Gas Games with Electricity

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Overview

Should policy makers be concerned when firms with market power in natural gas simultaneously generate electricity? One concern is that a higher price of natural gas (hereafter referred to as simply "gas"), raises the cost of gas-fired electricity generation, and is passed through to the electricity price. It is therefore possible that a large gas firm could increase its electricity profit by raising the gas price, if it generates electricity from non-gas-fired infra-marginal plants. This is an example of profiting by raising rivals' costs, as first identified in a general form by Salop and Scheffman (1983). A second concern arises when gas firms generate gas-fired electricity. When electricity and gas markets differ in terms of their timing and variability, this can create the type of adverse selection identified in theoretical work by Vives (2011). I present the first empirical evidence of this problem.

Before drawing policy conclusions, it is important to understand the the behavior of firms operating in both gas and electricity markets. To do this, I follow pioneering theoretical work by Vives (2011), and use a Bayesian supply function equilibrium (SFE) model with asymmetric information. I adapt this model to study the eastern Australian energy markets. To my knowledge, this application is the first empirical estimation of this type of model. I find evidence that both adverse selection and the incentive to raise rivals' costs are a concern, though adverse selection is more important in Australia's case.

In eastern Australia, retail markets for both gas and electricity have been deregulated and opened to competition. To support this deregulation, Australia, like many countries, has auction mechanisms for trading spot electricity. Uniquely, it also uses daily uniform-price auctions facilitate trade in wholesale gas. The fact that a market operator runs auctions for both electricity and gas gives a unique opportunity to study the links between the two markets. Each day, the market operator runs four separate gas auctions, in physical hubs based around the large cities. Bids take the form of supply schedules. Since 2018, these auctions have covered 55 to 60 percent of domestic gas use in eastern Australia. I focus on the largest gas hub, which covers all gas flows in the state of Victoria, including Melbourne. Three large companies dominate the gas auctions, supplying 75 to 50 percent of gas injections in Victoria. These same three companies also own electricity generation plants, fueled by gas, coal and renewable energy, amounting to almost 50 percent of total dispatchable capacity. The firms are vertically integrated, in the sense that they have retail arms for both gas and electricity

Methods

I contribute to the literature by estimating a theoretical model first proposed by Vives (2011), and later extended by Bergemann, Heumann, and Morris (2021). This theoretical work derives a unique SFE in which large firms compete by choosing supply functions. They do not know their costs before doing so, but receive private noisy signals about their own costs. Costs are correlated across bidders. I adapt this model to describe bidding behavior in Australia's gas auctions, paying particular attention to how electricity sales affect incentives. It is apt because firms do not know the electricity market outcomes before submitting their gas bids, and these outcomes are positively correlated across firms. Further, the three large firms are likely to have asymmetric information since they are better-informed about their own generation than that of their rivals.

Before estimating the model, I must construct key variables outside it. I require daily forecasts of firms' gas-fired generation to assess the importance of adverse selection; and each firms' net spot electricity sales to quantify incentives to raise rival's electricity costs. With this information, and detailed bidding data, I estimate the remaining cost and information parameters in the structural model, using necessary conditions for optimal bidding. Then, I use counterfactual analysis to disentangle the two channels through which electricity sales affect gas bidding, and to measure their impact.

Results and conclusions

Adverse Selection

I find that adverse selection is a problem in the Australian gas auctions. When firms submit bids to supply the gas hub, they do not yet know how much gas they will need for electricity. This is because the gas market is cleared ahead of time, with the bids and outcomes covering a full 24 hours, while the electricity auction is settled close to real time. However, the more gas a firm uses for gas-fired generation, the higher its marginal cost of supplying the gas hub. When designing its gas bids, the firm can use public and private information to forecast its daily gas-fired generation, but it can also use information contained in the gas price itself. A high realized gas price indicates that the firm's rivals anticipate using a lot of gas for electricity that day. In this case, the firm itself is also likely to have high gas-fired generation, since this is positively correlated across the firms. That is, a high gas price informs the firm that it will likely have a high marginal cost of supplying the gas hub. In response, at higher prices, the firm offers smaller quantities to the hub than it otherwise would.

Thus, firms bid by submitting steeper supply schedules than otherwise, and, in equilibrium, trade smaller volumes in the daily gas auctions. This is counter to the intended purpose of the markets – which is to promote spot trade of wholesale gas, so that gas is delivered to the hub at lowest cost. I find evidence that gains from trade are left on the table every day, lowering the trade surplus by an estimated 10 per cent on average. To reduce adverse selection, policy-makers should take steps to improve the information that firms have about electricity outcomes before they submit their gas supply bids. One possibility is to make public electricity forecasts more accurate, although this may not be feasible. Another possibility is to increase the frequency with which the gas auctions are cleared, so that firms can gather more information about their electricity generation before committing to gas supply bids. A naive policy response of requiring firms to divest gas-fired electricity generation would do little to alleviate adverse selection. The information problem would remain as long as the firms supply gas to any power plant, even if they do not own the plant themselves.

Raising Rivals Costs

The incentive to raise rivals' electricity costs is also a potential concern. I show that the spot gas price is passed through to the spot electricity price, whenever a gas-fired generator is setting the electricity price. While a higher gas price would increase a firm's own gas-fired generation costs, the resulting higher electricity price means that its other infra-marginal generation types (coal and renewables) would earn additional revenue without the cost increase. A firm's incentive to raise rivals' costs is larger the more electricity it sells in the spot market, and the more often a gas-fired generator sets the electricity price. Net buyers of electricity have the opposite incentive: to lower the gas and electricity prices. I find evidence that Australian firms both recognize and act on the incentive to raise rivals electricity costs. However, this has only raised the daily gas price by an estimated 0.8 per cent on average. The incentive to raise rivals costs is small in Australia because the large firms tend to make only small net sales (or purchases) in the spot electricity market, due to their retail sales and forward contracts. However, given the evidence that firms act on this incentive, it may be of concern in other markets where there is limited vertical integration between generation and retail, and where firms sell greater volumes of electricity in the spot market. If policy makers wished to address this issue, they could require glass walls between the electricity and gas traders at each company, or require gas firms to divest their non-gas-fired electricity plants. However, the impact of such polices on the Australian gas market would be small.