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Assessing welfare impact of entry into power market ☆

In-Koo Cho [a], Hyunsook Kim [b,*]

[a] Department of Economics, University of Illinois at Urbana-Champaign, IL 61801, United States
[b] Department of Economics, Soongsil University, 511 Sangdo Dong, Dongjak Gu, Seoul 156-743, Republic of Korea

HIGHLIGHTS

- This paper calculates the welfare impact of a new entrant based on the location of entry.
- We use two different models to estimate the entry effect.
- The minimum and maximum cost savings of a new entrant are about 0.3% and 0.84% of total generation cost.
- Even if a new entrant has no cost advantage, its choice of location could save money.

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ABSTRACT

This paper calculates the welfare impact of a new entrant based on the location of entry in the Korean electricity market. We use two different models. One is the optimal fuel mix model to estimate the effect of a new entry in the long run. The other is the variable cost minimization model to assess the contribution of an existing installed private generator in the short run. A specific private generator, which has a cost advantage, saves a substantial amount of system-wide variable costs. We show that the right location for a new entrant can save power generation costs significantly, even if a new entrant does not have a cost advantage.

1. Introduction

The core of electricity deregulation policies around the world is to promote entry by private firms to increase generation capacity and to improve service to consumers beyond what traditionallyregulated industry can offer. Large initial capital investments as well as increasingly strict environmental regulations pose considerable challenges for any potential entrant to the industry and also for the success of deregulation of the electricity market. It is therefore an important policy problem to assess the social benefit and cost of new additional capacity, and to identify the key factors that should be considered to devise a sensible policy to guide entry.

The goal of this paper is to examine quantitatively the social planner's problem to understand the factors the policy maker must consider in order to propose a sensible guideline for entry into the electricity industry.

It seems obvious that the optimal entry point for new production capacity is where the demand exceeds the supply. But, the power industry poses two unique challenges to the otherwise "routine" exercise of assessing the marginal welfare impact of entry. First, the optimal entry point is determined endogenously. As the electricity is delivered through a network of grids and transmission lines with a limited capacity, delivery can be disrupted by transmission line congestion. If transmission lines are congested, the market for power is segmented, as the supply of power is disrupted. However, the pattern of market segmentation is determined endogenously by the distribution of the demand and the supply over the entire network, which varies over time and in response to weather and scheduled maintenance. To find the optimal entry point, we need to calculate the competitive equilibrium for an economy endowed with demand and supply along with a transmission network with limited capacities.

Second, if the market is not deregulated, the observed market outcome is not competitive, and may not be efficient. If the observed figures are not induced by the perfectly competitive equilibrium, we cannot use the existing market data on delivery price and congestion patterns to devise a policy to enhance the efficiency of the market. Even if one location is always segmented from the rest of the market, and has experienced excess demand, it is not clear at all whether the same pattern of market segmentation continues to hold under the efficient outcome. We need to calculate an efficient equilibrium price and the associated

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* Corresponding author. Tel./fax: 82 2 784 5260.
E-mail address: annakim@ssu.ac.kr (H. Kim).

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congestion pattern as the competitive benchmark to build a sensible policy to improve efficiency of the market.

Korea's electricity market is an excellent laboratory to analyze entry's potential benefits, and to derive a useful policy recommendation toward entry such as location of new generators. The national grid of Korea is self-contained. It is not connected to any generators outside of Korea, which considerably simplifies the model, as we need not consider the state of the market outside of Korea. The existing generation capacity and the demand are substantial, which is roughly one and a half times that of the California power market based on annual peak load.[1] The large size of the market is important for the quantitative analysis, as the market can absorb and endogenize exogenous shocks without disrupting the basic function of finding the market clearing price and allocating the power accordingly.

In the past decade, the government initiated a couple of attempts to deregulate the power industry, but withdrew in response to economic and social conditions. Traditionally, Korea Electric Power Company (KEPCO) had monopolized generation, transmission, distribution and retail. As an attempt to deregulate the market, most of the generators of KEPCO were split into six large KEPCO subsidiaries, while other divisions remain under the direct control of KEPCO. In fact, Korea Power Exchange (KPX) trades power, but its function is not substantive because most of generators except small Independent Power Producers (IPPs) practically remain under the control of KEPCO.

The government began to allow private companies to generate power commercially, delivering power through the existing transmission lines. This policy offers a natural experiment to see the welfare impact of entry. Because of the large initial capital investment, only a few large corporations decided to enter the market by building mainly LNG combined cycle (CC) generators. Moreover, the policy uncertainty regarding deregulation generally discourages large scale entry. As a result, around 11% of the total generation capacity is provided by private companies other than KEPCO subsidiaries.

We experiment with the impact of a new LNG CC generator on the system-wide production cost depending on the location of entry. We focus on the example of a private generator with a production capacity less than 1.5% of the national generation capacity, and with a considerably lower marginal generation cost than comparable pre-installed generators. This small scale entry serves as a social experiment to assess the marginal welfare impact of entry.

While capturing the key features of demand and supply of power in Korea, we can simplify the network into two zones: the Metropolitan area including Seoul and Gyeongi-Do which accounts for around 40% of the national demand, and the Southern area which is the rest of the country.[2] For economic and environmental reasons, nuclear and coal burning generators, which are base load generators, are located in the Southern area. Roughly speaking, the center of the demand for power is the Metropolitan area, and the transmission network and the distribution of generators are designed accordingly.

Korea has one of the most reliable electricity services in the world. Despite the fact that the transmission line to the Metropolitan area is congested, there have been few blackouts in the Metropolitan area, or any other areas. Therefore, the observed demand is the actual demand for power, which allows us to recover the demand for power from the data. Combined with the micro data about the cost structure of the individual generators, we can construct a zonal competitive benchmark model following Kim and Kim (2010) and Cho and Kim (2007).[3]

Using the competitive benchmark, we calculate the social welfare based on the location of entry. First, we use the optimal fuel mix model to calculate the long-term effect of a new incoming small entrant. Second, we use actual data to calculate the short term welfare loss, for a given portfolio of generators. In each case, we carry out counter factual experiments, locating efficient private generators in the Metropolitan area rather than in the Southern area. The rest of the paper is organized as follows. Section 2 describes the two models and the focal points of our exercise. Section 3 describes the data in detail for the estimation. Section 4 shows the estimated result of an entry effect. Section 5 concludes this paper.

2. Formal description

We calculate the impact of entry on social welfare, using two different models. The key difference between the two models is whether or not the social planner can choose the technology and the capacity of a new generator. In the first model, we assume that the social planner chooses the portfolio of generating technology and the output level in order to minimize the social cost subject to technological and environmental constraints. As the portfolio of production technology determines the distribution of fuel mix, the first model is called the optimal fuel mix model, which measures the long term effect of entry.

In the second model, we assess the short term impact of entry by private generators, for a given portfolio of generators. We focus on how entry point can affect welfare by alleviating the transmission congestion, for a given set of generators.

2.1. Preliminaries

Following Kim and Kim (2010), we abstract the national grid of Korea into a network with two zones connected by a single transmission line. Each zone is endowed with supply and demand curves, and the transmission line has a finite capacity.

We call the first zone “Metropolitan area” roughly covering Seoul and its suburbs and the second zone “Southern area” covering all area outside of the Metropolitan area. Around one half of the entire population of Korea is living in the Metropolitan area with a significant portion of industrial production of Korea coming from the same area. Base load generators, which typically use coal or nuclear technology, are located in the Southern area. Power is then transmitted to the Metropolitan area through a network of transmission lines. If congestion occurs, it occurs typically in the direction from the Southern to Metropolitan area.

Let I be the set of all generators in Korea, which include pre-installed and planned generators. Each generator is classified according to two criteria: whether the generator is pre-installed (“*Old*”) or planned and whether the generator is located in Metropolitan area (“*M*”) or not. Given the location of a planned generator, the social planner decides the type of fuel and the capacity for the generator.

Let I_{Old} be the set of all pre-installed generators, covering both Metropolitan area and the rest of the country. The social planner

[1] The peak load of Korean power market in 2012 is 73,833 MW, while the peak load of California in 2011 is 45,545 MW. See http://www.caiso.com for the California power market information.

[2] We suppress Jeju Island, which is an isolated island off the southern coast with minuscule demand, connected to the national grid through an underwater cable.

[3] Two papers have different approaches. Kim and Kim (2010) construct the optimal fuel mix based on the total cost minimization in Korea. The model in Cho and Kim (2007) is based on the welfare maximization for California. However, both papers have common that they consider zonal network constraints to get the optimal results.