

# Empirical Analysis of Price-Elastic Demand with Forward Contracting in Electricity Market<sup>\*</sup>

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## (1) Overview:

The ongoing deregulation of electricity industries worldwide has been predicated on the theory that creating markets will improve economic efficiency. By providing price signals to both consumers and producers, more timely capacity investment decisions could be taken, which would lead to lower average prices in the long run. However, since the resulting markets for electricity would not be perfectly competitive, the use of forward contracts has been proposed to blunt the exercise of market power by generators. We first generalize the Allaz-Vila model, which shows the presence of forward markets for a durable good enhances economic efficiency, to an arbitrary number of firms and degree of price response. Then, we test how forward trading and price elasticity interact and the extent to which each policy measure is a more effective tool for improving efficiency.

## (2) Methods:

We first expand the Allaz-Vila framework for analysing the strategic effect of forward markets in an oligopolistic industry by allowing for a finite number of firms and an arbitrary level of price elasticity. This then enables us to test the following theoretical results empirically using data from the 2004 (January to October, inclusive) operation of the Singapore electricity market, which incorporated forward contracting as of that year:

1. level of the optimal forward contract cover
2. predicted median spot price

By comparing these two results with the observed quantities, we are able to confirm that the generalised Allaz-Vila model is reasonably good at capturing the characteristics of oligopolistic markets with forward contracting. Next, we determine theoretically what the counterfactual median predicted price would have been in the absence of forward contracting. According to the model, it would be about 50% higher than the median predicted price with forward contracting. In order to explore the tradeoff between forward contracting and price response, we then calculate how much of an increase in price response is required without contract cover in order to decrease the median predicted price to the same level as that with forward contracting but with less price response. We find that the price elasticity would have to be doubled in magnitude in order to match the lower median predicted price obtained with forward contracting.

## (3) Results:

First, we have made an incremental, but necessary, generalisation of the Allaz-Vila model to account for an arbitrary number of firms and level of price elasticity. This enables us to explore the properties of Cournot equilibria for any set of parameters given constant marginal costs. Next, using the two-stage least squares (TSLS) regression analysis, we estimate the level of price elasticity for Singapore. At  $-0.009498$ , it is relatively low, which may be due to

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the constant year-round demand for cooling. By using these two parts together, we are able to obtain the following insights about the Singapore electricity market for the year 2004:

1. Due to the concentration of generation ownership, there are effectively 3.76 identical firms in the Singapore market, which we round up to 4.
2. The median optimal contract cover is 66.43%, which is quite close to the actual level of 65%.
3. The median predicted price is S\$60.51/MWh, which is less than the actual median price for the period studied, S\$79.31/MWh.
4. If there were no contract cover, then the median predicted price under the current market structure and level of price elasticity would be S\$89.94/MWh. Since the model's estimate of the predicted price with contract cover was smaller than the actual median price, we would expect the actual median price in Singapore without contract cover to be higher than S\$89.94/MWh.
5. In order to reduce the median predicted price without contract cover to the median predicted price with contract cover, we require a near doubling (in magnitude) of the price elasticity to  $-0.0199$ .

#### **(4) Conclusion:**

Using data from Singapore for the year 2004, we find that forward contracting has kept actual median electricity prices lower than what they would have been without contracts. Furthermore, if there were no forward contracts, then the demand for electricity would have to be almost twice as responsive to the price in order to offset the resulting increase in price from market power. From the results, we conclude that Singaporean regulators have set the level of contract cover nearly optimally. Indeed, in order to keep prices close to the competitive benchmark level of S\$68.50/MWh without any forward contracting, they would have to increase price elasticity substantially. This would involve more profound reforms, such as the installation of distributed generation (DG) and the implementation of real-time controls to adjust electricity consumption, the effects of which may not be easy to gauge. Nevertheless, as forward contracting and price response work together to check market power, it would be advisable in the long term to proceed with measures to enable more effective price response by consumers, especially large industrial ones.

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