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Entry and externality: Hydroelectric generators in Brazil ☆

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ABSTRACT

This paper analyzes the entry problem in the hydroelectric generation industry. The operation of an upstream generator regularizes the river flow for generators located downstream on the same river, increasing the production capacity of the latter. This positive externality increases the attractiveness of the locations downstream whenever a generator decides to enter upstream. Therefore, the entry decision of a generator in a given location may affect all entry decisions in potential locations for plants downstream. This type of externality takes place whenever the first firm to enter in a market facilitates the following entries. I first develop a method to estimate an entry model specific to this type of externality, considering the specifications of the hydro-generation industry. At last, I use a data set on investment decisions of Brazilian hydro-generators to estimate the model. The results show a positive incentive to locate downstream both from existing plants and from locations where entry is likely to occur. An interesting by-product of this analysis is that the year effects' estimates show an increase one year before the energy crisis of 2001, providing evidence that the market had anticipated the crisis. It contradicts the governmental version that the crisis was due to an unexpected drought.

1. Introduction

This paper analyzes the entry problem in the hydroelectric generation industry. The operation of an upstream generator regularizes the river flow for generators located downstream on the same river, increasing the production capacity of the latter (in this context, regularization means a reduction in the variance of the river flow). This positive externality increases the attractiveness of the locations downstream whenever a generator decides to enter upstream. Therefore, the entry decision of a generator in a given location may affect all entry decisions in locations downstream. I first develop a method to estimate an entry model specific to this type of externality, considering the characteristics of the hydro-generation industry. The specificity of the method derives from technological characteristics of hydro-generation, and significantly simplifies the estimation when compared to other standard entry models. At last, I use a data set on investment decisions of Brazilian hydro-generators to estimate the model.

This type of externality takes place whenever the first firm to enter in a market facilitates the following entries. A typical situation is the case in which the first entrant has to build a part of the infrastructure, and the later firms can 'free ride' on it. For example, the first retail store built in a town may build roads and parking lots that make it easier for later entrants.[1] Another example is the political protection of regulated industries, in which entry is not allowed.[2] The first entrant has to bear the cost of breaking the political barriers to enter the market, but once it is done it becomes much easier for later firms. This paper proposes a method to estimate this type of effect.

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1 This suggestion was given by an anonymous referee.
2 It was common in industries such as airlines, transportation, telecommunications, etc., prior to the deregulation wave of the 80s and 90s, and it is still quite common in many industries in different countries.

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The empirical results show that firms have a positive incentive to locate downstream and that location characteristics matter on the decision to enter. The externality has a positive effect on entry decisions, and it is an increasing function of the river flow regularization done by the upstream plants, and a decreasing function of the distance between them. On rivers with several available locations, there is also an incentive to locate downstream, since entrants take into account the probability that entries occur in the locations upriver. The physical and geographical characteristics of each location also play a strong role in the entrant's decision. The model identifies a pattern on the entry dynamics of new hydro-generators: once someone enters in a given location, entry becomes more likely to happen on the downstream locations of that river. Further, we have found evidence of multiple entries by the same firm on the same river, which is another evidence of the externality, since firms may try to capture the externality by entering more than one location on the river basin.

The year effects estimates of the entry model capture the variation in market conditions for the different years covered by the sample, and can be understood as an average for the non-observable prices of the bilateral contracts, which govern most of the electricity trade. Interestingly, these estimates show an improvement in market conditions one year before the crisis of 2001, when spot prices reached unprecedented high levels (see Fig. 2). It indicates that the market had anticipated the net excess demand that would take place in the following months. This conclusion has three strong implications. First, it contradicts the government's claim that the crisis was due to an unexpected drought. If the crisis was truly unexpected, anticipation would not exist. Second, despite high sunk costs and uncertainty about future market conditions, investments in hydro-generation did respond to an expected excess demand, which absolves the market design of any blame for ineffectiveness. In fact, the crisis happened due to the length of time required for new plants to begin operating. Last, despite the fact that the market anticipated the crisis, the centralized dispatch algorithm failed in preventing it. Few months before the crisis, the ISO was still dispatching the hydro plants instead of turning the thermo generators on.

I have benefited from information on the entry order to analyze a commonly used assumption in the empirical literature on entry: that entries occur at the same time. Since my data set has information on the entry order, I have estimated the model both with and without the entry order. The results show that not considering the entry order, and estimating a one shot entry game in which everyone enters at the same time, it overestimates the externality effect and the interactions of the agents.

1.1. Background

The Brazilian electricity industry underwent major reforms during the 90s. A broad privatization and deregulation process changed the industry from a state-owned vertically integrated monopoly to a private industry separated in the three different segments of generation, transmission and distribution. The main purposes of the reforms were to increase efficiency and to attract private capital to the sector. Among the major changes, there was the creation of a market for long term contracts of electricity supply, as a way to introduce competition in the generation segment. Generators would be free to negotiate contracts with consumers, which would create competition for better deals. The market would provide incentive for efficient behavior on the firm's side and would have a price working as a signal for new investments in electricity generation.

In 2001, five years after the reforms, Brazil went through its most severe energy crisis ever. An unexpected dry summer[3] caught the water levels of the Brazilian system dams at an already low level leading to a water shortage that culminated in a rationing of electricity consumption with penalties for over-consumption. Unclear market rules led to major lawsuits from different parties, leaving the electricity market in complete chaos. The official government explanation for the crisis was the unexpected drought of the first months of 2001 that added to a series of unfavorable rain seasons in the previous years, leading to the acute water shortage of 2001. However, reforms critics argued that the crisis was in fact the consequence of mis-designed market rules. More specifically, they argued that the price from the market for contracts of electricity supply could not attract enough investments in new generation capacity. They also claimed that due to the high sunk costs and number of years required for the new plants to start operating, entry of new plants should be the result of a centralized decision and not be left to a decentralized market. In order to analyze how investments in new plants respond to different market conditions, it is needed information on prices and on the profitability of the plants, and how investment in new plants proceeded.

The problem is that even after the reforms, the electricity industry in Brazil (and also in other places) is characterized as being centralized and regulated. The generation segment operates under centralized dispatch, with the ISO (Independent System Operator) deciding the quantity produced by each agent. Also, generators are paid according to their long term production capacity (called assured energy) instead of their actual production. Besides, around 90% of the trade happens through bilateral contracts, which means that the spot price and quantity traded cannot be used to analyze the entry decisions of new plants, since they are not representative of the plants profitability.

The contract market is the only competitive segment in this industry. Unfortunately, the contracts prices are kept secret by the parties. However, the decision to enter the generation market is public information and well documented. The literature on empirical entry models in industrial organization (Bresnahan and Reiss, 1988, 1991; Berry, 1992 among others) provides a way to estimate the profit function of the entrant firms based solely on entry data. This is the method I adopt in this paper.

However, when using the entry decisions to identify the profit function, one characteristic specific of hydroelectric generation must be considered: the externality in production. The externality arises from the fact that the operation of a generation plant regularizes the river flow downstream, since it stores water during the rain season and releases it while

[3] Summer is the rain season for most part of Brazil.