By studying average variable costs, researchers examining the California energy crisis were sure to find examples of "market power" even if that power may not have really existed.

Mismeasuring Electricity Market Power

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OPENING WHOLESALE ELECTRICITY markets, in which energy is purchased for subsequent delivery to those who use it, has been accompanied by concerns that such markets fail to be competitive. The California electricity market "meltdown" in the summer of 2000 brought with it numerous accusations of inadequate competition and analyses of the role that it may have played in creating price spikes and destabilizing the market.

Some theoretical models do suggest that electricity markets may be unusually susceptible to the exercise of market power, particularly at peak demand periods, compared to markets for other goods with similar structural characteristics. However, the approach taken in most empirical analyses of market power in electricity rests on a flawed application of a standard measure of market power — the fraction of a good's price exceeding its marginal production cost (known as the Lerner index or the price-cost margin). The rationale for using price-cost margins is essentially that, in a competitive market, price-taking firms will supply output up to the point where the marginal cost of production just equals the market price. A substantial difference between price and marginal cost indicates that firms are not taking price as given.

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In a nutshell, the flaw in those electricity market studies is not that the price-cost margin is theoretically inappropriate, but that it is inappropriately implemented. The proxy for "marginal cost" used to estimate price-cost margins is typically the average variable or operating cost of the last or marginal generator that would be dispatched to meet energy demand. Let us call this the PAVC test, for "price-average variable cost," recognizing throughout that we are referring to the AVC of the "last" unit.

The need to recover fixed costs can lead to prices substantially above average variable costs in peak periods. Real-world "noise" in the form of uncertainty regarding demand and supply shocks (e.g., unanticipated hot weather, generator outages) could lead to patterns of market bids that fail the PAVC test without necessarily indicating market power. Unless one posits that we have an overbuilt industry (in the sense that the peak plants are destined to lose money), peak plants are going to earn capacity rents in a well-functioning, competitive market.

WHY THE MISMEASURMENT MATTERS

Erroneous use of price-cost margins to measure market power is not merely an academic issue. Under a PAVC standard for competitive pricing, no generator would be built; in any market, competitive or not, even the most expensive "marginal" generator has to expect that prices will, on average, cover not just its variable costs but also its fixed capital costs. If not, it would find entry unprofitable.

Such measures may already be leading regulators to prevent sales of electricity above the highest average variable cost of gen-

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erators used to provide electricity. The Federal Energy Regulatory Commission, in an order issued in June 2001, has used the "highest average variable costs" standard in setting its wholesale price cap, explicitly saying that it will not allow higher prices so that firms can earn capacity rents.

Under such a policy, in the long run no firm would build a peaking plant. Keeping marginal firms from earning revenues in excess of their average variable costs would encourage present suppliers to leave the market and discourage entry needed to provide power during peak hours of use. Without such entry, electricity restructuring will be more likely to fail. Moreover, through a kind of "domino effect," no firm would enter the industry at all, if the firm with the highest operating cost were not allowed to recover its capital expense.

Flawed methods for ascertaining market power do not imply that the means and motivation for setting prices above competitive levels are absent. Findings of flaws in the way in which market power is measured could lead policymakers to reject inappropriately the possibility that such power may yet be present. A better method for ascertaining the extent of market power in electricity would be to focus on withholding of supply directly rather than prices.

ILLUSTRATING THE PRINCIPLE: HOTEL ROOMS

To get a feel for the flaw in the PAVC test, consider a more familiar industry: resort hotels. Imagine that, in a seaside town, the optimal size for a hotel is 100 rooms. Once built, it costs $50 a day to maintain a room, including cleaning, electricity, water, and predictable wear and tear from usage. The fixed annual capital costs for the hotel are $1,095,000 per year ($30 per day per room, for 365 days and 100 rooms). There is no relevant restriction on entry, i.e., if one thinks that one can profitably operate a 100-room hotel in this town, one can build it. To make the example simple, we assume that the firms are acting competitively, i.e., take the going room rate as given when making decisions on whether to build a new hotel.

Suppose first that demand to use the resort is roughly the same all year round. In that case, hotels will enter the market up to the point where the price of a room is $80 per day. Some $50 of that $80 covers the cost of maintaining a room — the average variable cost. The remaining $30 goes to cover the capital cost of the hotel. At prices above $80, more hotels would be built. If price were forecast to be below $80, say $50, no one would enter. The PAVC test would fail to predict competitive prices in the market.

Seasonal pricing Next, imagine that demand for hotel rooms at this resort town is seasonal. For three months out of the year, people really want to go to the beach; the rest of the time, demand for rooms is weak. In such a situation, a decision to build a new hotel will be predicated on filling it up during the summer season. Accordingly, the price of hotels in the summer will be $170 per day. Again, $50 of that rate is the average variable cost, with $120 going toward fixed costs.

Because every hotel (not just hotels constructed to handle the summer surge) rents its rooms at the higher rate during the summer, they all will capture their capital costs at that time. The price of a room off-season would then be only $50. The PAVC standard would correctly predict off-peak rates, but would fail on peak, setting the price at $50 when the competitive rate would be $170. Holding hotels to a PAVC standard would mean not only that none would be built to serve summer visitors to the resort, but it would also imply that year-round hotels would be unable to recover their capital costs.

> Keeping marginal plants from earning revenues in excess of average variable costs would discourage firms from building much-needed peaking plants.

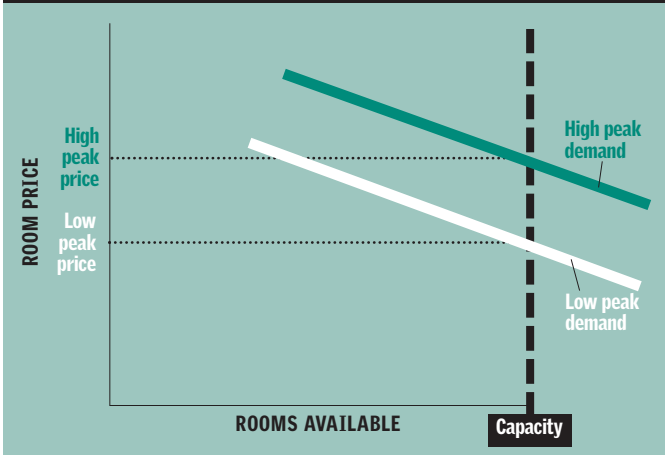
Real-world complications make PAVC-based price tests even worse. Over the life of a hotel, demand during peak periods will vary. During some peak times, demand will be high; during some it will be low, yet output (the quantity of hotel rooms) would be the same in both situations, as illustrated in Figure 1.

Thus, peak period price can vary with demand, even if firms are price takers. Yet, because output remains fixed, a PAVC-based measure (or any other output-based measure of cost that one

FIGURE 1

Vacation Season

The pricing of hotel rooms both on- and off-season.



might want to use) would remain constant. Measures of market power based on comparisons between price and a static output-based proxy for marginal cost will vary even if the underlying degree of competition remains unchanged. A measure that varies when the property it is supposed to measure does not is inherently suspect; hence, it is time to look for a new yardstick.

The PAVC test could be relevant if interest in visiting the resort fell dramatically after hotels were already built. Hotels would compete through reduced prices until they were full at a rate below $170, or prices fell to the average variable cost of $50. If the market had large amounts of excess capacity, defined in terms of the long-run unprofitability of a new entrant, the PAVC standard might apply. But expecting excess capacity in hotels (or electricity) as a permanent feature would be unrealistic.

BACK TO ELECTRICITY

Peak-load pricing principles that hold for hotels hold for electricity as well. Before getting to some important complications, imagine there is only one kind of electricity generator with 100 megawatts of capacity and average variable costs of $30 per megawatt-hour (MWh). Suppose also that of the 8,760 hours in a year, demand is at peak for 450 hours, about two percent of the time. The fixed annualized costs of building and maintaining the generator is $7.65 million, a figure chosen to come out to $170 per MW per peak hour. (That is also about 30 percent of the total variable cost of running a plant at full capacity.) For simplicity, again, assume that capacity exceeds the amount of electricity demanded off-peak at $30 per MWh.

Using the hotel analogy, the price of electricity would be $30 per MWh off peak and $200 per MWh ($30 + $170) on peak. Assume that during peak periods the demand for power at the peak price would be 6,000 MWh and that the industry has just enough capacity to meet that demand. Plotting the predicted price of electricity and average variable cost as a function of power demanded would produce a graph like the one shown in Figure 2.

The lower dotted line indicates average variable cost at $30 per MWh; the small white dots along that line and the large dot at $200 per MWh at 6,000 MWh supplied constitute the predicted supply curve.

Complications During peak periods, price will be substantially above the average variable cost of the marginal generating unit. To get a more realistic view of the competitive supply curve, a number of significant complications should be recognized:

First, because of the difficulty of recovering large capital costs during only short periods of operation, a generator operated only at peak periods would have relatively lower fixed and higher variable costs than a unit operated all the time. With higher variable cost plants brought on-line during peak periods, one might expect the average variable cost curve to slope upward to some extent as one approaches overall industry capacity.

Second, the industry's capacity could be exhausted at different levels of demand, producing price-quantity points filling in the vertical line at the capacity level of output (between $30 per MWh and $200 per MWh). Extra profits in those "shoulder" demand periods would induce entry, reducing the maximum peak price. In the other direction, super-peak demand reached in fewer than five percent of all hours would increase the maximum observed price. In any event, the observed supply curve would tend to have a vertical component as well as a horizontal one, forming a backward "L" shape.

Third, prices will have to exceed not just average variable costs, but produce enough revenue to cover start-up and shutdown costs before a generator will go online. When those, along with revenues from sales of "ancillary services" that maintain grid reliability, are factored into profitability estimates, deciding whether a plant is profitable enough to operate at a seemingly high price is not easy.

FIGURE 2

Price and Power

The price and quantity of power at peak demand.

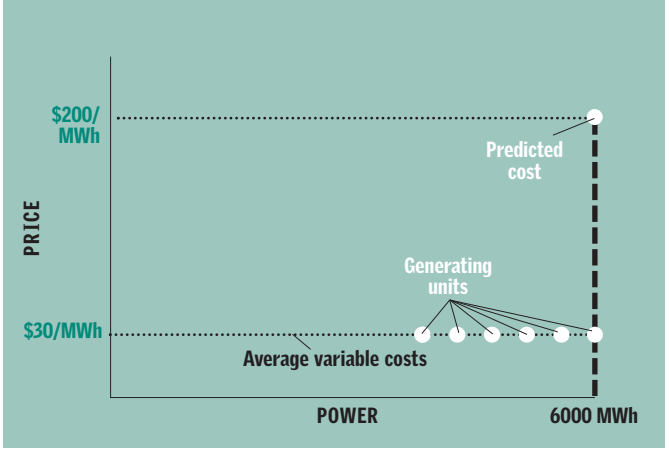
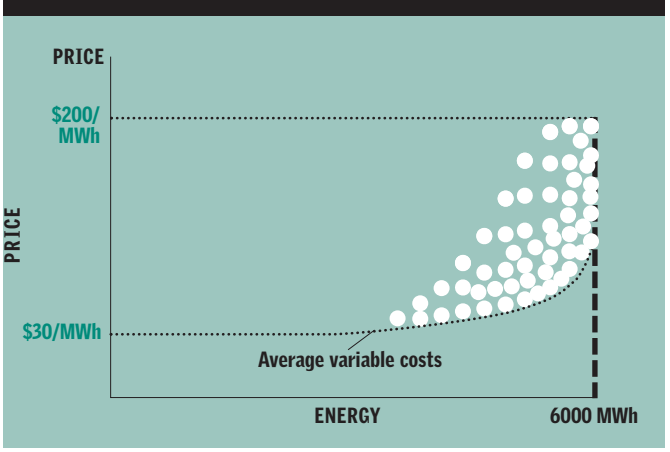


FIGURE 3

More Complex World

The price and quantity of power under assumptions more similar to the real world.



Fourth, generators will face uncertainty regarding predicted demand, the price of electricity in distant markets, transmission capacity, and whether competitors' generators will be unavailable because of scheduled maintenance or unforeseen shutdowns. In the California situation, prices also have been inflated by the prospect that bankrupt distribution utilities would not honor their promises to pay for wholesale energy. Generators may guess that price may be above variable cost at times when actual supply ends up below the full industry capacity. That will tend to "fill in" the backwards L with observed quantity-price data points. One would expect greater density of data points toward the boundaries of the backwards L.

Putting those together would give an observed set of quantity-price data points and an AVC graph that looks something like Figure 3. Of course, the dotted area of price and quantity observations does not represent a precise prediction of prices and outputs we would observe. However, the economics of peak-load pricing with a bit of real-world noise could produce patterns like those observed in the studies described above, without necessarily any exercise of market power.

RESPONSES AND REJOINDERS

One objection to this argument is that rates need not be set to recover capacity costs of the last generator. According to this view, generation companies own a portfolio of plants. In its aforementioned order, FERC stated, "Amounts earned on the more efficient plants [owned by a generation company] will cover the investment in the marginal plant." But that leaves unanswered why such a company would build and operate the marginal peaking plant. That company would have higher overall profits if it did not build such a plant, if it would not expect to recover that peaking unit's capital costs.

Another challenge might be that capital costs could be recovered in a separate capacity market. If so, one needs to describe such a market. The returns from any such sales would then need to be factored in to determine whether the marginal plant is making excessive profits because prices are too high. PAVC-based studies do not incorporate such an analysis.

Even if capital costs were trivial and one would not need rents to cover them, capacity constraints would bind during the time it takes to build the plants, producing scarcity rents until new plants are built. But the existence of scarcity rents would not imply anticompetitive conduct or effect. Again, the question should not be whether prices are higher than they would be if plants could be built instantaneously, but whether suppliers are withholding output to make the prices go even higher.

In some parts of the country, the generation sector could be overbuilt, in the sense that the marginal plant is expected to lose money over the long term. If so, variable costs are likely to determine price even at peak periods, and the PAVC test would be appropriate. But the excess-capacity justification for the PAVC test is inconsistent with the assumption of inelastic supply that forms the basis for predicting that market power may be exercised in electricity markets on peak. If excess capacity exists because of regulatory or reliability requirements, the price of electricity would include implicit payments for that capacity over and above what is needed to cover average variable costs.

> If the revenue from a marginal peaking plant does not cover that plant's fixed and variable costs, why would a power company build and operate the plant?

QUANTITY-BASED EMPIRICAL APPROACHES

Some defend price-cost studies, at least in part, on the basis that critics have not suggested alternative tests for market power. But there are better alternative tests, focusing not on prices but on output, i.e., withholding. One should seek to identify generation capacity that would have been profitable to run at prevailing market prices but was withheld from sale.

Econometric analyses may offer some insight. Increased profits achieved by withholding output accrue not just to the withholder, but also to all electricity suppliers. All else equal, a power producer is more likely to withhold capacity if it has a greater share of overall capacity because it will capture more of the profits from restricting output. If output is being withheld to exercise market power, one should observe a disproportionate number of "maintenance shutdowns" among producers with larger market shares. A simple measure of concentration (e.g., the Herfindahl-Hirschmann Index, or HHI) of outages would thus exceed the measure of concentration of capacity as a whole. Were one to regress the likelihood of outages on firm characteristics, the coefficient of a term relating to market share should significantly exceed one if strategic withholding is going on.

A better tactic might be to examine output decisions directly. Few industries offer the level of firm-specific cost and output data available for electricity generation. If those data are reliable, one should not have to resort to econometrics to infer market power. If anticompetitive withholding is occurring, the regulator ought to be able to "name names," i.e., to identify those generators that have withheld electricity that otherwise

would have been profitable to produce if the generator were taking prices as given. Regulators could investigate specific incidents of peak-period maintenance to see if the output reductions were warranted.

To meet an appropriate legal burden before enforcing any policies or punishments, one should evaluate other explanations for alleged withholding. Whether one employs econometric techniques or analyzes specific supply decisions made by electricity suppliers, output data will not be free from ambiguity. Generators frequently need to be taken offline for maintenance purposes and, as noted earlier, costs of starting up and shutting down units may make generation companies less willing to operate than might seem immediately profitable. Some industry analysts have noted that firms may end up holding capacity in reserve against outages, and such capacity may remain unsold even during a price spike.

Without careful evaluation, regulators could end up imposing possibly unwarranted mandatory supply requirements on generators. FERC's 2001 order that generators in the western United States "must offer" unscheduled nonhydroelectric capacity unless committed to maintain minimum operating reserves could prove to be a relevant example. But output-based approaches remain theoretically better than price-based approaches and are at least as practical.

CONCLUSION

Criticism of the competitiveness of wholesale generation markets is widespread. Most of those critiques are based on comparisons of prices to the average variable cost of the marginal generator. Even in a competitive electricity market, one would expect to see prices substantially above average variable cost during peak demand periods. Variation in demand, increasing average variable cost curves, and, particularly, uncertainty among generators regarding market demand and supplies from their competitors can give price-cost data patterns not unlike those some analyses use to support claims that the industry is not behaving competitively.

That said, low supply and demand elasticities for electricity, particularly at peak periods, support some prior concern that generation markets may not be competitive. Better tests for market power would look to quantities rather than prices, e.g., by seeing if firms with larger market shares are disproportionately more likely to have outages. Perhaps the best test, given the data available, would be for regulators to identify directly the suppliers that do not seem to be generating nominally profitable electricity, and then see if any excuses for apparent withholding are sound. If regulators attempt to set prices equal to a measure of costs that does not allow firms to earn rents sufficient to cover fixed costs, entry will be discouraged and competition subverted.

Finally, a philosophical observation: Different approaches may arise out of different interpretations of what "market power" involves. From the neoclassical perspective, questions about market power are about looking for efficiency losses, which fundamentally follow not from higher prices per se but from reduced output. By that criterion, "market power" is fundamentally about withholding. A less neoclassical perspective may focus on the distributive effect of higher prices.

To the extent that one cares about distributive effects, one might be drawn more to price than to output. If demand for wholesale power is perfectly inelastic, e.g., because retail prices are fixed by regulation (as was the case in California), one could observe higher prices without the output reductions characteristic of the exercise of market power. I would include "price but no output reduction" effects as questions of "market design" or "gaming the auction," but not "market power" — a term properly reserved for reductions in supply in order to raise prices and profits. To the extent that one combines high prices and withholding output under the "market power" heading, one might be drawn to price-based tests for market power. Unfortunately, those tests may not help determine whether market power has in fact been exercised. R

READINGS

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