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Economies of vertical integration in the Swiss electricity sector☆

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ABSTRACT

Over the last two decades, several European nations have introduced reforms to their electricity sector. Generally, these reforms require a legal and functional unbundling of vertically integrated companies. These unbundling processes may reduce the possibilities that exist to fruitfully exploit the advantages of vertical integration.

The goal of this paper is to empirically analyze the presence of economies of scale and vertical integration in the Swiss electricity sector. Economies of vertical integration between electricity production and distribution result from reduced transaction costs, better coordination of highly specific and interdependent investments and less financial risk. Different econometric specifications for panel data, including a random effects and a random-coefficients model, have been used to estimate a quadratic multi-stage cost function for a sample of electricity companies. The empirical results reflect the presence of considerable economies of vertical integration and economies of scale for most of the companies considered in the analysis. Moreover, the results suggest a variation in economies of vertical integration across companies due to unobserved heterogeneity.

1. Introduction

Several European countries have embraced new and modern reforms to their electricity sector over the past two decades. The general principles adopted in these reforms included the introduction of competition in electricity generation and the introduction of new regulatory instruments such as the price cap method in the transmission and distribution of electricity, still considered natural monopolies.

These reforms have introduced some changes to the managerial organization of electric utilities, traditionally maintained as vertically integrated utilities with generation, transmission and distribution under a common corporate roof. For instance, the directive 2003/54/EC of the European Parliament and of the EU Council of 26 June 2003 requires a legal and functional unbundling of the utilities.[1] Generally, the vertically integrated companies are required to separate the production, transmission and distribution functions.

The thesis behind this policy is that unbundling the services into separate functions allows greater efficiency through stronger and more transparent competition in the generation and sale activities of this sector. Not only does unbundling reduce the possibilities of cross-subsidizing generation activities with transmission activities, it also curtails the possibility of limiting the access to the network for competing generators.

However, one has to consider that unbundling processes reduce the possibilities that exist to exploit the advantages of vertical integration. In fact, a vertically integrated structure can be cost effective if there is a substantial need for coordination across stages and if high transaction costs are associated with using intermediary markets. This means that policymakers should be concerned about the efficient balance between integration and unbundling. [2] According to the EU policy directive, EU

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[1] The EU distinguishes five main types of such unbundling: 1. Accounting unbundling; 2. Functional unbundling (separate accounts and management for transmission and generation activities); 3. Legal unbundling (transmission and generation are separate legal entities); 4. Ownership unbundling (generation and transmission have to be owned by independent entities).

[2] The welfare implications of this policy results from the magnitude of the price savings associated with the introduction of competition and the cost increases caused by a reduction of the exploitation of vertical economies. Unfortunately, no study at the European level has systematically analyzed these welfare implications.

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member states can exempt utilities with fewer than 100,000 customers from any functional unbundling requirement of the distribution network. In this case, the EU seems to consider that for relatively small electric utilities the economies of vertical integration are considerable.

Economies of vertical integration between electricity production and distribution result from reduced transaction costs; better coordination of highly specific and interdependent investments in generation, transmission and distribution; less financial risk due to higher certainty in the sale activities; and avoiding the hold-up problem from technological interdependencies in different production stages.[3] A reduction in transaction costs implies a drop in the coordination costs for daily activities in the coordination costs of planning a reliable, and least-cost production and transmission system, and a cut in the negotiation costs. [4]

Despite its policy importance, only a few studies have estimated directly the economies of vertical integration in the electricity sector. Kaserman and Mayo (1991), Kwoka (2002), and Isaacs (2006) estimated a quadratic multi-stage cost function for a cross section of US electricity companies. Jara-Diaz et al. (2004) estimated a quadratic multi-stage cost function for a sample of Spanish electricity companies using panel data, whereas Fraquelli et al. (2005) estimated a composite multi-stage cost function with a log-quadratic input price structure and a quadratic output structure using panel data for a sample of Italian utilities. Recently, Greer (2008) estimated a multi-stage, multi-output cost function for a cross section of US rural electric cooperatives. In general, all studies found that economies of vertical integration exist. Moreover, these studies indicate that larger utilities exploit a higher degree of economies of vertical integration. [5]

The purpose of this paper is to make a contribution to the empirical literature on the economies of vertical integration using panel data for a sample of Swiss electricity distribution utilities. This analysis has important policy implications in view of the ongoing electricity market reforms in Switzerland as well in several European countries, especially for discussion on the exemption limit for the functional unbundling requirement of three activities—generation, transmission and distribution.[6]

From a methodological point of view, one of the major difficulties in estimating economies of vertical integration is that different networks, environmental and technical characteristics influence the costs of vertically integrated and vertically disintegrated electricity companies. From the empirical analysis point of view, many of these characteristics are not observed or are difficult to measure—and therefore, not included in the cost model specification. Such an omitted-variables problem could bias the estimation results. Moreover, the strong heterogeneity among utilities suggests that a cost function with constant coefficients might be inadequate for a reliable analysis of economies of vertical integration.

In this study, to account at least partially for such heterogeneity and to perhaps assess the potential biases, we use some econometric specifications for panel data. To our knowledge, only the study by Jara-Diaz et al. (2004) has used the advantages of panel data models to account for heterogeneity among companies. However, the approach used by these authors, a fixed-effects model, is able to only partially consider the effect of the unobserved heterogeneity on the coefficients of the econometric model.

In this paper we estimate a multi-stage cost function using two panel data econometric models, a Generalized Least Squares (GLS) model with random intercept and a random-coefficients (RC) model. The data set comprises 74 Swiss electricity companies observed during the period between 1997 and 2005. The sample includes both specialized and integrated companies.

This paper is organized as follows. Section 2 presents the model specification and the estimation methods; Section 3 describes the data; Section 4 presents the regression results; the definition of economies of vertical integration and economies of scale and their estimates are discussed in Section 5; the paper ends with a summary of main results and policy conclusions.

2. Model specification

Empirical studies on the cost structure of vertically integrated electricity utilities and of specialized utilities assume total cost as a function of output, price of inputs and some output characteristic variables such as area size, customer density and load factor. Generally, these output characteristic variables are introduced in the model to capture heterogeneity in the output and in the different service areas. Most of these studies also include a time trend to control for potential changes in the technology.

For the empirical analysis of this paper we considered a sample of small and middle-sized electricity companies. While some of them are vertically integrated companies, others are active only in the distribution of electricity. Vertically integrated companies are characterized by the presence of hydropower plants, a small high-voltage transmission network, and a regional distribution network.

The model specification used in this study is based on a cost function with two outputs (electricity generation and distribution), two inputs, three output characteristic variables, and a linear time trend. As in Sing (1987), Kwoka (2002), Filippini et al. (2004) and Fraquelli et al. (2005) customer density is introduced as a service area characteristic. Furthermore, the load factor of the network and the capacity utilization factor at the generation level are also included in the model to control differences in the load profiles across the companies.[7]

Following Kwoka (2002), the share of the sales to end consumers has also been introduced in the cost model. In fact, distribution to end consumers needs more transformation and more infrastructures compared with distribution to resellers, and are therefore assumed to be related to higher losses and higher costs. We are aware that these output characteristics variables consider just one part of the heterogeneity of the electric companies included in this study. However, as we will see later, part of the unobserved characteristics variables will indirectly be taken into account using panel data econometric models.

If it is assumed that the firm minimizes cost and that the technology is convex, a total cost function can be written as:

$$C = C(Q1, Q2, PC, PL, CD, EC, LF, CU, T) \qquad (1)$$

where C represents total costs; $Q1$ and $Q2$ are respectively the electricity generated and electricity distributed during the year; PL

[3] The organization of the electricity industry in several production stages (generation, transmission and distribution) implies that generators need transmission and distribution to get electricity to consumers and that transmission and distribution assets need generators. In this situation, the generator, transmission and distribution assets, created and independently owned, cannot be dedicated to other uses. Therefore, either side can 'hold-up' the other.

[4] For a detailed discussion on the sources of the economies of vertical integration in the electricity industry see Michaels (2004).

[5] Other methodologies to analyze if vertical effects exist are by separability test of cost functions (see Lee (1995) and Hayashi et al., 1997) and by the estimation of cost complementarities (see Gilsdorf (1994), and Ida and Kuwahara, 2004). However, these approached do not allow quantifying the effects.

[6] Although Switzerland does not belong to the European Union, the Swiss electricity market reform has introduced some unbundling requirements. For instance, the large interregional high-voltage transmission network has been functionally unbundled. Moreover, the small and middle-sized electricity companies have introduced an accounting and informational unbundling. To note, that the Swiss reform does not foresee a formal exemption limit for the functional unbundling of the different activities. However, because the majority of the Swiss companies have less than 100,000 customers, implies indirectly an acceptance of the European limit.

[7] See also studies by Gilsdorf (1995), Filippini (1996, 1998), Yatchew (2000) and Filippini et al. (2004) which included the load factor of the network and studies by Maloney (2001), Kwoka (2002), Ida and Kuwahara (2004) and Jara-Diaz et al. (2004) where the generation capacity utilization factor was included.