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Deregulation, market competition, and innovation of utilities: Evidence from Japanese electric sector

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ABSTRACT

This paper explores the determinants of electric utility innovation, and examines the impact of electric sector deregulation and market competition on it using a balanced panel database of nine Japanese utilities from 1978 to 2014. Both input (R & D expenditure) and output (patent application number and patent quality) aspects of innovations are examined. The empirical results indicate that deregulation and market competition decrease the former, but increase the latter. These results are followed by a discussion on why this scenario occurs. The results also suggest that, after deregulation, utilities focus more on short-term, business-oriented R & D projects. Hence, we call for governments to support long-term, public-oriented, and environmental research in the electric sector.

1. Introduction

Over the last two decades, deregulation has been implemented in Japanese electric sector in order to stimulate competition, increase efficiency, and reduce electricity prices, following the global deregulation trend. Deregulation policies were adapted to the overall economic reforms meant to activate the Japanese economy. Along with gas deregulation scheduled in 2017, electric deregulation has been changing the make-up of the industry. Electricity retailing in Japan was fully deregulated in April 2016. Consequently, gas, oil, and telecommunication companies immediately entered electricity retailing. Thus, fierce competition and restructuring are expected to activate the electric industry.

1.1. Japanese electric sector deregulation and the impacts on efficiency

Japanese electricity reform was gradually implemented based on the experiences of the EU and the US. However, the crucial importance of electricity to society makes deregulation a long and difficult process fraught with political interference, opinion conflicts, and policy uncertainties. The confidence in market mechanism and competition motivates the government to open access to generation and retail markets, despite strong resistance from incumbent utilities. The generation market opened in 1995, while full deregulation of retail markets took more than 15 years, from 1999 to 2016. However, sectoral restructuring has not been able to proceed, because researchers argue that the functional separation of generation, transmission, and distribution will increase the cost of the industry (Nemoto and Goto, 2004; Goto et al., 2013). Wang and Mogi (2017) also provided a detailed description of the process of Japanese electricity deregulation. Table 1 illustrates the main measures taken during the process.

Electric sector deregulation, in theory, should produce an increased alignment of managerial incentives with firm financial performance, ultimately promoting a more efficient use of resources. Indeed, most studies on the economic consequences of deregulation in the Japanese electric sector generally show consistent efficiency gains and improvements in productivity (Goto and Sueyoshi, 2009; Goto and Tsutsui, 2008). A large body of literatureis also focused on evaluating the effectiveness of Japanese electricity reforms. Hattori and Tsutsui (2004) elaborated the relationship of deregulation and electricity price using OECD panel data. Kaino (2005) evaluated the impacts of electricity and gas reforms based on firm-level financial statistics. His analysis revealed that deregulation leads to a reduction in capital investment and labor expenditure of the electric companies, which, in turn, results in reduction of total cost and increasing efficiency. Nakano and Managi (2008) also examined the efficiency of electric companies with Luenberger indicator using the DEA approach. They showed that deregulation increases efficiency, but may also lead to investment uncertainty and blackouts. Deregulation resulted in important structural changes in the electric sector, along with technical efficiency improvements.

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Table 1
Main measures of electricity sector deregulation in Japan.

Year	Deregulation measures
1995	Generation market entry liberalization, opening access for IPPs.
1999	Partial retail market entry liberalization (capacity over 2000 kW).
2003	Establishment of the wholesale power exchange market: Japan Electric Power Exchange (JPEX).
2004	Partial retail market entry liberalization,(capacity over 500 kW).
2005	Partial retail market entry liberalization (capacity over 50 kW).
2015	Establishing the independent grid regulator: Organization for Cross-regional Coordination of Transmission Operation, Japan.
2016	Retail deregulation for residential users and low power users.
2018–2020	Legally unbinding of the transmission and distribution sector. Removal of price regulation in residential sector electricity retailing.

Joskow (2006), in his keynote speech at the 2004 International Industrial Organization Conference, noted that:

> "Research in industrial organization and related public policy prescription has placed too much emphasis on static efficiency gain or loss and not enough emphasis on the factors influencing the rate and direction of product and process innovation which are likely to have much larger consumer welfare effects."

Most previous studies in Japan only focus on the benefit of static efficiency brought on by reforms. However, in the long run, innovation must be the source of continued efficiency and productivity improvements. Thus, the impacts of deregulation on innovation within the electric sector should not be neglected.

1.2. Innovation in the electric sector

The electric and energy industries, despite their crucial importance to economy and society, exhibit low levels of R & D intensity (GEA, 2012). The report on science and technology by Statistics Bureau of Japan also provides an overview of R & D intensity of all Japanese industries for 2014.[3] In a comparison of R & D intensity (R & D expenditure divided by total sales) of each industry, we find that the electric and gas utilities (0.19%) and the oil and coal industries (0.19%) have one of the lowest concentrations of R & D activity, though slightly higher than the broadcast industry (0.10%).

Researchers have raised concerns regarding the "unintended consequences" of deregulation since the beginning (Dooley, 1998). Numerous studies also reported post-deregulation R & D decline (GAO, 1996; Bell and Schneider, 1996; Bell and Seden, 1998; Margolis and Kammen, 1999). Through examining activities of companies related to the electric industry under deregulation in the US and the EU, recent scholarship, however, argues that static efficiency improvements may come at the expense of dynamic efficiency and overall R & D intensity (Sanyal and Cohen, 2009; Sterlacchini, 2012; Kim et al., 2012). Studies have concluded that deregulation reduces R & D outlays, leaving profound implications for the future reliability of electricity systems (Joskow, 2006).

In Japan, the Central Research Institute of Electric Power Industry (CRIEPI) serves as the primary research institute of the electric sector. The commitment that each electric utility should fund it with 0.2% of its operating revenue helps maintain CRIEPI research despite R & D funding cuts during deregulation. This fund is included in the overall R & D expenditure of each utility. Even though more than 90% of the research fund is directly obtained from electric utilities, CRIEPI's research activities are relatively independent from the electric utilities'. For instance, joint research between CRIEPI and electric utilities is still very low, accounting for less than 10% among CRIEPI's total collaborative research. However, "the 0.2% commitment" policy was left invalid after April 2016 due to the financial deterioration and strong motivation to cut the cost of the utilities. We may expect R & D funds from electric utilities to CRIEPI to decline in the following years. As the behavior of research institutes is different from utilities, CRIEPI is excluded as a sample in this research.

This work examines the impact of deregulation on innovation in electric utilities with Japanese data. It contributes to extant literature in two aspects. First, to our knowledge, this is the first analysis that investigates the effect of regulatory reform on electric utilities innovation. It econometrically measures both innovation input and output. Most previous studies focused on either input or output, and thus, could not provide an overall assessment of the impact of deregulation on firm innovation. Second, in Japan, this topic has been scarcely investigated. Only Hattori (2005) is known to have reported initial observations on R & D investment and patent activities within the Japanese electric sector. Due to lack of empirical analysis, the impacts of Japanese deregulation and competition on electric utilities innovation remains unclear. However, we aim to address this gap by investigating the impact of deregulation policy and competition in both generation and retail markets with respect to utility innovation behaviors. The results of this study could have important policy implications in the ongoing deregulation of the Japanese electric sector.

This paper proceeds as follows: In Section 2, we build hypotheses based on economic theory and literature reviews. Section 3 outlines the research methodology and model specifications. Models are established to estimate the impacts of deregulation andmarket competitions. Section 4 explains data and variables. Section 5 reports the results of the analysis. Finally, Section 6 draws the conclusion of this study, along with a discussion on policy implications.

2. Economic theory and literature review

2.1. Market structure, competition, and firm innovation

What kind of market structure promotes rapid technology progress? This question can be traced back to "Theory of Economic Development" by Joseph Schumpeter in 1911. In the book "Capitalism, Socialism and Democracy" published in 1943, he further developed his theory that large firms with market power accelerate the rate of innovation. In that book, Schumpeter notes that "a market involving large firms with a considerable degree of market power is the price that society must pay for rapid technological progress." He argues that monopolies favor innovation because they face less market uncertainty and have larger and stable cash flow to fund innovation activities. Thus, Schumpeter suggests that monopolies have a stronger incentive to innovate.

According to the Solow's growth model, technology advancement is crucial to economic growth. How to balance the social gains from Schumpeter's innovation and social loss from high monopoly price is a recurrent topic of regulation economics. However, even though a large variety of empirical tests of the Schumpeter hypothesis have been implemented, it is still controversial. Adolf and Gardiner (1932) argued that the R & D in large firms might be less efficient because of agency problems; large incumbent companies may be resistant to radical innovation due to organizational inertia. Arrows (1962) claimed that competition pressure is the main driving force of innovation.

A large number of studies focus on uncovering the relationship between competition and innovation (Kamien and Schwartz, 1975; Cohen and Levin, 1989; Gilbert, 2006). However, the findings are always diverse and sometimes conflicting. More recently, Aghion et al. (2005) suggested that product market competition and innovation follows an inverted-U shape based on the Schumpeter and agency models. The authors used the UK industry data (17 industry from 1973 to 1994) to support their results. Thus, it is difficult to find strong theoretical support to describe the behaviors of firms under transition from a regulated and protected market to a competitive and liberalized one.

[3] The report can be found at http://www.stat.go.jp/data/kagaku/.