be too expensive for consumers. Other regulated industries, such as water and natural gas companies, also suffer from similar infrastructure upgrades. The results of this study suggest that ROR regulation creates additional barriers to new technology adoption, causing the firm to over-invest in cheaper, less risky technologies in terms of cost.

This paper also contributes to the literature on the substitution between renewable and non-renewable resources (André & Cerdá, 2005; Krautkraemer, 1986; Mosi no, 2012; Tahvonen & Salo, 2001). ROR regulation affects the firm's ability to substitute between the two types of resources. The results suggest that the firm will overinvest in the physical capital and technologies that require nonrenewable fuel sources. As a consequence, the demand for nonrenewable resources will be greater under ROR regulation, causing quicker extraction of fossil fuels and causing the switching point from nonrenewable to renewable resources to occur sooner. Furthermore, the transition to renewable sources will not be a smooth transition due to the distortion in prices caused by ROR regulation. Restructuring electricity markets and removing ROR regulation will decrease the demand for non-RE capital and decrease the extraction of nonrenewable sources.

The paper proceeds with a discussion of the electricity industry in Section 2. A theoretical model of firm behavior under the constraint of ROR regulation with two capital types is presented in Section 3. Section 4 extends the model to include the RPS. In Section 5, we compare regulated and restructured states in terms of capacity for renewable sources. The results show some evidence that deregulation can increase capacity that utilizes RE sources. Section 6 concludes with a discussion of policy implications.

2. Electricity generation, regulation, and restructuring

The supply of electricity starts at a power generating plant. Generated electricity comes from coal, natural gas, water, wind, solar, and other energy sources, but the source of generation becomes indistinguishable once the electricity is placed on the transmission grid. A network grid of transmission substations, transmission lines, power substations, and transformers distributes power to consumers for final use. Although electricity demand varies throughout the day or season, a minimum level is supplied through what is termed baseload generation, typically supplied by coal or nuclear power plants because of their ability to produce a constant level of energy. Variable sources, such as wind, geothermal and solar energy, supply power when the fuel source provides enough energy to generate electricity. Natural gas, a more consistent source, typically fills peak-load demand, because starting up such a generator has a low fixed cost compared to coal or nuclear generators.

The supply of electricity from power plant to consumer is more complicated than a simple competitive firm model. Utility companies take part in generating, transmitting, or distributing electricity for sale to the consumers. Due to presumed economies of scale and scope or cost subadditivity, utility companies within a state or region are often granted monopoly power but are regulated by their prices and service conditions (Christensen & Greene, 1976; Greer, 2008). A few states have restructured markets with competition among generating utilities, but a monopolist remains in the transmitting and distributing sector (Saplacan, 2008).

Due to the ability to generate electricity from different sources, the vertically integrated electric utility is faced with a decision to invest in different capital types. For example, coal-fired generation plants are reliable and well-known. On the other hand, wind turbines are more capital intensive per MW, require more land and labor, and provide intermittent output. As a consequence, wind energy, as well as most RE sources, provide uncertain revenue for developers, making it a riskier investment and difficult to acquire financing for new wind projects. Thus, RE sources typically have a higher cost of capital than non-RE sources.