RESEARCH INSTITUTE OF
INDUSTRIAL ECONOMICS

Economics research digest

News in English from IFN • no 1 • 2014

Market power reduces incentives to invest in nuclear power

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The debate about nuclear power focuses mostly on safety, environmental costs for nuclear waste and climate benefits due to reduced carbon emissions. A further potentially important aspect is the consequences associated with the concentrated ownership structure of Nordic electricity plants, including the Swedish nuclear power plants. In this article, Sven-Olof Fridolfsson examines the contested issue of whether market power may lead to underinvestment in nuclear power.

In the Nordic countries about half of the electricity production originates from the five largest electricity producers. In addition, the three largest Swedish producers own large portfolios of hydroelectric plants and jointly own the three Swedish nuclear power plants. Ownership concentration raises many questions about producers' production and investment incentives, particularly so in deregulated electricity markets. One of the reasons that many electricity markets have been and remain regulated is the risk that companies have the ability and incentive to exercise market power. That is, they may limit the production of electricity in order to sustain a high price. Against this background, it is noteworthy that such a behavior is rarely discussed in the context of nuclear power.

There is reason to believe that for nuclear power companies the incentives to exercise market power are weaker than for other electricity producers because the variable cost of nuclear power production is usually lower than for other power plants. A utility company that owns both nuclear power plants and other power sources will therefore in the short run, for a given installed capacity, first reduce the production of these other more costly power sources. However, this does not mean that market power necessarily is irrelevant when it comes to nuclear power as the incentives to invest may be weakened.

The issue whether nuclear power is under-utilized due to market power is especially interesting in a Swedish context for two reasons. Firstly , Swedish nuclear power plants have historically had low capacity utilization in comparison with Finnish plants. Market power may explain this as the large Swedish electricity producers, on top of nuclear power, primarily own hydropower with comparatively lower variable costs. Secondly, existing nuclear plants are planned to be decommissioned in 10-15 years. Therefore electricity consumption must be reduced or else these older nuclear power plants must be replaced, either by new nuclear or other power sources. The consequent investment need raises the question whether there is a risk of underinvestment due to long-run market power.

Capacity utilization and short-term market power

Several factors make electricity markets especially vulnerable to market power (Joskow 2008) : a few large companies often control the greater part of the production capacity, demand is price inelastic and bottlenecks in the transmission grid give rise to the dominance of local producers. There is also empirical evidence that power producers have exercised market power across a spectrum of deregulated markets (see Wolfram 1999, Borenstein, Bushnell and Wolak 2002 and Wolak 2003). The evidence primarily concerns coal and gas, however, because these studies presume that nuclear power plants operate at full capacity and thus are not used to exercise market power. But is this assumption justified?

Capacity utilization in the U.S. nuclear power industry

A recent study by Davis and Wolfram (2012) highlights the importance of competition. They examine how the recent wave of deregulations in U.S. electricity sectors affected capacity utilization in nuclear power plants. Before the deregulations, the electricity companies' revenues were determined by more or less strict rate of return regulations. These regulations offered little incentive to operating nuclear power plants efficiently. For example, if a power company replaced cheap nuclear power with electricity from a more expensive source, the rate of return regulations would at least partially compensate for the higher costs.

These weak incentives were one of the reasons for deregulation which exposed the production of electricity to competition, while keeping its transmission and distribution regulated. The vertically integrated power companies were encouraged to sell their power plants, including nuclear, to independent power companies or to unregulated affiliates. The divestments meant the revenues of power plants now depended on the market price for electricity. Because the electricity price almost systematically exceeds the low variable costs of nuclear power plants, their owners got stronger incentives to ensure high capacity.

Over a period of about ten years around 2000, 48 of the 103 U.S. reactors were sold. Davis and Wolfram (2012) in their study use a database reporting monthly capacity utilization in every U.S. reactor from 1970 to 2009. The database also contains information about changes in ownership as well as the reactors' location, manufacturer and type.

The study examines how the divestments affected capacity utilization. It compares how the divested reactors' capacity utilization evolved compared to non-divested reactors of similar age, manufacturer and type. The evolution of the non-divested reactors' capacity utilization is thus used as benchmarks for how the divested reactors' capacity utilization would have evolved in the absence of deregulation.

The chief finding of the study is that following the deregulation and subsequent consolidation in the nuclear industry, capacity utilization substantially increased, mainly through shorter maintenance cycles. It is estimated that capacity utilization increased by 10 percent. This finding is consistent with the view that liberalization strongly incentivized electricity companies to operate their nuclear power plants more efficiently. The study thus provides no evidence that deregulations increase power producers' incentives to exercise market power by underutilizing nuclear power. Still it indicates that capacity utilization is not solely determined by technology, but also by competitive conditions.

Capacity utilization in Sweden

The Nordic countries deregulated their electricity markets in the 1990s. Unlike in the U.S., these changes appear to have had little effect on capacity utilization in nuclear power plants. The reason may be that the Nordic power plants performed efficiently prior to the deregulation. But the capacity utilization in Swedish nuclear power plants has been systematically lower than in Finnish plants. What is causing this difference? Could stronger incentives to exercise market power in the Nordic countries than in the U.S. be a contributing factor?

The low capacity utilization in Swedish nuclear power plants are probably not explained by the reactors' manufacturer, type or age, as the differences between the Swedish and Finnish reactors are too small in these respects. Likewise, neither economies of scale nor the learning effects of running several plants constitute a likely explanation for the high capacity utilization rates in Finland. Olkiluoto, the top performing nuclear plant in the Nordic region, is indeed owned by Scandinavia's smallest operator, Finnish TVO. Other explanations appear more realistic.

One important reason is probably the weak political support for nuclear power in Sweden and the associated uncertainty for its domestic nuclear industry. The owners of Swedish nuclear power have thus had less incentive to ensure high capacity utilization, for example by stockpiling spare parts to shorten maintenance

1) *A potential objection to deregulation is that owners could neglect safety in order to ensure high capacity utilization. This would, however, also increase the likelihood of unplanned and, from the owners' perspective, costly maintenance. A study by Hausman (2013) suggests that there is no conflict between high capacity utilization and safety.*

Photo: Hans Engbers/Mostphoto.

cycles. Many observers, especially in the energy sector, believe that weak political support constitute the most important explanation for the low capacity utilization in the Swedish nuclear power plants.

Thomas Tangerås and I argue in an IFN research paper that market power may have promoted incentives for low capacity utilization (Fridolfsson and Tangerås 2009); cutbacks in nuclear power production may be especially profitable in a system with plentiful hydropower. In order to ensure security of supply, reactors are maintained during the summer when demand and electricity prices are low. Hydro power must then substitute for nuclear power, which reduces the water supply for the winter. Extended stops in nuclear power production in the summer will therefore have a price impact even during the more profitable winter, and may thereby be profitable even though nuclear power has low variable costs. The incentive to exercise market power is also likely to be stronger in Sweden than in Finland, as the Swedish nuclear power plants are owned jointly by the largest electricity producers. In contrast, Finnish nuclear power plants are either owned jointly by Fortum and large consumers, namely energy-intensive industries, or by Fortum alone.

Market power and new investments

As argued above, electricity producers with market power may have an incentive to under-utilize their capacity. Similarly, investors with long run market power may underinvest in new capacity. Because of their very large size, new nuclear reactors may considerably decrease electricity prices and thereby reduce the profitability of already installed capacity. Underinvestment incentives in nuclear power may for this reason be particularly problematic. And yet the literature on risks that market power generates underinvestment in nuclear power is scarce. Several factors probably explain this gap in the literature.

Historically, nuclear power investments have been made in regulated electricity sectors where over- rather than underinvestment has been the problem. For example, it is well known that rate of return regulations such as once applied in the U.S., can generate excessive investment incentives (Averch and Johnson 1962). A growing number of countries, including the Nordic ones, have deregulated their electricity sectors, partly due to the belief that prior regulations distorted investment incentives. Deregulation means that the problem of overinvestment may have been replaced by a risk of underinvestment due to market power.

Another reason for the lack of interest in nuclear power underinvestment is the belief that market power is limited in the long run, as entrants may invest in new capacity and the transmission grid may be expanded. But all entry barriers are not necessarily eliminated in the long run. In Sweden, legal entry barriers may for instance prevent investment. Although the new Swedish law allows investment in new nuclear

power, it stipulates that any new reactor must replace an older one, and must be built on the site of one of the three current nuclear power plants. Since the owners of existing Swedish nuclear power plants also own the land they occupy, the new law in effect delegates the responsibility for investing in new nuclear power plants to the current owners.

Nuclear power's competitiveness

Perhaps the most important reason for the low interest in underinvestment in nuclear power is that many economists (e.g. Davis 2012) question whether nuclear power is competitive at all. If so, the question of investment (and thus underinvestment) in nuclear power is of secondary importance.

Operating nuclear power plants are competitive due to their low variable costs. But the fixed costs of building nuclear power plants are very large and uncertain at the time of investment. The French made reactor being built at the Finnish nuclear power plant Olkiluoto illustrates this well. Construction started in 2005 and the reactor was initially scheduled for completion in 2009 at an estimated construction cost of € 3.2 billion. The construction has been delayed and the latest forecast is that the reactor will be connected to the grid in 2016. Such considerable delays sharply reduce profitability by increasing construction costs and postponing revenues. The most recent prediction is that construction costs will be € 8.5 billion. Although it is unclear what precisely this amount encompasses, the vast increase in cost is certainly striking and suggests the investment may turn out to be unprofitable.

A model to estimate construction costs for nuclear power plants has been developed at the Massachusetts Institute of Technology (MIT). It is used to make rough estimates about what it would cost to build nuclear power plants in the U.S., as well as to compare these costs with those of alternative power sources. The estimates are based mainly on nuclear power plants built in Korea and Japan from 1994 to 2006. The original study (MIT, 2003) has been updated several times to incorporate additional nuclear power plants completed in Korea and Japan (see , for example, MIT 2009 and Du and Parsons 2009) .

Not surprisingly, these studies confirm that construction costs are vital to the profitability of nuclear investments. Du and Parsons (2009) estimate that the construction costs of a nuclear power plant constitute more than 70 percent of its total costs. They also find that the economic viability of nuclear power relative to coal and gas largely depends on whether or not carbon emissions are taxed. The latest update by Davis (2012) suggests that nuclear investments in the United States are no longer viable because shale gas has significantly cut the costs of gas power.

Incentives for nuclear power investment in Sweden

The new Swedish law allowing for investments in new nuclear power plants may against this background appear surprising. However, investments in coal and gas as well as in large hydro plants are today not politically viable in Sweden. And renewable energy such as wind power is, according to Elforsk (2011), more expensive than new nuclear power, at least absent subsidies to renewable electricity and absent taxes on nuclear power. Investment in new nuclear power is thus not entirely inconceivable in Sweden, but presumably construction costs must be limited. And if new nuclear power is profitable, then there is also a risk of underinvestment due to market power.

A profit maximizing power producer with market power takes into account that investments in new capacity lead to reduced electricity prices, which reduce the profitability of existing capacity. This effect may manifest itself in a lack of nuclear power investment, even though nuclear investment would be profitable in a competitive market. In Fridolfsson and Tangerås (2013), we illustrate how market power might erode Vattenfall's incentive to invest in a reactor of the same size as the one under construction in Finland. The investment would increase Vattenfall's production capacity in Sweden by about 18 percent. We assume that this increase in capacity would reduce electricity prices by 2.5 percent. Because electricity demand typically is very price inelastic, this price reduction is probably small as it presumes that Vattenfall's competitors sharply reduce their capacity in response to the investment. The effect on the profitability of Vattenfall's other hydro and nuclear power production is not negligible, however. At a 5 percent interest rate, the present value of the reduced profitability in these plants would exceed 1 billion euros. This loss amounts to almost a third of the planned construction cost of the new Finnish reactor at Olkiluoto, and should be added to the estimate of the power plant's profitability.

Joint ownership of the Swedish nuclear power has long been perceived as problematic, yet so far all attempts to dissolve it have failed. The new Swedish law may appear to cement this ownership structure, as it stipulates that the new reactors must be built on the current nuclear sites, which belong to the current owners. But from a competition law perspective, the land ought to be regarded as essential facilities, not least as it is the law itself that renders the land indispensable. From this point of view the current owners could be

forced to relinquish control of their sites in exchange for a reasonable compensation. The closure of the old Swedish nuclear power plants could thus constitute a unique opportunity for dissolving the current ownership structure and opening up the Nordic electricity market for large scale entry. Which companies should then have the right to build the new plants?

It is likely that the cost of building and running nuclear plants will vary considerably across potential investors. Current owners may have cost advantages stemming from economies of scale in running several plants on the same site, or due to superior knowledge about Swedish regulations or local technical constraints. Entrants, on the other hand, may have greater experience in building modern plants. The problem of determining which companies should build the new power plants is that the government does not know the companies' costs. We therefore propose in Fridolfsson and Tangerås (2013) that the government allocates the right to build new nuclear power plants to the highest bidder in a nuclear capacity auction. This should ensure that the company with the lowest costs will build and operate the new plants.

A potential problem with such an auction is that market power may raise the current owners' willingness to pay. As argued above, long run market power may reduce the willingness to pay of a bidder such as Vattenfall. By imposing a threat of entry, an auction counteracts this reduction in willingness to pay. The relevant alternative to the investment is that an entrant invests, not that an investment fails to take place. The potential problem is rather short run market power. To win the auction, the current owner may be forced to build -- from their perspective -- a nuclear plant that is too large. If so, there is also a risk that they will underutilize the newly built nuclear plant and this possibility increases their willingness to pay. On top of the direct welfare cost stemming from low capacity utilization, one has to add the cost associated with the possibility that the current owners may win the right to build the new nuclear power plant, even though they have higher construction costs.

We therefore propose to combine the auction with an obligation to regularly sell so-called virtual power plant contracts (VPP contracts). A VPP contract is an option giving its holder the right to buy the contracted quantity of electricity at marginal cost. The owners of the new nuclear power plant would then earn their revenues through the sales of the VPP contracts, rather than from the direct sales of electricity. The point is that the production decision is delegated to the holders of VPP contracts lacking market power. And without market power, the willingness to bid for market power also vanishes in the capacity auction.

Photo: Hans Engbers/Mostphoto.

Conclusions

Market power may lead to an inefficient use of nuclear power, both in the short and long run. Short-run market power entails the risk that operating nuclear power plants are underutilized whereas long run market power can result in weak investment incentives. Thomas Tangerås and I propose to mitigate the underinvestment problem by opening up the Swedish electricity market to large scale entry through a nuclear capacity auction allocating the right to build and operate new nuclear power plants. The proposal to force the owners of the new nuclear power plants to sell VPP contracts counteracts potential incentives to underutilize the new nuclear power plants.

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News from IFN:
This newsletter in English is published twice a year.

Economics research digest

Editors: Professor Henrik Horn and Professor Lars Persson. Publisher: Professor Magnus Henrekson.
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