THE WELFARE IMPACT OF STATE ELECTRICITY CAPACITY SUBSIDIES IN PJM

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“...the thought that the lights might go out in Maryland as a result of our actions, or inactions, during our term as Commissioners is one that keeps us awake.”  
--Maryland Public Service Commission (2012)

1. Introduction

Restructured electricity markets have arisen around the world and in numerous states in the US. Restructuring is based upon the conclusion that the generation of electricity is not a natural monopoly and therefore can be opened to market forces. It is also based upon the assumption that political forces will not actively seek to alter the resulting market-clearing prices through direct market intervention.

The assumption of limited political intervention is currently being tested by at least two state governments in the eastern United States: New Jersey and Maryland, which are located in the PJM electricity market. The governments of these states argue that the component of electricity prices that reflects the cost of system reliability—the capacity price—is excessively large and has brought no concomitant investment in new power plants. In spite of evidence to the contrary
presented by PJM, these governments have also voiced concerns over inadequate system reliability and the threat of costly power blackouts.

Based on these concerns, governments in these states are pursuing subsidized investments in base-load generation capacity. New Jersey implemented its Long-term Capacity Agreement Pilot Program (LCAPP) in 2011 to develop of 2,000 MW of new electric generation facilities in the state. Maryland similarly ordered construction of from 650 to 700 MW of baseload generation capacity in 2012. The states assert that these resources will improve system reliability and provide better outcomes for consumers, but it is not clear that these benefits will follow.

Whatever happens, the actions of New Jersey and Maryland affect incentives for competitive supply of generating capacity both in their states and beyond their borders. New Jersey imported 13.5 terawatthours (TWh) out of 79.2 TWh consumed in 2010, while Maryland imported 21.7 TWh out of 65.3 TWh consumed in the same period. The imported electricity is delivered from other states via transmission lines that are often congested. In this paper, we therefore develop a model that accounts for this linkage, as well as the many unique elements of electricity markets. We deploy this model to analyze the implications of subsidized capacity additions for short-run consumer welfare and reliability in the long run. This analysis informs our discussion of the current electricity market policy actions of New Jersey and Maryland and mitigation actions taken by PJM.

To analyze the impact of subsidized government investment in electrical generation on electricity markets in the short and long runs, we extend the model of Joskow and Tirole (2007) to address the interconnected nature of the PJM grid by considering a market with two different locations—an “upstream” exporter and “downstream” importer—connected by transmission lines. We assume that these lines are constrained during peak periods as in Borenstein, Bushnell,
and Stoft (2000). We characterize the Ramsey equilibrium of this model and discuss the role of capacity markets in supporting this optimum. We then analyze the effects of government capacity investments.

We find that subsidized base capacity investments have significant potential for adverse effects on electricity markets. Subsidized investment in baseload capacity is never optimal in our model. In the short run these policies do artificially depress prices, with some benefits for both downstream and upstream consumers, but they do so at the expense of misallocating resources and reducing incentives for peak capacity investment in the long run. Intervention creates expectations of regulatory costs, leading suppliers to invest relatively less at every capacity price. If governments respond to this state of affairs by intervening again, a vicious cycle can arise and government’s perceived need to intervene may become self-fulfilling. PJM’s regulatory response to subsidized capacity investments—the Minimum Offer Price Rule in its capacity markets—may somewhat mitigate this cycle, but it does not restore optimality.

We proceed to show these results as follows. Section 2 of this paper provides background on capacity markets and the debate over direct government interventions. In Section 3, we describe the model of Joskow and Tirole (2007) and extend it to allow for transmission constraints and derive the necessary conditions for efficient outcomes in a competitive market (the Ramsey equilibrium). We analyze the role of capacity markets as an instrument to induce the Ramsey equilibrium and investigate the effects of government generation investments in Section 4. This analysis informs our discussion in Section 5.

2. Background: Capacity Markets and State Capacity Investment Policies

Section omitted for conference proceedings.

The debates over the capacity investments of New Jersey and Maryland raise several related questions: How does the presence of transmission constraints affect the optimal design and function of capacity markets? Does it ever make sense for governments to subsidize capacity, and if so how? Are price floors like the MOPR sufficient for ensuring the optimal functioning of capacity markets? How will markets react to subsidized capacity investments in the short and longer runs?

To provide a more formal framework for analyzing these questions, we extend the competitive electricity market model of Joskow and Tirole (2007) (J&T) to incorporate a transmission constraint and government investment in capacity. Specifically, similar to Borenstein, Bushnell, and Stoft (2000), we assume that the two energy markets in our model are connected via a set of transmission lines with limited capacity. In this section, we confine ourselves to describing the critical characteristics of the J&T model and the implications of transmission constraints for the social optimum and competitive equilibrium. The full model appears in Appendix A.¹

3.1 Competitive Electricity Markets with Transmission Constraints

Joskow and Tirole (2007) set out by considering an electricity market where some consumers are insensitive to price (demand is based on an average price) while others can adjust based on real-time price information. Consumers in the model demand more or less electricity based on the random realization of the state of nature $i$, where demand increases as $i$ increases.

¹ Appendix A is omitted for conference proceedings.
Consumers purchase electricity from LSEs that may ration their supply. LSEs, in turn, purchase electricity from generators. Generators choose one-shot investments and utilization rates over capacity with constant returns to scale and variation over marginal costs.

The original J&T model considers a single electricity market where all electricity demanded is supplied from a single location. In today’s markets, however, electricity is often exported from one zone to another. The quantity of electricity that flows between zones is limited by the capacity of transmission lines. In turn, these constraints affect electricity prices across zones and may therefore affect policy interventions.

We therefore extend the model of J&T to include two locations and a transmission constraint between them (cf. Borenstein, Bushnell, and Stoft, 2000). In our formulation, we add a location index \( j \in \{1,2\} \) to most terms. Demand in our model may be satisfied by supply from either location, but only a limited amount of electricity may flow between the locations at any time. Without loss of generality, we assume one location is a net exporter of electricity (upstream: \( j = 1 \)), and the other is a net importer (downstream: \( j = 2 \)). The total electricity supplied to both locations in the market in state of nature \( i \) is thus:

\[
Q_i = Q_{i1} + Q_{i2} .
\]

Let \( D_{ij}(p_j) \) represent the unrationed demand of price insensitive consumers in location \( j \) given average price \( p_j \), and let \( \tilde{D}_{ij}(p_{ij}) \) represent the demand of price sensitive consumers in location \( j \) given real-time price \( p_{ij} \). In the absence of a binding transmission constraint, the market clearing condition is:
(2) \[ \sum_{j=1}^{2} [D_{ij} + \bar{D}_{ij}] \leq Q_{11} + Q_{12} . \]

Let \( k \) represent the fixed quantity of power that can flow between the two markets. When the constraint binds, exactly \( k \) electricity is sent from location 1 to location 2 and the markets must separately clear in each location such that:

(3) \[ D_{11} + \bar{D}_{11} \leq Q_{11} - k, \text{ and} \]
(4) \[ D_{12} + \bar{D}_{12} \leq Q_{12} + k . \]

Besides these two innovations, we leave the electricity markets model of J&T intact.

3.2 Transmission Constraints, the Social Optimum, and the Ramsey Equilibrium

From a practical point of view, if constraints always bind, the markets may be treated separately with the analysis of J&T applying in whole to each market. On the other hand, if constraints never bind, the model again collapses to the case considered by J&T. The interesting case to consider is therefore when constraints bind only some fraction of time, which we analyze below.

The following proposition characterizes the competitive implementation of the optimal allocation, or “Ramsey equilibrium”, in the J&T electricity market model:

**Proposition 1:** The second-best optimum (that is, the socially optimal allocation given the existence of price-insensitive retail consumers) can be implemented by an equilibrium with retail generation competition provided that:

a) the RTP reflects the social opportunity cost of generation
b) available generation is made use of during rationing periods;
c) load-serving entities face the RTP;
d) price sensitive consumers are not rationed; furthermore, while price-insensitive consumers may be rationed, their load-serving entity (LSE) can demand any level of
state-contingent rationing \([\alpha_{ij}]\), by, for example auctioning price-contingent interruptible contracts to retail consumers;
e) consumers have homogenous demand and surplus functions (possibly up to a scaling factor). (J&T, 67)²

Because the equations that lie behind condition (d) show that it is possible to have equilibrium either with or without rationing, J&T distinguish between the “rationing” and “no rationing” cases. For ease of exposition, we work with the “no rationing” case throughout this paper—the possibility of optimal rationing does not change the character of our results.

4. The Impacts of Government Intervention in Capacity Markets

Since the addition of transmission constraints does not alter the critical features of the model, the J&T characterization of capacity markets can be extended to analyze our case without major changes. We thus begin this section by summarizing the relevant remarks on price caps and capacity markets from J&T and summarize their key results. We then formally investigate the model with transmission constraints, focusing on the two-state of nature (off-peak and peak) case. Using this framework, we consider optimal capacity market interventions as well as the short and longer run effects of subsidized baseload capacity investments in the downstream market.

4.1 Price Caps and Capacity Markets

As J&T note, price caps can be used to curtail market power during peak demand periods, to extract rents from peak suppliers, or to address the presence of a “choke” price in the market, where price-sensitive consumer demand falls to zero. While price caps address several concerns,

² See J&T as well as Joskow and Tirole (2005, 2006) for further discussion of these conditions.
the presence of a cap creates a “missing money” problem (Shanker, 2003) such that electricity prices may provide inadequate incentives for investment in capacity to meet peak demand. The analysis of J&T implies that capacity markets can address the missing money problem when markets can be characterized by two states of nature (“off-peak” and “peak”). In this case, capacity markets restore the proper incentives for investment in peak generating capacity under two conditions: (1) Base-load plants, as well as peakers, are eligible for capacity payments; and (2) Price sensitive consumer marginal prices incorporate capacity payments.

The intuition behind this result is that capacity payments provide incentives not only for peak capacity but for baseload capacity as well, because baseload plants are also dispatched during peak events. Consumer prices incorporate capacity payments because these payments effectively provide part of the correct return to the supply of electricity. With more than two states of nature, the combination of a price cap and capacity payment cannot induce the Ramsey equilibrium. If the rents available to peakers increase with demand, a single-valued capacity payment cannot create the correct incentive for investment in each state.

4.2 Price Caps and Capacity Markets Under Transmission Constraints

Taking the simplest case as an illustration, assume two states of nature such that the transmission constraint binds when on peak. Maintaining notation as in J&T, let the frequency of these states be \( f_1 \) and \( f_2 \), respectively, with \( f_1 + f_2 = 1 \) and \( f_2 = \theta \), with \( \theta \) as defined above. Define the average price in each location as:

\[
(5) \quad p_j = f_1 p_1 + f_2 p_2 \, ,
\]
where the price in state 1 is equal across locations. Let the capacity available to export from upstream to downstream be decomposed such that \( k = \kappa_1 + \kappa_2 \), where \( \kappa_1 \) is the baseload capacity and \( \kappa_2 \) is peak capacity. As in J&T, assume that peak capacity decisions are made in a typical two-stage game where Cournot players choose capacity and then set prices. Since quantities determine prices, the representative Cournot player in the peaking capacity market in each location \( j \) chooses peak capacity \( K_{2j}^* \) in the first stage to maximize the second stage price problem:

\[
(6) \quad \max_{p_{2j}} \left[ f_2(p_{2j} - c_{2j}) - l_{2j} \right] \cdot \left[ D_{2j}(p_{2j}) + \bar{D}_{2j}(p_{2j}) - K_{1j} - (-1)^j \kappa_1 - \sum_{m \neq r} K_{2j}^m \right],
\]

where \( K_{1j} \) is baseload capacity in location \( j \) and \( r = 1, ..., n \) indexes firms. To solve (6), differentiate this objective with respect to \( p_{2j} \), apply the equilibrium condition \( D_{1j}(p_{1j}) + \bar{D}_{1j}(p_{1j}) = K_{1j} + (-1)^j \kappa_1 \), and note that under Cournot competition, \( K_{2j} = \sum_r K_{2j}^r = nK_{2j}^* \).

These conditions then imply that the Lerner index in each location satisfies:

\[
(7) \quad \frac{p_{2j} - l_{2j}}{p_{2j}} = \frac{1}{n\hat{\eta}_{2j}} \left[ \bar{D}_{2j}(p_{2j}) - D_{2j}(p_{1j}) + D_{2j}(p_{1j}) - D_{1j}(p_{1j}) \right],
\]

where the elasticity of demand of price sensitive consumers at the peak in location \( j \) is given by

\[
(8) \quad \hat{\eta}_{2j} = -\frac{\frac{d\bar{D}_{2j}}{dp_{2j}}}{\frac{dD_{2j}}{dp_{2j}}}.
\]
In either location, peakers take the contribution of transmitted baseload capacity as a fixed quantity, with the locations otherwise behaving as separate markets with distinct capacity prices. Cournot players, who may reside in either location, then choose peak capacity accordingly. Thus the result (7) adds a small extension to J&T: when transmission constraints limit the flow of electricity between zones in PJM, each zone should have separate capacity markets. This feature is in fact captured in PJM’s capacity market design (cf. PJM 2012b, Cramton and Stoft 2005 *inter alia*). In all other respects, J&T’s results on capacity markets remain intact under our assumptions: base capacity plants should be eligible for capacity payments and the consumer price should reflect capacity costs (J&T, 73).

4.3 Characterizing Optimal Intervention and its Limitations

Section omitted for conference proceedings.

4.4 Government Intervention in Downstream Baseload Capacity: Short Run Effects Off-Peak

Assuming governments do make baseload capacity investments in the downstream market, how will these investments affect capacity supplied? To address this question, suppose that government investment adds excess baseload capacity downstream such that off-peak supply exceeds the Ramsey off-peak demand. For simplicity, we again assume two states of nature. We investigate off-peak and peak markets separately and consider effects in both downstream and upstream markets.

Let \( g \geq 0 \) be some amount of subsidized baseload capacity added in the downstream market \((j = 2)\). Define the functions \( p_j(g), p_{1j}(g), p_{2j}(g) \) to describe the new equilibrium prices in location \( j \) after the addition of the baseload capacity with \( p_j(0) = p_j^*, p_{1j}(0) = p_{1j}^*, p_{2j}(0) = p_{2j}^* \). Consistent with typical inverse demand curves, assume each...
of the price functions are non-increasing in \( g \) for \( j = 1 \) and strictly decreasing for \( j = 2 \).

Similarly, let \( K_{1j}(\tilde{p}(g)) \) denote the baseload capacity supplied in location \( j \) conditional on the subsidy. Consistent with upward-sloping supply curves, we assume all components of \( \nabla_p K_{1j} \geq 0 \), again with strict inequality when \( j = 2 \). Finally, define \( \kappa_1(\tilde{p}(g)) \) as the electricity sent from the upstream market to the downstream market.

Off-peak, the upstream and downstream markets satisfy the equilibrium conditions:

\[
\begin{align*}
(11) & \quad D_{11}(p_1(g)) + \tilde{D}_{11}(p_{11}(g)) = K_{12}(\tilde{p}(g)) - \kappa_1(\tilde{p}(g)) \\
(12) & \quad D_{12}(p_2(g)) + \tilde{D}_{12}(p_{12}(g)) = K_{12}(\tilde{p}(g)) + \kappa_1(\tilde{p}(g)) + g,
\end{align*}
\]

respectively. Differentiating these conditions with respect to \( g \) yields:

\[
\begin{align*}
(13) & \quad \frac{dD_{11}}{dp_1} \frac{dp_1}{dg} + \frac{d\tilde{D}_{11}}{dp_{11}} \frac{dp_{11}}{dg} = \left[ \nabla_p K_{11} - \nabla_p \kappa_1 \right] \cdot \nabla_g \tilde{p} \\
(14) & \quad \frac{dD_{12}}{dp_2} \frac{dp_2}{dg} + \frac{d\tilde{D}_{12}}{dp_{12}} \frac{dp_{12}}{dg} = \left[ \nabla_p K_{12} + \nabla_p \kappa_1 \right] \cdot \nabla_g \tilde{p} + 1,
\end{align*}
\]

which equates the change in demand in each market to the change in supply. On the whole, subsidized capacity crowds out private capacity, since summing (13) and (14) yields:

\[
\begin{align*}
(15) & \quad \frac{dD_{11}}{dp_1} \frac{dp_1}{dg} + \frac{d\tilde{D}_{11}}{dp_{11}} \frac{dp_{11}}{dg} + \frac{dD_{12}}{dp_2} \frac{dp_2}{dg} + \frac{d\tilde{D}_{12}}{dp_{12}} \frac{dp_{12}}{dg} = \left[ \nabla_p K_{11} + \nabla_p K_{12} \right] \cdot \nabla_g \tilde{p} + 1.
\end{align*}
\]

The term \( \left[ \nabla_p K_{11} + \nabla_p K_{12} \right] \cdot \nabla_g \tilde{p} \) is the change in privately supplied capacity. Given the assumptions above, this term is strictly negative.
While suppliers necessarily face losses under capacity additions, consumers may see some short-run gains before accounting for reliability concerns. In the downstream market, consumers see some benefit to the increase in quantity supplied since \(\frac{dD_{12}}{dp_2} \frac{dp_2}{dg} + \frac{dD_{12}}{dp_{12}} \frac{dp_{12}}{dg} > 0\). On balance, however, these gains are offset by the cost of the subsidy paid via non-bypassable charges, decreasing welfare. The net result for downstream consumers depends on the relative magnitudes of these effects.

Interestingly, consumers in the upstream market stand to gain—or at least be no worse off—from downstream interventions in the short run, again before accounting for any reliability concerns. In equilibrium, off-peak, real-time prices are equal across locations. Therefore, \(\frac{dp_{11}}{dg} = \frac{dp_{12}}{dg} < 0\) and real-time prices off peak fall in both locations. Price sensitive consumers upstream must therefore directly benefit from price subsidies downstream in the form of lower prices. Since \(\nabla_p K_{11} \cdot \nabla_g \bar{p} \leq 0\) and prices are non-increasing in \(g\), (13) implies

\[
(16) \quad \nabla_p \kappa_1 \cdot \nabla_g \bar{p} < 0.
\]

This result shows that capacity subsidies in the downstream market reduce upstream exports.

4.5 Government Intervention: Effects on Peak Capacity Investment

While interventions artificially reduce prices off-peak in the short run, what are their implications for peak markets, where reliability is necessary to serve high demands without system failure. Consider again the optimization problem (6) faced by peak capacity suppliers.
The representative peak capacity supplier \( r \) in the downstream market solves a two stage Cournot game as before, setting capacities in the first stage with the second stage objective:

\[
(17) \quad \max_{p_{22}} [f_2(p_{22}) (p_{22} - c_{22}) - I_{22}] \cdot \left[ D_{22}(p_{22}) + \hat{D}_{22}(p_{22}) \right] - K_{12}(g) - g - \kappa_1(g) - \sum_{m=1}^{n} \hat{K}_{m22}^{m}.
\]

where \( n \) is the number of suppliers, \( m \) indexes the suppliers, \( f_2(g) \) is the probability of peak demand conditional on the added base capacity, and the equilibrium condition (12) holds off peak. Solving as before, the Lerner index for this problem is:

\[
(18) \quad L_2(g) = \frac{p_{22}(g) - \left[ c_{22} + f_2'(g) \right]}{p_{22}(g)} = \frac{1}{n\hat{\eta}_{22}} \left[ \frac{\hat{D}_{22}(p_{22}(g)) - \bar{D}_{12}(p_{22}(g)) + D_{22}(p_{22}(g)) - D_{12}(p_{22}(g))}{\hat{D}_{22}(p_{22}(g))} \right].
\]

In the case \( g = 0 \), the indices (7) and (18) are equal.

We are interested in the effects of policy on incentives for peak capacity, or how the Lerner index changes as \( g \) changes. Differentiating (18) with respect to \( g \) yields:

\[
(19) \quad \frac{dL_2}{dg} = \frac{1}{n\hat{\eta}_{22}} \left[ \frac{d\hat{D}_{22}}{dp_{22}} \frac{d\hat{p}_{22}}{dp_{22}} + \frac{d\hat{D}_{22}}{dp_{22}} \frac{dp_{22}}{d\hat{p}_{22}} + \frac{dD_{22}}{dp_{22}} \frac{d\hat{p}_{22}}{dp_{22}} + \frac{d\hat{D}_{22}}{dp_{22}} \frac{dp_{22}}{d\hat{p}_{22}} \right] + \left[ L_2(g) \frac{d\hat{p}_{22}}{dp_{22}} + \frac{d^2\hat{D}_{22}}{dp_{22}^2} \hat{p}_{22}^2 - \frac{d\hat{D}_{22}}{dp_{22}} - \frac{d\hat{D}_{22}}{dp_{22}} \hat{p}_{22} \right].
\]

Assuming that demand is concave, the sign of the bracketed term on the right-hand side is strictly negative. Since the price elasticity \( \hat{\eta}_{22} \) is strictly positive, the sign of the derivative (19) depends on the sign of:
which represents the difference in the change between on peak demand and off peak demand.

The addition of subsidized capacity is assumed to decrease prices both on peak and off peak, and the quantity of electricity demanded in both states increases in turn.

If the term (20) is positive, the change in the Lerner index can be, although is not necessarily, positive. In this case, changes in prices create a greater spread between peak and off-peak demand and thereby increase the quantity of demand that peakers face. If the change in off-peak demand is larger than the change in peak demand for both types of consumers, then (19) is negative and the Lerner index strictly decreases. In this case, government intervention reduces the need for peak capacity investment and the capacity price falls.

To sign (20), it is sufficient to assume that peak demand is less elastic than off-peak demand for both types of consumers. This assumption is consistent with the definition of peak periods, where demand is higher than off-peak amongst all consumers in spite of higher prices. In this case, consider the inequality

$$(20) \quad \frac{d\tilde{D}_{p22}}{dp_{22}} \frac{dp_{22}}{dg} - \frac{d\tilde{D}_{p12}}{dp_{12}} \frac{dp_{12}}{dg} + \frac{d\tilde{D}_{12}}{dp_{2}} \frac{dp_{2}}{dg} \frac{d\tilde{D}_{12}}{dp_{12}} \frac{d\tilde{D}_{12}}{dp_{12}},$$

which is simply the term (20) divided by $\frac{p_{12}}{\tilde{D}_{12}} \frac{p_{22}}{\tilde{D}_{22}} \frac{p_{2}}{\tilde{D}_{22}} \frac{p_{2}}{\tilde{D}_{12}}$. Given that peak demand is less elastic than off peak demand, this inequality holds. To see this result, note that by assumption the inverse peak elasticities, $\frac{d\tilde{D}_{p22}}{dp_{22}} \frac{d\tilde{D}_{p12}}{dp_{12}}$ and $\frac{d\tilde{D}_{12}}{dp_{22}} \frac{d\tilde{D}_{12}}{dp_{12}}$, are greater than inverse off-peak elasticities, $\frac{d\tilde{D}_{22}}{dp_{22}} \frac{d\tilde{D}_{p12}}{dp_{12}}$ and $\frac{d\tilde{D}_{12}}{dp_{22}} \frac{d\tilde{D}_{12}}{dp_{12}}$.
\[ \frac{dP_{12}}{dP_2} > 0 \] \quad \text{Since} \quad \frac{dp_2}{dg} < 0 \quad \text{the bracketed term on the right must be strictly negative. The term on the left is similarly negative if}

\[ \frac{dp_{22}}{dP_2} \frac{p_1}{p_2} \frac{p_2}{D_{12} D_{22} D_{12}} < \frac{dp_{12}}{dP_2} \frac{p_1}{p_2} \frac{p_2}{D_{22} D_{22} D_{12}}. \]

Cross-multiplication reveals that (22) is equivalent to:

\[ \frac{dp_{22}}{dP_2} \frac{p_1}{p_2} \frac{p_2}{D_{22}} < \frac{dp_{12}}{dP_2} \frac{p_1}{p_2} \frac{p_2}{D_{12}}. \]

which again holds if peak demand is less elastic than off-peak demand.

Changes in the downstream capacity market may affect the upstream capacity market as well, through at least two mechanisms. First, equilibrium price changes drive changes in capacity supplied since upstream Cournot players solve a similar problem:

\[ \max_{p_{21}} [f_2(g) (p_{21}(g) - c_{21}) - l_{21}] \cdot [D_{21}(p_{21}(g)) + D_{21}(p_{21}(g)) - K_{11}(g) + \kappa_1(g) - \sum_{m \neq r} K_{21}^m], \]

After applying the equilibrium condition (13), the Lerner index in this problem has the familiar form:

\[ L_1(g) = \frac{p_{21}(g) - [c_{21} + f_2(g)]}{p_{21}(g)} = \frac{1}{n_{21}} \frac{[D_{21}(p_{21}(g)) - D_{11}(p_{1}(g)) + D_{21}(p_{21}(g)) - D_{12}(p_{1}(g)))]}{D_{21}(p_{21}(g))}, \]
with a derivative similar to (19). Again assuming that peak demand is less elastic than off-peak demand and that demand is concave, capacity prices fall as long as the change in upstream equilibrium prices are non-zero. These prices must fall at least for off-peak periods, since prices must be equal across the markets off-peak.

4.6 Effects of Capacity Interventions in the Long Run

In comments before the Maryland Public Service Commission, the Independent Market Monitor (IMM) for PJM warned that government investment in electricity markets “will have long lasting, negative consequences for PJM markets,” leading unsubsidized suppliers to exit the market for new capacity (Bowring as quoted in Maryland PSC, 2012). Using the analytic framework of this paper, we sketch here how this can occur. Because subsidizing baseload capacity does not clearly improve outcomes for consumers or society as a whole, we model government imposition of these policies as a random event rather than the outcome of a policymaker’s optimization problem.

Consider again the two-state case with no rationing. Suppose that firms face the risk of government intervention in the downstream market after capital is committed. Cournot players downstream then face the problem:

\[
\max_{p_{22}} E_g \left[ f_2(g) \left( p_{22} - c_{22} \right) - l_{22} \right] \cdot \left[ D_{22} \left( p_{22} \right) + D_{22} \left( p_{22} \right) - k_{12} (g) - g - \kappa_1 (g) - \sum_{m \neq r} k_{r22} \right].
\]

As long as the expectation is that \( g \) takes a positive value, market participants react as in the short run, reducing the quantity of peak capacity supplied at every price, even when the government does not intervene. The effects in the upstream market are symmetric. Essentially,
the threat of intervention imposes expected costs on suppliers in the form of an expected regulatory taking. As a result, reliability decreases in both markets.

In this scenario, higher capacity prices than would otherwise prevail would be necessary to induce suppliers to provide the correct level of peak capacity. If states respond to this scenario by providing subsidized capacity, they simply strengthen the expectation that they will do so again. As this expectation grows stronger, the expected costs to suppliers increase and the cycle becomes self-reinforcing and governments become ever-larger suppliers. Note that this model does not distinguish between intervention in the form of adding base capacity or peak capacity: whether governments invest in peak capacity or base capacity, the market would react by reducing supply.

To avoid an extreme scenario where all unsubsidized suppliers of new capacity exit, the market requires a mechanism to insure against regulatory takings. The PJM MOPR attempts to provide such a mechanism by establishing a price floor for capacity prices. Because MOPR does not preclude subsidized capacity additions, it does not restore optimality. Nonetheless, the price floor limits the expected cost of regulatory takings by establishing a minimum return to capacity investment, regardless of government action. Letting $M$ denote the MOPR policy, the optimized value of the problem,

$$\max_{p_{g2}} E_{g} \left[ f_{2}(g) \left( p_{g2}(g) - c_{g2} \right) - l_{g2} \right] \cdot \left[ D_{22}(p_{2}(g)) + \bar{D}_{22}(p_{22}(g)) - K_{12}(g) - g - \kappa_{1}(g) - \sum_{m \in M} \hat{K}_{m} \right],$$

is therefore greater than or equal to the optimized value of (25). Peak capacity investment under MOPR is therefore greater than or equal to peak capacity investment without it. Note that even when MOPR is set to equal to the optimal capacity price, optimality is not assured because the
level of intervention $g$ is independent of the price floor. Thus, while MOPR is not sufficient for re-establishing optimality, it may mitigate to some extent the extreme outcome the IMM warns against by providing baseline incentives for suppliers to remain in the market.

5. Conclusions

Due to the highly inelastic demand for electricity, the “public good” nature of grid reliability, and the “missing money” problem induced by wholesale electricity price caps, electricity generators underinvest in capacity in the absence of corrective policy. Capacity markets address these problems by giving generators incentives to provide reliability. Against this backdrop, New Jersey and Maryland recently committed to subsidize new capacity in their states. Ratepayers in these states have also been committed to pay for these subsidies.

We investigate the impact of these market interventions, extending the framework of Joskow and Tirole (2007) to account for transmission constraints. In our model, subsidizing new base capacity in the downstream market is allocatively inefficient. Although some rationale exists for supplying peak capacity, we show that market power considerations limit the practical desirability of this option. In off-peak markets, subsidized capacity crowds out privately supplied capacity, resulting in losses for producers. Before accounting for reliability concerns, consumers in the downstream market see some short-run benefit from this policy in the form of artificially lower prices. These gains are offset by the non-bypassable charges they pay to cover subsidy costs. Upstream consumers do not pay these costs, but they nonetheless benefit from these capacity additions as well because real-time off-peak prices fall because exported supply is crowded out.
A distortionary addition of baseload capacity in the downstream market necessarily affects the incentives for peak capacity provision in both locations in our model. Assuming that peak demand is less elastic than off-peak demand, capacity prices decrease in both the downstream and upstream markets and less peak capacity is provided. These interventions are therefore likely to provide too much baseload capacity and too little peak capacity relative to the Ramsey Equilibrium in the short run.

In the longer run, the oversupply of baseload capacity reduces incentives for peak capacity—even when the government does not intervene. The expectation of regulatory costs exacerbates the missing money problem and reduces incentives to supply capacity. These costs grow as suppliers expectations of government action become reinforced. This state of affairs creates a problem for long run grid reliability and runs counter to the stated intent of the governments of New Jersey and Maryland. Price-floor policies like MOPR may mitigate this extortion, but they do not correct the problem.

Our analysis shows that in the context of restructured electricity markets, subsidized additions of base capacity by state governments have the perverse effect of reducing the incentives for reliability. These interventions cause a chain of effects that reduce overall welfare. In the end, our analysis suggests that to “keep the lights on,” states either need to let markets work or face the prospect of continued, costly interventions over the long run.

Abbreviated References


