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Regional electric power demand elasticities of Japan's industrial and commercial sectors

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ABSTRACT

In the assessment and review of regulatory reforms in the electric power market, price elasticity is one of the most important parameters that characterize the market. However, price elasticity has seldom been estimated in Japan; instead, it has been assumed to be as small as 0.1 or 0 without proper examination of the empirical validity of such *a priori* assumptions. We estimated the regional power demand functions for nine regions, in order to quantify the elasticity, and found the short-run price elasticity to be 0.09–0.30 and the long-run price elasticity to be 0.12–0.56. Inter-regional comparison of our estimation results suggests that price elasticity in rural regions is larger than that in urban regions. Popular assumptions of small elasticity of 0.1, for example, could be suitable for examining Japan's aggregate power demand but not power demand functions that focus on respective regions. Furthermore, assumptions about smaller elasticity values such as 0.01 and 0 could not be supported statistically by this study.

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1. Introduction

Understanding the power demand of industrial and commercial users is very significant in Japan from a regulatory policy viewpoint. This is partly because such users consume a large part (about 70%) of power served by power companies and partly because the recent power market reforms in Japan have been particularly targeted at these users, who are supposed to actively respond to changes in power charges induced by the reforms. In this study, we estimate price elasticity to capture the characteristics of their power demand, considering the differences of demand patterns in nine service areas in Japan.

1.1. Motivation for the empirical analysis of power demand in Japan

Authorities regulate entry and the rates of return of power companies and impose obligations of universal service on them while permitting them to act as monopolistic service providers within their jurisdictions and to exploit economies of scale. These regulatory measures can be justified only when the economies of scale are significantly large compared with the inefficiency caused by the regulation and information on the power companies' true costs is available to the authorities. However, these assumptions are not always consistent with reality. For example, technological progress in recent years has improved the efficiency of small-scale thermal power plants (for example, combined-cycle gas turbine ones), which were previously less competitive than large-scale ones. That is, economies of scale have been decreasing in the power generation sector as Shinjo (1990) suggested. Moreover, regulatory authorities cannot obtain complete information on the true cost structures of power companies as such information is considered to be private information. Poor charge regulations and a lack of (potential) competitive pressures lead to inefficient resource allocation, such as the so-called X-inefficiency and overcapitalization found by Averch and Johnson (1962).

In the 1990s, European countries and several states in the United States (US) had initiated regulatory reforms to reduce the inefficiency caused by monopolies. These reforms were designed to promote competition in order to improve the efficiency of resource allocation through market mechanisms, rather than the use of direct and indirect controls by the authorities. In liberalized markets, players, particularly incumbents, attempt to exploit the monopolistic power they are endowed with from the old regime; hence, we require a deeper understanding of the market in order to develop effective surveillance. In Europe and the US, theoretical insights and empirical findings about their markets were available and supported their reforms.

The recent "lost decade" after the bubble burst compelled the Japanese government to implement structural reforms through

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Table 1
Estimates of the price elasticity of power demand.

	Country	Type of users	Data	Estimates of price elasticity
Anderson (1971)	US	Industrial	Cross-sectional state-level data 1958, 1962	1.94
Mount et al. (1973)	US	Commercial	Pooled data: 47 states 1947–70	SR: 0.17 LR: 1.36
		Industrial		SR: 0.22 LR: 1.82
Pindyck (1979)	Canada	Industrial and commercial	Time series 1959–73	0.14
	France			0.16
	Italy			0.13
	Japan			0.12
	Netherlands			0.07
	Norway			0.08
	Sweden			0.12
	UK			0.15
	US			0.08
	West Germany			0.12
Matsukawa et al. (1993)	Japan	Industrial	Pooled data: 9 regions 1980–88	0.63
Hisnanick and Kyer (1995)	US	Manufacturing	Time series 1958–85	0.185
Kamerschen and Porter (2004)	US	Industrial and commercial	Time series 1973–98	0.34–0.55

Note: SR and LR refer to short run and long run.

deregulation in order to facilitate a recovery from the severe recession. As part of the structural reform package, various regulatory reforms have been implemented in the power market, which had long been regionally monopolized. Recent reforms have been designed to promote competition among power companies. For example, the authorities liberalized entry requirements for new providers into the retail market segment for industrial and commercial users in 2000. Such power market reforms were, however, mostly planned on the basis of studies and conclusions drawn from countries other than Japan. Although such conclusions might be informative, they could be misleading for Japan. It is essential to understand empirically the various features of Japan's power market. In particular, in quantitative assessments of reforms, critical parameters such as the price elasticity of power demand must be appreciated. While it is widely recognized that the results of assessments are significantly sensitive to assumptions about such a key parameter, quantitative analyses of Japan's power market have often employed *a priori* assumptions of 0.1 or 0 for the price elasticity of power demand.

There have been several empirical analyses on Japan's power market in connection with the recent power market reforms. Kanemoto et al. (2006, Ch. 5) and Tanaka (2007) simulated cases where incumbents exercise their market power in order to rig the market at a peak hour during summer. They assumed the price elasticity of demand to be 0.1 in an *a priori* manner. In contrast, a similar analysis conducted by Hattori (2003) assumed a wide range for price elasticity—0.1–1.0. He chose to conduct this type of sensitivity analysis due to the scarcity of literature on the price elasticity of power demand in Japan.

1.2. Literature survey

Although there are many empirical analyses of power demand in Europe and the US, they mostly deal with residential demand and aim to examine whether deregulation has benefited both large-scale users and small-scale ones, particularly residential users. In contrast, our review of the analyses of industrial and commercial power demand revealed only a few studies on the price elasticity of power demand in this market segment (Table 1). For example, as Taylor (1975) surveyed, Anderson (1971) and Mount et al. (1973) analyzed industrial and commercial power demand and found small elasticity close to the *a priori* assumption.[1] Later, Pindyck (1979) too conducted a similar analysis. Using the recent time series dataset for the US, Hisnanick and Kyer (1995) found the price elasticity of power demand at 0.185, while Kamerschen and Porter (2004) found it to be between 0.34 and 0.55.

Pindyck (1979) estimated the energy cost functions in ten countries using time series data. In the case of Japan, Pindyck's study, where electric power demand was considered as one of the energy inputs, found that the price elasticity of power demand was 0.12. Using regional data for Japan, Matsukawa et al. (1993) estimated the price elasticity of the power demand of the manufacturing sector. They assumed translog energy cost functions with four energy inputs (oil, gas, coal, and electricity). They estimated the energy cost share functions using pooled data from 1980 to 1988 for nine regions in Japan (i.e., all regional jurisdictions except Okinawa). They found price elasticity of power demand to be 0.63.[2] The Cabinet Office (2001, 2007) estimated the log-linear demand functions of total electric power (i.e., the sum of industrial, commercial, and residential) for Japan, excluding Okinawa, and found the price elasticity to be 0.441 for the period 1981–1998 and 0.373 for the period 1986–2005. In those studies, power demand was regressed on power charges and gross domestic product (GDP), (with, only in the Cabinet Office (2001), two dummies controlling for a temporal drop and a fall of power demand due to exogenous shocks in 1986 and 1994).

Estimating the price elasticity of power demand by using nationwide or pooled data presumes that all the regional power demand functions are identical and dependent on various exogenous factors of the same magnitude. This is the approach taken by the above four studies for Japan. However, vertically integrated regional power companies in Japan have a developed self-sufficient power system, where the domestic load is almost fully met with domestic power supply in each jurisdiction, even after deregulation. Based on company size, for example, the Tokyo Electric Power Company (TEPCO) is the world's largest power company in terms of the volume of power supply. In contrast,

[1] Besides, Fisher and Kaysen (1962) estimated industrial demand using cross-sectional state data for the US in 1956.

[2] Matsukawa et al. (1993) also estimated residential demand and found the price elasticity to be 0.37.

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