Thriving on uncertainty: Strategic interaction and long-term supplier contracts in oligopolistic settings

-**Peio Alcorta**, Department of Economics, University of the Basque Country (UPV/EHU), E-mail: peio.alcorta@ehu.eus
-**Maria Paz Espinosa**, Department of Economics, University of the Basque Country (UPV/EHU)
-**Cristina Pizarro-Irizar,** Department of Economics, University of the Basque Country (UPV/EHU) & Basque Centre for Climate Change (BC3)

Overview

Power Purchase Agreements, often abbreviated as PPAs, are long-term contracts established between an electricity generator and a buyer. Utilities have been the traditional signatories of these contracts, but they are now increasingly popular among electricity-intensive industries and corporations. The primary purpose of a PPA is to lock in a negotiated price for electricity, providing stability and predictability in a volatile energy market.

Currently, some companies within specific industries opt to sign a PPA with a supplier, while many others have not yet done so. The decision to enter into a long-term agreement with an electricity supplier is a strategic process involving a range of complex factors. Companies evaluate the costs associated with procuring energy through a PPA compared to acquiring it from the spot market, where both renewable and non-renewable sources are available. Financial considerations play a crucial role. Firms must assess the long-term financial advantages, including stable energy prices and risk mitigation against market fluctuations. Simultaneously, environmental responsibility may significantly influence their decision, as adopting PPAs can enhance a company's reputation and foster positive stakeholder relationships, especially in sectors where sustainability is a key differentiating element.

In addition to financial considerations and environmental responsibility, in industries characterized by oligopolies, where electricity expenses make up a substantial portion of their variable operating or production costs, whether to enter a PPA becomes strategic. These companies regularly encounter challenges associated with energy price volatility, which injects uncertainty into their operations and profit margins. Yet, the impact of committing to a long-term contract with their electricity supplier is more nuanced. When electricity prices rise, having a PPA can provide a competitive advantage over competitors with no long-term contract secured. This advantage arises from the stability of energy costs, enabling these companies to operate with more predictable and steady profit margins, thus bolstering their competitiveness. However, during periods of low electricity prices, companies with PPAs may experience higher energy costs than competitors without long-term contracts. This situation presents challenges as their competitors can capitalize on lower production costs, potentially affecting their market position.

The market for PPAs is evolving, and academic research has delved into the economic and political implications of the PPAs. In particular, several authors have explored the role of long-term contracts in scenarios where competing companies grapple with significant variable costs (Allaz and Vila 1993; Cohen and Agrawal 1999; van Eijkel and Moraga-González 2010; Sun and Xiang 2011; Ledvina and Sircar 2012; Teixeira 2014). More recently, Fabra (2023) analyzed the role of PPAs in the European Commission's proposal to reform electricity markets.

We contribute with a game-theoretic analysis of the strategic interaction among firms that belong to an electricity-intensive oligopoly regarding the decision of whether to sign a long-term contract with electricity suppliers at a fair price. In this context, we analyze the equilibrium outcomes for different numbers of competing firms.

Our results show that, under certain assumptions, in an oligopoly composed of n risk-neutral or moderately risk-averse firms, no more than half of the competing firms sign a PPA in equilibrium. This outcome may seem paradoxical, as a risk-neutral agent is, in principle, indifferent between buying insurance at a fair price or not. However, the strategic interaction between rival firms makes most of them thrive in an uncertain cost environment. This result points to a possible strategic reason why some companies in electricity-intensive sectors have not signed a PPA to hedge their operational costs. Given the regulator's current willingness to implement these agreements (European Commission 2023), our results may have relevant policy implications.

Methods

We examine how strategic interaction modulates the positive convexity effect of electricity price uncertainty. Even though we consider firms that are symmetric ex-ante, we present the Cournot solution with asymmetric costs, which allows us to consider the case where one of the firms has a long-term contract with a given cost, whereas the other, is subject to the uncertain spot market prices for electricity (X). We model this spot price as a stochastic process. In each period t, the random variable X is described by a cumulative distribution function F(x). Production costs are assumed to be linear.

Firms can sign a contract with a supplier that guarantees a fixed unit cost c for T periods. We assume this contract is priced at the expected electricity price in the spot market. Therefore, the fixed value c is such that the net present value (NPV) at t=0 of the stream of expected costs in the spot market over a horizon of T periods is equal to the NPV of a constant stream of cost c.

To focus on cost uncertainty, market demand p(q) is assumed to be deterministic and constant over time, and we present the case of a linear demand p(q)=a-bq, with a>0 and b>0. We assume that the support of the distribution of X is a subset of $[0, a)$ and that the firms are risk-neutral.

Assume that in a market with n symmetric firms, a subset of ns firms $(0 \leq n_s \leq n)$ is committed to a long-term contract with suppliers, while the remaining $n - n_s$ firms must decide whether to purchase the electricity in the spot market or to sign a long-term agreement with the supplier. We compute the solutions for each firm's optimization problem and solve all subgames depending on whether firms have signed a long-term contract.

Results

In this section, we briefly outline the main results of our study for different numbers of competing firms.

Monopoly (n=1): A risk-neutral, or moderately risk-averse, monopolist strictly prefers not to sign a long-term contract. Usually, a risk-neutral agent would be indifferent between buying insurance at a fair price or not buying. However, in the case of a risk-neutral monopolist, the objective function is convex in the cost parameter, and therefore, the monopolist benefits from cost variability.

Duopoly (n=2): If the rival firm signs a long-term contract, not signing a contract is the best response. If the rival firm does not sign a contract, then, depending on the distribution of X, there either are one or three Nash equilibria; if cost uncertainty cannot drive any of the firms out of the market, there are three equilibria: only one firm signs a long-term contract, or none does. In contrast, when cost uncertainty may drive any of the firms out of the market, not signing a contract is a dominant strategy for any of the firms.

Oligopoly (n>2): There is an equilibrium in which n_s firms (where $0 \leq n_s \leq n/2$) sign and $n - n_s$ firms do not sign the long-term agreement. Under conditions for the distribution F, there are multiple equilibria with fewer signatories than n_s. Multiple equilibria appear when the n_s firms are indifferent between signing the agreement or not.

Conclusions

We present a game-theoretic analysis of the strategic interactions among firms in an electricity-intensive oligopoly when deciding whether to enter into long-term contracts with electricity suppliers (i.e., PPAs). Within this framework, we examine the equilibrium outcomes for varying numbers of competing firms and establish equilibrium conditions for each scenario. Our findings reveal that subject to specific assumptions, in an oligopoly consisting of either risk-neutral or moderately risk-averse firms, the equilibrium outcome involves no more than half of the competing firms opting to sign a long-term electricity contract. This outcome might appear paradoxical, as risk-neutral entities should, in theory, be indifferent between buying insurance at a fair price or not. However, the strategic rivalry among firms causes them to thrive in an environment characterized by uncertain costs for most of the firms. This observation may mirror the existing situation in certain industries, where some companies have refrained from adopting PPAs to hedge their operational expenses. Given the regulator's current push for the implementation of these agreements, our results could have significant policy implications.

References

- Allaz, B., & Vila, J. L. (1993). Cournot competition, forward markets and efficiency. Journal of Economic theory, 59(1), 1-16.
- Cohen, M. A., & Agrawal, N. (1999). An analytical comparison of long and short term contracts. IIE transactions, 31(8), 783-796.
- European Commission, 2023. Electricity market design revision: Proposal to amend the electricity market design rules.
- Fabra, N. (2023). Reforming European electricity markets: Lessons from the energy crisis. Energy Economics, 126, 106963.
- Ledvina, A., & Sircar, R. (2012). Oligopoly games under asymmetric costs and an application to energy production. Mathematics and Financial Economics, 6, 261-293.
- Sun, G., & Xiang, T. (2011). The strategic motivation for long term contract and oligopolistic collusion: Explanation on iron ore benchmark price mechanism. In 2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC) (pp. 6003-6008). IEEE.
- Teixeira, J. C. (2014). Outsourcing with long term contracts: capital structure and product market competition effects. Review of Quantitative Finance and Accounting, 42, 327-356.
- van Eijkel, R., & Moraga-González, J. L. (2010). Do Firms Sell Forward Contracts for Strategic Reasons? An Application to the Dutch Wholesale Market for Natural Gas. In ESE Business School Working Paper No. 864.