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Nontransferable water rights and technical inefficiency in the Japanese water supply industry

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ABSTRACT

This study examines whether the Japanese scheme of nontransferable water rights results in technical inefficiency. Using data on 1280 Japanese retail water suppliers in 2011, technical efficiency is measured via data envelopment analysis. The determinants of this technical efficiency are then examined via a bootstrapped truncated regression model. The estimation results reveal that the nontransferability of water rights leads to technical inefficiency among retail water suppliers. Furthermore, this inefficiency costs about 133.9 billion yen per year, underlining the importance of the Japanese government flexibly reallocating water rights to improve efficiency.

1. Introduction

Water rights, the rights of users to use water from a given source, determine water allocation, sometimes resulting in overuse of surface water or suboptimal adoption of water conservation. This lack of transferable water rights can result in considerable inefficiency: Australia, Chile, China, South Africa, and the western United States all have tradable water rights regimes, and research has shown that these systems make water usage more efficient.[1] While these studies have produced interesting results on the efficiency of water resource usage, none have considered water suppliers' efficiency.[2] The purpose of this study is thus to examine whether a Japanese regulatory scheme involving nontransferable water rights leads to technically inefficient outcomes.

Using data on 1280 Japanese retail water suppliers (retail suppliers henceforth) for 2011, we compare the Japanese nontransferable rights scheme to a counterfactual scenario in which water rights are reallocated in order to raise the efficiency of the water supply industry. The results indicate that the technical inefficiency of retail suppliers cost about 133.9 billion yen in 2011. This amount is equivalent to 5.82% of Japanese suppliers' total revenue from water sales. This result suggests that the government should reallocate water rights flexibly in order to ensure efficiency.

In Japan, water rights are not transferable across retail suppliers. The government sets strict guidelines for the amounts of water that retail suppliers must supply daily and annually and regulates the purposes for which they can supply it. The government prohibits users with water rights from incomplete water use, rescinding water rights when they are not used. In addition, the government has not established a water-trading scheme among retail suppliers, so suppliers cannot buy and sell water access entitlements. Because of this and the difficulties of water resource development, suppliers rarely obtain new water rights. Overall, this rigid regime provides suppliers with an incentive to retain water rights, irrespective of efficiency.

Such a water rights regime could give rise to two types of inefficiency. The first type arises when suppliers with sufficient

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[1] Qureshi and Whitten [1], for example, estimate dollar values of the net benefit of water market presence in Australia, and Grafton et al. [2] compare the gains from water trade between Australia and the western United States.

[2] Burness and Quirk [3,4], Johnston et al. [5], and Anderson and Johnson [6], for example, show theoretically that water rights transfers can achieve an optimal allocation of water among users. Caswell and Zilberman [7,8] examine the choice of irrigation technologies in California and suggest that the adoption of inefficient technologies is caused by a water rights regime that prevents water from being allocated according to the marginal willingness to pay for water. Rosegrant and Binswanger [9] and Fisher [10], applying the Coase theorem and focusing on developing countries, suggest that transferable water rights could improve the efficiency and sustainability of water use.

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water rights have an incentive to retain those rights but are slow to adopt new water conservation technologies. The second type results from excess capital being utilized by suppliers with insufficient water rights—i.e., in cases when they may be near a water source but must instead purchase water from a wholesaler farther away. This may result in the creation of excessive water pipeline infrastructure.

A number of studies have considered the relationship between regulatory schemes and the efficiency of water suppliers, but none allow for the formulation of stylized facts.[3] Aubert and Reynaud [12], for instance, focus on the U.S. state of Wisconsin and find that rigorous regulation results in more efficient suppliers. On the other hand, Byrnes et al. [13] focus on water management policies in New South Wales and Victoria and suggest that rigorous regulation results in less efficient suppliers. The present study can thus contribute additional evidence on whether rigorous regulations lead to less efficient water suppliers.

Quantitative studies have measured the technical inefficiency of water suppliers mainly by stochastic frontier analysis (SFA) or data envelopment analysis (DEA); DEA has been adopted most commonly, according to the survey of See [11].[4] Using the DEA technique, studies have measured the efficiency of retail suppliers in various countries, for example, the United States [16,17], England and Wales [18,19], Mexico [20], Brazil [21], Australia [22,23], Spain [24,25], and Portugal [26]. Some studies, such as Aida et al. [27], Nakayama [28], Harada [29], and Marques et al. [30], use DEA to examine Japanese water suppliers. However, there are only two English-language papers examining Japan: Aida et al. [27] and Marques et al. [30]. Aida et al. [27] considers 108 water suppliers in the Kanto region in 1993, and Marques et al. [30] uses 5538 observations of 1144 water suppliers from 2004 to 2007. The current paper adds to these by using more recent data and focusing on the efficiency of water suppliers and the Japanese nontransferable water rights scheme.

This study examines whether the Japanese regulatory scheme, with its nontransferable water rights, causes technical inefficiency based on the two-stage procedure proposed by Simar and Wilson [31,32]. Many past studies have used a two-stage approach: in the first stage, technical efficiency is calculated using DEA, and in the second stage, the estimated efficiency becomes the dependent variable in a Tobit model. However, Simar and Wilson [32] show that the Tobit estimator is inappropriate and then suggest using a bootstrapped truncated regression, proposing an estimation algorithm. The present study adopts their procedure and algorithm.[5]

Furthermore, this paper explores a counterfactual scenario in which water rights are transferable among water suppliers and uses this to estimate the cost increase arising due to the technical inefficiency caused by nontransferable water rights. This is believed to be the first study providing such an estimate of the cost of this technical inefficiency. This estimation also reveals the scope of the problems caused by the Japanese nontransferable water rights scheme.

The remainder of this paper is organized as follows. Section 2 provides a brief overview of the Japanese retail water supply industry. Section 3 then outlines the methodology used for the analysis, explaining how technical efficiency is measured using DEA and presenting the regression model used to examine the determinants of efficiency. Next, Section 4 describes the dataset and presents the estimation results, while Section 5 assesses the technical inefficiency characterizing the current system. Section 6 concludes.

2. Industry background

2.1. Types of water utilities

Water suppliers provide their services for certain purposes, as depicted in Fig. 1. Water use in Japan is divided into three broad categories: agricultural, industrial, and domestic use, accounting for 54.4 billion m^3, 11.3 billion m^3, and 15.2 billion m^3, respectively, of usage in 2011. Water for domestic use is supplied and distributed by both wholesale and retail suppliers. Wholesale suppliers sell purified water not to individual households but to retail suppliers.[6] Retail suppliers can be distinguished in terms of the size of the population they serve. Suppliers serving a population of up to 5000 people are classified as small-scale suppliers and are not subject to the Local Public Enterprise Act (LPEA); suppliers serving a population of more than 5000 people are subject to the LPEA. This study focuses on the latter group, the members of which are hereafter referred to as water suppliers.

2.2. Scope of water rights

Water rights are the rights of users to use water from a resource owned and administered by the relevant ministry and prefectural governments. Water rights in Japan are defined in the River Act. Article 2 of the River Act stipulates that Japanese surface water sources are public property, while Articles 9 and 10 state that surface water sources are administered by either the Ministry of Land, Infrastructure, Transport and Tourism (hereafter referred to as “the Ministry”) or a prefectural government.[7] As per Article 23, only authorized water users have access to surface water sources.

Water supplies rely fundamentally upon water rights. Fig. 2 shows the distribution of withdrawals, by source, in Japan. Due to Japan's mountainous topography, about half of the water for domestic use comes from artificial lakes created by dams. The Ministry and prefectural governments administer surface water sources, including artificial lakes behind dams, rivers, intermittent streams, and lakes. About 80% of the water for domestic use is dependent on water sources subject to water rights. Water rights thus have a significant influence on the stable supply of water.[8]

2.3. Characteristics of Japanese water rights

Water rights are characterized in the rules governing water use. The Ministry or prefectural governments allocate water resources strictly to ensure adherence to quotas for annual total and daily usage for a predetermined purpose, assigning exclusive usage for ten years. The purpose of exercising a given water right is

[3] According to See's [11] survey, there are seven main determinants of technical inefficiency: ownership, population density, income per capita, non-revenue water, meteorological factors, chlorine tests, and other factors such as the source of raw water, the market structure, and regulations. Most studies on the efficiency of water suppliers focus on the effects of different ownership types and therefore are not directly relevant to this paper.

[4] Abbott and Cohen [14], Witte and Marques [15], and See [11] present brief summaries of water efficiency studies.

[5] Studies of the water sector that employ a methodology similar to that used here include Witte and Marques [15] and See [11].

[6] Of the wholesale suppliers, 78 are owned by prefectures and multiple municipalities and are subject to the LPEA.

[7] The River Act classifies rivers, breaks them into sections, and delegates responsibility for their administration. The Ministry administers Class A river systems, which are those systems deemed important for the national economy and people's lives nationwide. The other systems, Class B river systems, are overseen by prefectural governments.

[8] Groundwater is owned by the owner of the land under which the water is stored and is not subject to the water rights granted by the government. However, the daily or annual withdrawal of groundwater is often limited by ordinances in order to prevent land subsidence and saltwater intrusion.