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Electricity costs in irrigated agriculture: A case study for an irrigation scheme in Spain

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ABSTRACT

Electricity prices have risen sharply in Spain in recent years, to the point where they are now among the highest in the EU. The scant competition between power utilities, changes in the law, and the tariff deficit (accumulated debt in favour, mainly, of the electricity firms), have driven up the cost of electricity, affecting numerous other industries such as irrigated agriculture, a sector that has significantly increased its electricity consumption as a result of modernization processes over the past twenty-five years. We examine these issues through a case study of an irrigation scheme in Spain that provides irrigation water and infrastructure to 58 farming communities in north-eastern Spain, and is highly representative of the Ebro Valley. Based on the results of direct estimations and simulations of different tariffs, we propose the lowering of capacity-based tariffs to reduce sector problems and cut energy costs, especially for farmers. We also raise the possibility of increasing self-consumption, a complementary measure for many farmers and for medium-size firms.

1. Introduction

Electricity is key to the functioning of the Spanish, and of course every other, economy: industries cannot function without power. This is nowhere more true than in the case of irrigated agriculture, a sector that has considerably increased its energy consumption to pump and distribute water as a result of the modernization of the last thirty years (see Jackson et al. [1], Jiménez-Bello et al. [2], and Plappally and Lienhard [3]). A nationwide process of modernization over this period has raised farm output and competitiveness to unprecedented levels, significantly improving farmers' incomes. However, the resulting structure of irrigation systems is highly sensitive to energy costs, and the continuous increases and variability of energy prices in recent years have become a significant obstacle to the sustainability of agricultural earnings.

The link between energy and water has generated a global interest in this issue, with the objective of reducing consumption, especially, of conventional energy sources (which have many environmental impacts), particularly for irrigation applications. Gopal et al. [4] carry out a literature review on this topic, and there are several studies of alternative energy sources for pumping water (see Haddad [5], Bataineh [6], Chandel et al. [7], Ali et al. [8], and Purohit and Kandpal [9]).

The electricity industry in Spain faces serious problems: the lack of competition between power utilities, the premiums on renewable energy, the high dependence on gas and imported coal, and deficiencies in the grid. These problems have been further aggravated by the issue of the *tariff deficit* (accumulated debt in favour, primarily, of the electricity firms), resulting in a sharp rise in the cost of electricity in Spain, which has adversely affected the country's competitiveness.

In this context, our study examines these rising energy costs as they affect irrigated farming. Prior studies have analysed the impact of energy costs on agriculture, including Lecina et al. [10] and Rodríguez et al. [11], who observed a 400% increase in the costs incurred by one irrigation scheme in Andalusia, after the modernization of the infrastructure and technology. Our aim goes beyond the study of energy costs in irrigated farming to propose viable options to reduce the burden, in a context of increasing costs due to modernization.

One of the objectives of this study is, therefore, to analyse the Spanish electricity system in order to determine the effects of the different tariff systems on irrigated farming. We look at the *Upper Aragon Irrigation Scheme* (CGRAA in its Spanish acronym), which brings together 58 communities of farmers in the province of Huesca, in north-eastern Spain. The CGRAA irrigates more than 133,000 ha of land, which is very representative of irrigated agriculture in the Ebro Valley, and it is the largest irrigation scheme in Spain. Moreover, our ideas on this issue could be applied to other EU irrigation systems. The case of France is relevant, where there is a special green tariff for irrigation (see JORF [12]) that includes a capacity tariff, but this capacity tariff is very low compared to the one in Spain.

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Energy costs in the CGRAA have mushroomed in recent years, the result of growing energy needs on one hand, due to the modernization of irrigation systems (see Sánchez Chóliz and Sarasa [13]), and rising energy prices on the other.

We use data on electricity generation, consumption and supply provided directly by the CGRAA. Official electricity tariffs for both energy consumed and capacity contracted are published periodically in the Official Journal of the Spanish State (BOE in its Spanish acronym), allowing for the calculation of costs and observation of its growth, in particular due to price hikes. On this basis, we have calculated energy consumption and costs for the period 2010–2013 and estimated them for 2014. This period corresponds with the establishment of major electricity reforms in Spain. Moreover, despite the economic crisis, the first cause of increasing electricity consumption in agriculture is linked to water needs for irrigation that boost the modernization processes, with Spanish irrigated agriculture being one of the sectors least affected by the crisis. This makes this case study very suitable for the objective of our work, as the CGRAA presents water constraints that are addressed through improvements in technology (see Philip et al. [14]).

Additionally, based on the results of direct estimations and simulations of different tariffs, we propose to remove or, at least, to reduce the capacity-based tariffs to respond to the observed problems and to cut energy costs, especially for farmers. We also highlight the possibility of increasing self-consumption as a complementary measure.

In Section 2, we describe the Spanish electricity system and highlight its main problems. Section 3 examines the specific case of the CGRAA in terms of output and power consumption, and Section 4 proposes some possible solutions to the issues identified. The paper ends with some brief concluding remarks.

2. The Spanish electricity system

2.1. Competition issues

The electricity market began to be liberalized in several countries in the 1980s (see Erdogdu [15], Pollitt [16], and Slabá et al. [17]). In 1997, the Spanish Electricity Industry Act of the Spanish Government (see BOE [18]) was designed to foster competition between power utilities. To this end, it decoupled generation, transportation, distribution, and marketing, and prohibited any single company from engaging in more than one of these businesses.

At the time, it was believed that this unbundling would establish the conditions in which competition could flower. Today, however, we can question whether this measure has been a success, and if so in what ways. From the standpoint of economic theory, there is no particular reason why this vertical splitting should encourage competition. Furthermore, decoupling does not always work in practice, in spite of the legal separation of generation and distribution firms, because the shareholders often overlap and they avoid competing with each other and tend to cooperate in pursuit of common goals.

Power is sold at auction in a daily market, which operates by matching supply and demand so that the marginal price is the final price. The system is seriously flawed in terms of competition, among other reasons because a minimum guaranteed output is applied to nuclear power, while renewable energies like solar and wind power enjoy preferential access to the grid. Also, generating conditions allow producers of nuclear power to offer very low prices in the market in order to boost their sales. There can be no doubt, then, that this auction system creates winners (nuclear plants and wind farms) and losers (combined-cycle plants, which use two thermodynamic cycles: gas turbine and steam turbine), as can be observed in Table 1. Moreover, in this line, certain authors also suggest penalizing less combined plants (see Cardoso and Fuinhas [20]).

Table 1
Daily market power output by generating technology, January and February 2014. *Source*: OMIE [19].

	Daily market – January		Daily market – February	
	GW h	%	GWh	%
Oil-Gas	0	0.0	0	0.0
Thermal (subsidized)	300	1.3	250	1.2
Coal	1,238	5.6	108	0.5
Combined cycle	251	1.1	210	1.0
Nuclear	4,559	20.5	4,703	22.6
Hydroelectric	3,891	17.5	5,259	25.2
Imports	1,324	6.0	892	4.3
Wind	6,592	29.6	5,967	28.6
Cogeneration/Waste/ Small hydro	4,982	18.4	3,462	16.6
TOTAL	22,236	100.0	20,851	100.0

In addition, the transmission system suffers from a dearth of connections with Europe, and large areas of Spain itself are burdened by connection deficiencies, with the result that there is not enough external and internal competition. Moreover, in Spain, the distribution conditions are unquestionably optimized by the existence of a single grid, given the very large infrastructure investments required, the general use of the system, and its geographic extent, and for these reasons it would be quite justifiable for Government to take over management of the grid. By contrast, while the Spanish state could manage electricity distribution (not to be confused with marketing) and the upkeep of the grid directly, so far, it has preferred in practice to entrust responsibility to private firms, paying them the costs incurred in this activity and a guaranteed margin so that profits are assured. Under these conditions, there is little incentive to compete and firms have a clear interest in colluding to demand all they can from Government, increasing the upward pressure on electricity prices.

Finally, competitive conditions in electricity marketing are likewise questionable, in view of the market shares of the utilities involved. In reality, the market is an oligopoly in which just two firms account for most of the pie, as shown in Yusta [21].

2.2. The tariff deficit

As in the management of electricity distribution and the upkeep of the grid, so the Spanish Government has established by law a number of regulated activities for which the power utilities receive incomes as compensation for the regulated costs that they bear (see references in Table 2). The tariff deficit is the difference between the regulated income received and the regulated costs. The tariff problem first arose in 1997 as a consequence of intense lobbying (then as now) by the electricity industry. Given the clearly oligopolistic nature of the electricity market in the 1990s, the power utilities were able to wield significant social, media, and political influence in Spain. The Government at the time was keen to freeze the rising energy costs paid by consumers, as any hike in electricity bills would have been deeply unpopular among the general public and electricity prices already had a major impact on the economy and growth. In this light, the Government resolved in 1997 to freeze consumers' electricity bills, and this was the origin of the tariff deficit. It was decided that the electricity price would be split into two parts, one of which would be payable directly in cash through the electricity bill, and the other part deferred as a debt owed by the electricity system (guaranteed by the Spanish Government) to the utilities. This debt was the germ of the tariff deficit, which has since grown each year to become a massive cumulative burden, more than €35 billion in 2013 (see Fig. 1). The immediate result of the Government's decision was to rein in Spain's current electricity bill,

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