VOTING BEHAVIOR IN PJM REGIONAL TRANSMISSION ORGANIZATION

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ABSTRACT

Regional Transmission Organizations (RTOs) control the flow of electricity and market pricing for nearly 70% of electricity consumers in the United States, and will probably play a central role in how much of the U.S. adapts to new technology and environmental mandates applied to the electricity sector. The Federal Energy Regulatory Commission (FERC) wants RTOs to be stakeholder-driven organizations, but semi-structured interviews with stakeholders and RTO staff indicate some tension between FERC's desire for inclusive decision-making and the critical reliability functions that RTOs serve. In particular, coalitions of stakeholders may collectively wield pivotal power over PJM's rulemaking process, just as suppliers are deemed to be pivotal and possess market power in the energy, capacity or ancillary services markets. This study uses detailed voting data from the PJM stakeholder process to identify strong coalitions and pivotal voters, with special attention to a series of votes taken on reform of PJM's capacity market. A combination of community detection in voting networks and a theoretical framework from the political economy literature is used to identify three strategic aspects of PJM's current stakeholder process. First, a strong coalition exists both in theory and in practice among end-use interests (electric distribution utilities and large direct-access customers), which has the potential to be pivotal in stopping the passage of any proposed reform of any part of PJM's market or operational rules. No such coalition exists among suppliers (generation firms and vertically-integrated generation owners). Second, in many cases the pivotal voters in practice are not large coalitions but small sets of financial players in PJM's energy markets. Third and specific to capacity market reform, our modeling suggests that the space of reform proposals that could pass through the stakeholder process is small, existing only due to deviations from coalition voting. The expansion of the number of participants in the stakeholder process will likely require either a reform of the voting structure or the design of an alternative mechanism for institutional decision-making for those cases when the existing stakeholder process deadlocks.

Keywords: Regional Transmission Organization (RTO), decision making, voting network, pivotal voter

1 INTRODUCTION

Regional transmission organizations (RTOs) has been playing central role after electricity restructuring in the United States. They are independent electric grid operators ensuring reliable power resources and non-discriminatory access to transmission lines [4]. Since RTOs control two-thirds of the U.S. electricity, their substantial influence over people as well as the industry cannot be ignored. Indeed, RTOs are responsible not only for operating the grid and tariff/pricing system design but also for adapting to new technologies especially in terms of environmental mandates. Clearly, RTOs' decision would affect stakeholders in numerous aspects and thus, all RTOs shall have stakeholder process. Hence, Federal Energy Regulatory Commission (FERC) wants RTOs to be stakeholder-driven organizations to better reflect stakeholders' opinion in their decision making process. However, semi-structured interviews with stakeholders and RTO staff suggest some conflicts between FERC's ambition to have inclusive decision making process within RTOs and PJM's need to carry out its most critical missions. They perceive that although the process usually works, it start to deadlock more frequently than before. In particular, in PJM, a series of proposals related to the capacity market completely failed to pass through PJM stakeholder process because of convoluted interests of market participants. As a result, a special decision mechanism was employed by introducing a new committee. This implies that with current structure of stakeholder process, it was impossible to reach an agreement.

While the decisions that RTOs make have implications for industry, society and the environment, their decision processes have not been broadly studied. In 1997, Paul L. Joskow [5] raised issues concerning governance of independent system operator (ISO) from the representativeness of board of directors of ISO to voting rules within the system. At the end of his argument, Joskow warned that if the policies governing the ISOs move forward fast without any agreement on indicated questions, its performance would be deteriorated in the future. Also, Dworkin and Goldwasser [3] pointed out *"the complicated, technical, and expensive structure of stakeholder process"* leads failure in representing *public interest* which would provide reliable system through efficient and competitive markets. They highlighted a lack of accountability of RTOs due to the diversity of interests. Not to mention the diverse interests of different industries, even within the same sector, geographic diversity or temporal interest could influence dramatic and convoluted divergence in stakeholders' interest. The implication of the studies would be that it is imperative to reach an agreement on how the governance of RTOs should better represent public interest. Furthermore, because of its intricate nature, comprehensive and extensive understanding of this issue requires in-depth analysis.

This work would be the first attempt to model voting behavior within RTOs stakeholder process. It provides empirical evidence to support stakeholder perceptions of strong coalition and difficulties of frequent deadlock due to the coalition. Furthermore, with special attention to a series of votes on reform of PJM capacity market, this study describes conditions under which the stakeholder process is likely to impasse and identifies pivotal players both in theory and practice. I gathered a set of voting data in PJM MC from 2011 to 2015 and conduct two sets of analysis to figure out strategic aspects of PJM's current stakeholder process. First, community detection algorithm in network science is implemented to identify coalitions within the committee. Second, a theoretical framework from political economy literature is used to check probabilities of stakeholder deadlock in capacity market issue. Furthermore, with identified payoff functions, pivotal players are detected in difference circumstances.

2 PJM MEMBERS COMMITTEE

2.1 Overview of PJM Members Committee

PJM is one of RTOs in the U.S. serving all or part of 13 states mostly in Northeast region and the District of Columbia, with a total of 61 million people served and 183,604 MW generating capacity, making it, by far, the largest electric market in the world. In PJM's stakeholder process, any market participant can propose a rule change or address an issue related to the operation of PJM but it needs to go through many steps (the full structure is available in [12]). For an issue to be passed, it needs to pass from low-level subcommittees or task forces to the top level committee called Members Committee (MC). Once the issue passes MC, it goes to the board and then the board make filings at FERC. MC is open to all stakeholders and make decisions on behalf of all the others who could not participate in the meeting. Our focus in this paper is on voting behavior in the MC, for two reasons. First, detailed voting data is kept at the MC meetings for issues that do not clearly pass on a voice vote. Second, the MC has so-called "filing rights" in some areas of PJM governance, meaning that the MC can, in concept make filings directly with FERC, thus bypassing the PJM Board [13].

2.2 Sector-weighted voting

To vote in MC, members in the MC must identify with one of the five sectors: generation owner (GO) who owns power plant(s); transmission owner (TO) who owns transmission line(s); electric distributor (ED) who owns distribution facilities and has been approved as a load serving entity; end-use customer (EUC) who is a retail end-user such as large industrial retail customers or state offices of consumer advocates; and other supplier (OS) who is a member that engages in PJM market and does not qualify for the other sectors such as power marketer, curtailment service provider, financial trader, etc. Table 1 shows composition of MC voters along with example firms. While the definitions of sectors seem clear, when a firm has multiple types of assets, it can be ambiguous. For example, if a firm owns power generators and load servers, then they have a choice between GO and ED depending on their interest. Moreover, as MC applies a specific voting mechanism called *sector-weighted voting* in which votes are weighted by the number of firms of their sector, this sector choice has an impact on firm's voting power over the rulemaking process.

TABLE 1. Composition of MC voters

Sector	Number of Firms (%)	Example Firms
End Use Customers	6 (4%)	Air Products, Proctor & Gamble
Electric Distributors	14 (9%)	PEPCO, Northern Virginia Electric Cooperative
Generation Owners	22 (15%)	Calpine, NRG
Transmission Owners	5 (3%)	Duquesne Light, PSEG
Other Suppliers	105 (69%)	Direct Energy (CSP), Citigroup Energy (Financial), EDF Trading (Marketer)

* PJM (2015). Rosters of the Members Committee [14]

Sector-weighted voting gives equal share to each sector. Thus each sector gets 20 percent of the total score as there are five sectors. In PJM MC, they simply give 1 score to each sector so that the total score is 5. Individual firms get equal weight within a sector. So, as the number of firms increases in the sector, the score contribution of one firm decreases. Sub-total score of each sector counts YES votes and divide it by the number of voting firms in the sector. If the total sum of those score contribution exceeds the threshold following two-thirds majority rule, then a voting item would pass. If every firm votes YES then the total sum is 5 and if every firm votes NO then the total sum is 0. Its mathematical expression is described below.

$$Total\ percentage\ in\ favor = \sum_{i} \sum_{j=1}^{n_i} \frac{\delta_{ij}}{n_i}$$

$$where\ \delta_{ij} = \begin{cases} 1, & if\ firm\ j\ that\ is\ in\ sector\ i\ vote\ yes \\ 0, & if\ firm\ j\ that\ is\ in\ sector\ i\ vote\ no \end{cases}$$

$$n_i = the\ number\ of\ voting\ firms\ in\ sector\ i\ (excluding\ abstain\ vote),$$
$$i = GO, TO, ED, EUC, and\ OS$$

TABLE 1. Sector-weighted voting example

Sector	For	Against	Abstain	Total	Total - Abstain	% in favor
Transmission Owner	8	2	4	14	10	0.8
Generation Owner	15	0	1	16	15	1
Other Supplier	10	10	5	25	20	0.5
Electric Distributor	3	7	15	25	10	0.3
End Use Customer	12	2	0	14	14	0.857
				Total score in favor		3.457

Threshold = 3.335
(2/3 of total vote, .667 x 5 sectors)

For example, in table 1, there are 14 TOs. In this specific example, 4 TOs abstained so that the number of voting firms in TO is 10. And as 8 of them voted for this specific issue, the total score contribution of TO is 0.8. The other sectors also go through the same procedure, and in this example, the sum of the scores from all sectors is 3.457. Since this number is greater than the threshold 3.335 which is the two-thirds of the total score 5, this particular issue would pass. What this system implies is that any two sectors among five can kill an issue as they want, since the remaining sectors' score is 3 which is less than the threshold.

3 Analysis 1 – Voting Network and Community Detection

3.1 Introduction

Interviews with stakeholders and PJM staffs suggest that the process start to deadlock more frequently because coalitions within MC may collectively wield pivotal power. Furthermore, as described in section 2.2, the special voting structure is assumed to give some coalitions effective veto power allowing two sectors coalition can block an issue to be passed. Therefore, in this section, I adopt community detection algorithm to provide empirical support for stakeholders' perception of intra-sector coalitions with veto power.

3.2 Data and Method

Data contains 26 voting items from Aug 25, 2011 to Nov 20, 2014 including their results (pass or fail), sector-subtotal calculated by sector-weighted voting mechanism and 152 members'[1] vote decisions for every voting item. It also includes the information of stakeholders name, sector, whether a firm is a net buyer or a net seller, size of generation/transmission/load server, public power designation, etc.

With this voting data, I construct a voting network connecting firms (or nodes or vertices – in network science terminology) if they vote on the same side (yes or no[2]) on the same issue. In figure 2, circles are the voting members and they are located on one of the five axis depending on their sector. Connecting line becomes thinker as they vote more frequently together. Colors represent detected community (or coalition in this study) by hierarchical clustering.

[1] Originally, there were 203 members in the network, but abstained companies were removed.
[2] However, figure 2 includes only NO votes. That is, connected nodes voted NO together in the same issue.

In the scientific study of networks, community detection method is widely used to detect groups of nodes which are strongly connected within the group compared to connection with nodes outside the group. Therefore, in this voting network, detected community means that members in the same group tend to vote together more with each other than with members in the other groups. *Hierarchical clustering* is one of the popular community detection method especially among social network researches [6, 7] (figure 1). It starts with assigning a different community to each node. Then they cluster nodes when it gives higher *modularity*. Modularity measures difference between total number of edges within groups and expected number of edges that randomly placed. If the number of edges is as expected, then one can hardly argue that there is a meaningful community structure. However, positive modularity perhaps indicate existence of community structure if the value is significant. Accordingly, large values of the modularity is preferred in search for strong divisions of a network [6, 7].

$$Modularity = \frac{1}{2m}\sum_{ij}\left(A_{ij} - \frac{k_i k_j}{2m}\right)\delta(c_i, c_j)$$

where c_i is a community of node i, $\delta(c_i, c_j)$ is the Kronecker delta,
m is the total number of edges and k_i and k_j are the degrees of vertices

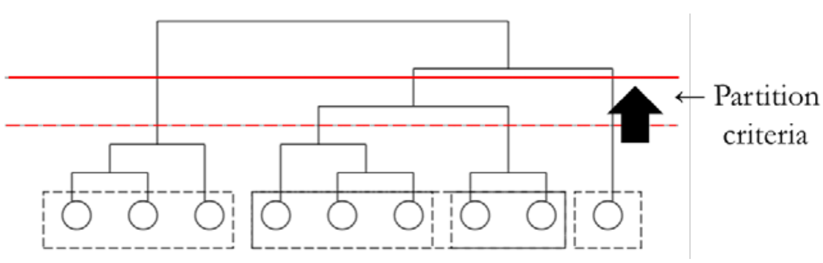

Figure 1. Hierarchical clustering

Depending on the partition criteria, the number of groups in the graph changes. Modularity is not only used to detect community structure but also to decide where to partition the graph. Determining whether good division of a graph is a contentious one. For instance, in figure 1, partition criteria could be located at the top. However, this division gives no compelling messages. In a software named *Gephi,* users can put a resolution value that scales the number of groups in the graph. I adjusted the resolution value to have 2 or 3 communities in the voting network.

3.3 Results

Hierarchical clustering identified three communities in NO network. In figure 2, they are indicated as green, yellow and orange colors. 100 percent of EUCs and 93 percent of EDs are in green community. It is clear that nearly all the firms in EUC and ED are in green community implying that they vote together frequently and their coalition is very tight. On the other hand, GO and TO do not necessarily vote together as there is no dominant community within these sectors. Indeed, among 17 failed voting items, four of them were failed because of green community coalition. Further, for 23 out of 26 voting items, more than 85% of the firms in the green community voted on the same side.

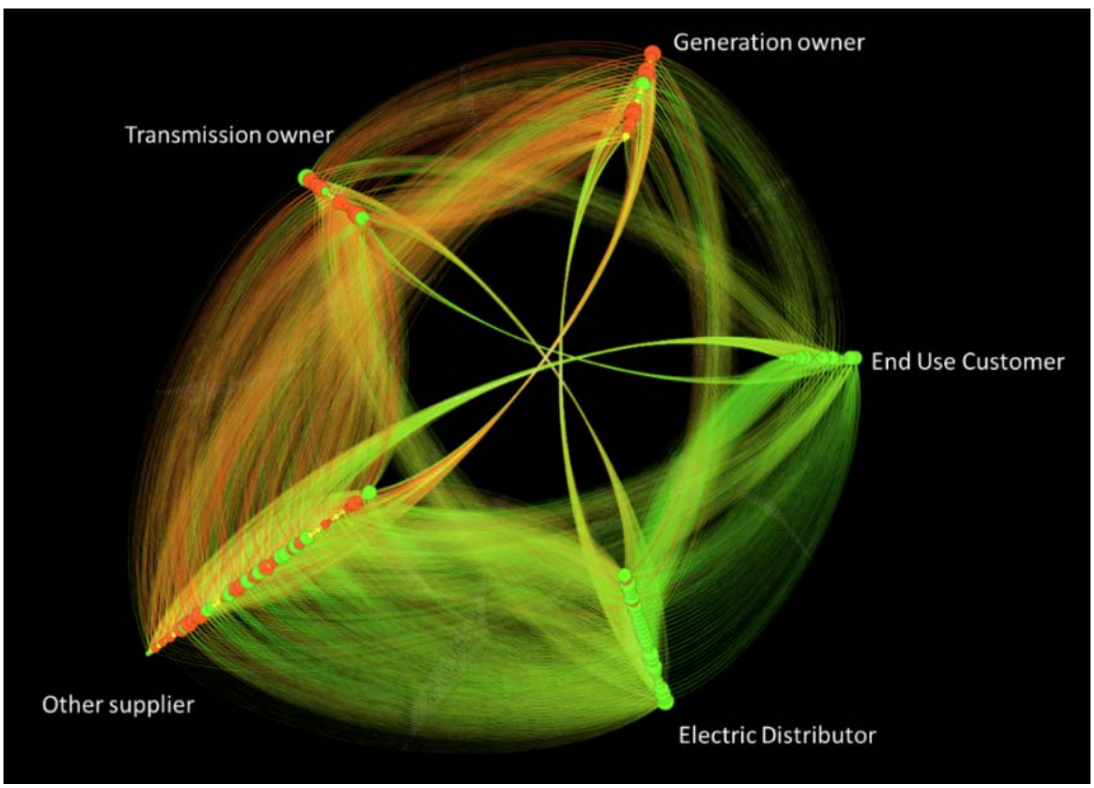

Figure 2. Voting network in PJM Members Committee

3.4 Discussion

Strong ties among consumer side is confirmed as perceived among PJM stakeholders while no such coalition exists among suppliers. This results shows empirical evidence of a strong coalition among electric-buyer interests (electric distribution utilities and large industrial customers). Moreover, it can be inferred that as this two sectors' coalition has effective veto power, it has the potential to be pivotal in stopping any proposed rule changes within PJM footprint. On the contrary, generation owners and vertically-integrated generation owners do not vote together as electric buyer coalition does. Therefore, sector affiliation is not a critical factor for PJM suppliers in their decision making process.

4 Analysis 2 – Acceptable Proposals and Pivotal Voters

4.1 Introduction

Given the voting structure and the coalition formation, there is a significant veto power which may block a certain voting item to pass. Accordingly, in this section, I examine possibilities of stakeholder process deadlock under PJM's voting structure and identify pivotal players. Borrowing from political economy paper of Plott (1967), *acceptable proposal* scheme is adopted [15, 16]. Contrary to the original work in which the author considered simple majority rule, this work considers PJM specific voting structure – supermajority rule with sector weighted voting. Consecutive voting packages on PJM's capacity market revision is used in this analysis and it helped us to better parameterize payoff functions of stakeholders.

4.2 Overview of Capacity market

Capacity market has been developed to recover long-term fixed costs of energy capacity especially of peak generators that operate infrequently. By setting up a forward market which provides additional revenue stream, generators are able to invest in future power supply and RTOs can secure reliable supply for the future [1, 2, 10]. PJM's capacity market is also called Reliability Pricing Model (RPM) capacity market. A forward auction called base residual auction (BRA) is held every three years where suppliers offer their bids. Between those three years, incremental auction is held annually to compensate unsatisfied capacity requirement. Due to the lack of representativeness of electric consumer side, PJM estimates *Variable Resource Requirement (VRR) curve* (figure 3). VRR curve is essentially an estimated future demand curve that helps settling the capacity market price. VRR curve is estimated based on expected cost and revenue determined by a few parameters [8, 9, 11]. PJM determines the parameters' value itself or way to calculate them and a combination of the parameters shape VRR curve. Triennial review of the curve is required and the voting data employed in this study is about changing shape of the curve after the review.

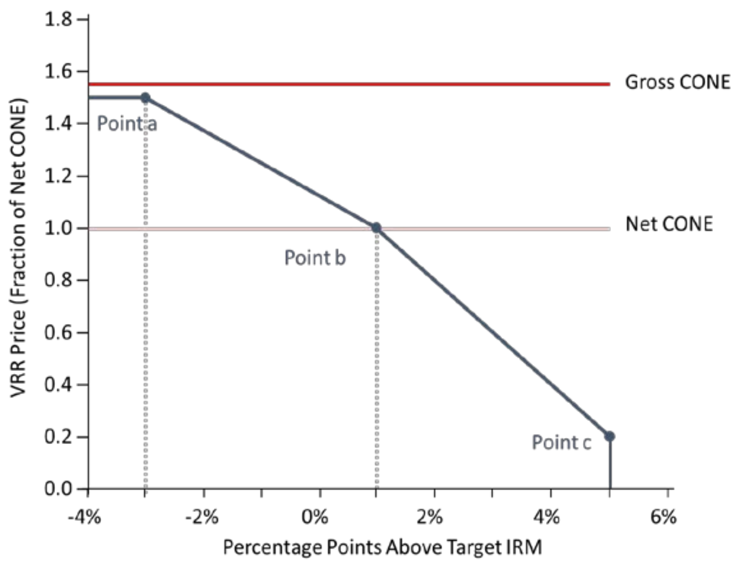

Figure 3. Status Quo VRR curve; 1) Point a is where 1.5 X Net CONE = Target reserve margin - 3%; 2) Point b is where Net CONE = Target reserve margin + 1%; 3) Point c is where 0.2 X Net CONE = Target reserve margin + 5%

VRR curve parameters include the cost of new entry (CONE)–initial investment cost for a new power generator, energy and ancillary services (E&AS) offset–revenue estimates, Net CONE–initial investment cost minus expected revenue price cap (cost that is not recovered from E&AS market), and target reserve margin (or Installed Reserve Margin, IRM). Target reserve margin is the installed capacity margin above the predicted peak load satisfying reliability standards. The curve takes a piecewise linear form as illustrated in figure 3. Since it is a demand curve, X and Y-axes are quantity and price respectively. X-axis of the graph is percentage points above target IRM and Y-axis is VRR price in fraction of Net CONE. The curve is anchored at point b located at the level of Net CONE and one percentage above target IRM. In other words, at the capacity reserve target with 1 percent margin, clearing price in capacity market would be the same as Net CONE price. Point a is the price cap set for IRM-5% and below which means that even if supply is limited (below -5% from targeted reserve margin), price cannot get above the level of point a.

A series of proposals on reforming the shape of VRR curve were voted in October 2011 in PJM Members Committee. However, even though assorted proposals were suggested, none of them was able to pass (table 2). This study intends to question the possibility to have a consensual proposal accepted by a majority of the actors. Further, if it is impossible that an issue can have enough support to be passed, it will imply that there are effective pivotal players or coalitions that wield veto power and this section tries to identify them.

4.3 Data and Method

4.3.1 Proposals on RPM and voting results

Stakeholders voted on total of six proposals, with one of the options being to make no changes to the VRR curve (status quo). Each package is consisted of different combinations of VRR curve parameters such as CONE, Net CONE, E&AS offset, the level of point a and point b. Figure 4 shows VRR curves based on each package's proposed parameters. Compared to status quo (dark blue line), package 11, 12, and 13 assume that willingness to pay of future demand would be smaller than that of status quo leading the capacity price to be settled at lower level. On the other hand, package 1 and 10, in which it sets the point a vertically align with point b, induce the clearing price to be at the price cap even when the supply offer is a little less than the target margin. This is more than 60 percent or 40 percent increase in the price for package 1 and 10 respectively. Hence, ED and EUC strongly against package 1 and 10 and favored package 11, 12, and 13. On the other hand, while it is not as obvious as ED and EUC, TO and GO favored package 1 and 10 and less favored package 11, 12, and 13. Note that for other suppliers, it is hard to tell which package they preferred as a whole.

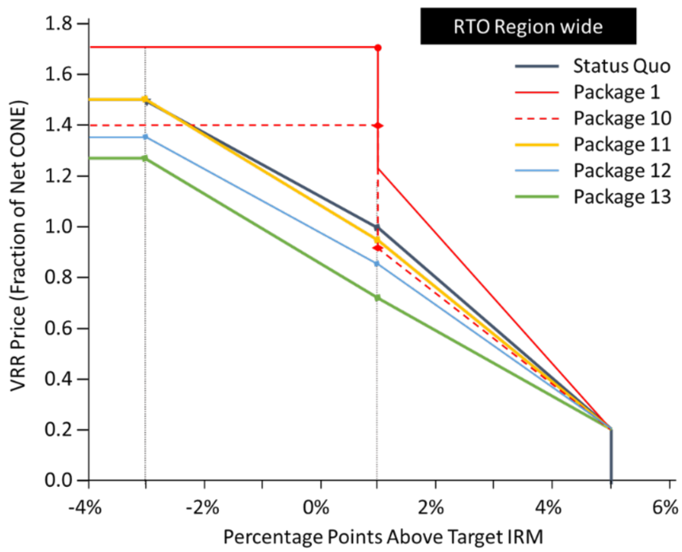

Figure 4. VRR curves according to each package's proposed parameters[3]

TABLE 2. Voting results by sectors

	Status Quo	Package 1	Package 10	Package 11	Package 12	Package 13
TO	0.083	0.8	0.75	0.167	0.167	0.333
GO	0.071	0.833	0.714	0.077	0.231	0.267
EUC	0.083	0	0	0.909	1	1
ED	0.043	0	0	0.913	0.913	1
OS	0.056	0.667	0.323	0.235	0.25	0.513
Results	0.336	2.3	1.787	2.301	2.561	3.113
	Failed	Failed	Failed	Failed	Failed	Failed

Table 2 shows the voting results of each package by stakeholder sector and as in the results, all proposals failed to pass. The numbers of individual sectors were calculated by sector-weighted voting mechanism. For example, for status quo proposal, 8.3 percent of the transmission owners voted yes which,

[3] In this study, I only include RTO region-wide VRR curve proposals. In addition to this VRR curves applied to PJM region-wide, there are other VRR curves specific to five designated sub-regions within PJM footprint. PJM estimates region specific parameters considering locational features. However, since package 1 and 10 suggest increasing clearing price of CONE area and package 11, 12, and 13 suggest decreasing clearing price similar to RTO region-wide VRR proposals,

in turn, means 91.7 percent of the transmission owners voted against it. The total result is the sum of percentage in favor of each sector and the threshold for a package to pass is 3.335.

Figure 4 and the voting results suggest that despite the number of different parameters specified in the VRR curve, most critical factors in stakeholders' decision making on this issue are the levels of points a and b. Besides, all other VRR curve parameters could be boil down to functions of the levels of points a and b. Hence, these two points are crucial points deciding capacity market price. Further, it is assumed that players care more about point a and b than point c since none of the proposals mention relocating point c.

4.3.2 Acceptable proposals framework

To examine the possibility of existence of a PJM's capacity market reform proposal on which PJM stakeholders could have supported enough to pass, this study adopts Plott's *acceptable proposal* theory. This section explains Plott's framework to prove presence of consensual proposal and to demonstrate mathematical conditions to have a solution.

Suppose there are m individuals and the set of individuals is $M = \{1, \cdots, i, \cdots, m\}$. They decide on magnitude changes in n variables $X = (x_1, \ldots, x_n)$ (with $\bar{X}$ being current magnitude). Differentiable utility function of an individual i is assumed as $U^i = U^i(x_1, \cdots, x_n)$. Now consider a proposal $y = (dx_1, \ldots, dx_n)$, small changes from existing situation $\bar{X}$. The author assumes that if an individual vote for a proposal, then it needs to increase one's utility. That is in mathematical expression, one would favor a change if the change satisfies

$$(1) \qquad \frac{\partial U^i}{\partial x_1} dx_1^* + \frac{\partial U^i}{\partial x_2} dx_2^* + \cdots + \frac{\partial U^i}{\partial x_n} dx_n^* > 0$$

which represents increase in utility of an individual i according to the proposal $y^* = (dx_1^*, \ldots, dx_n^*)$. If a proposal **y** increases every voter's utility, then it is acceptable for all individuals. That is **y** such that

(2) $\quad Ay > 0$

$$\text{where } A = \begin{bmatrix} \lambda_1 \frac{\partial U^1}{\partial x_1} & \cdots & \lambda_1 \frac{\partial U^1}{\partial x_n} \\ \vdots & & \vdots \\ \lambda_n \frac{\partial U^m}{\partial x_1} & \cdots & \lambda_n \frac{\partial U^m}{\partial x_n} \end{bmatrix}, y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \ \lambda_i > 0$$

In PJM MC, proposal **y** does not need to satisfy all individuals but only need to satisfy two-thirds of them because for an issue to be passed it only needs supermajority. In section 4.4 and 4.5, I just proceed with original assumption of unanimity and in section 4.6, I introduce more relaxed condition.

In the case of RPM capacity market, proposal y is a vector of small changes in the level of a and b and matrix A is of marginal utility with respect to a and b. Once the proposal vector and the marginal utilities are determined, next problem is to find the solutions to equation (2). However, the author warns that before actually solving the problem, we need to make sure that a solution does exist. If there is no such solution, then that means it is impossible to have an acceptable proposal.

Considering this problem as a simple linear programming problem, from the maximizing utilities standpoint, these inequality requirements (equation (2)) are the constraints of the problem. One of the conditions to have a solution in linear programming is that there will always be a solution if a set of all constraints is closed and nonempty. When a set is empty, there is no overlapping area among constraints which makes it infeasible to get a solution. Also, closed set means the problem is bounded so that we can find extreme solution. Otherwise, the solution is either infinity or negative infinity. Accordingly, what we need to prove here is whether **Ay** is nonempty and closed.

4.4 Payoff functions

Among five industry sectors, TO and OS have diverse assets and interests so that it is challenging to set up their payoff functions whereas most of GO, ED, and EUC have relatively clear payoffs. Therefore, this work starts with building payoff functions of GO, ED, and EUC in section 4.4.1. Then with some additional restrictions and assumptions, payoff functions of TO and a part of OS are identified in section 4.4.2 and 4.4.3 respectively.

A few assumptions are needed specific to PJM capacity market: First, let's assume that there are 3 players in the beginning: generation owner (GO), electric distributor (ED), and end use customer (EUC). Note that this setting of players follows PJM sector definition. Also, for simplicity, I assume there is only one firm within a sector and all the actors have one asset. For instance, GO owns only power plant, TO owns only transmission line, and so forth; second, regarding each stakeholder's marginal utility, since Plott argued that it is unnecessary to find actual marginal utility, we can use approximation, proportional to the real value. Hence, this study assumes that monetary profit from the capacity market is proportional to stakeholders' marginal utility; third, it would be simple and tractable to consider utility is directly proportional to net profit for GO and ED and inversely proportional to payment for EUC; forth, profit is a function of the level of point *a* and *b*; fifth, GO receives the payment from ED and EUC. ED's share of the payment is θ and EUC's share is $(1-\theta)$ where θ is in between 0 and 1. Because ED's are regulated not to make excess profit, their costs would be eventually transferred to end users; sixth, this work focuses on when the total supply bid is less than the target IRM.

4.4.1 GO, ED, and EUC

Suppose generators are paid for securing the new peak capacity through RPM by VRR price times new capacity or $P_{RPM} \times Q_{new}$. Since the payment comes directly from ED and indirectly from EUC, I set a share of this burden of ED as θ and $(1-\theta)$ to EUC where θ is between 0 and 1. Consequently, profit function for each voter considering RPM market could be as shown below.

$$
(3)\qquad
\begin{aligned}
&\pi_{GO}(P_w, Q, C) = (P_w - C) \times (Q + Q_{new}) + P_{RPM} \times Q_{new} \\
&\pi_{ED}(P_w, Q, P_T, P_R) = (P_R - P_T - P_w) \times (Q + Q_{new}) - \theta \times (P_{RPM} \times Q_{new}) \\
&\pi_{EUC}(P_R, Q) = -P_R \times (Q + Q_{new}) - (1-\theta) \times (P_{RPM} \times Q_{new})
\end{aligned}
$$

Profit functions for GO, ED, and EUC considering capacity market. Where P_W = wholesale price, C = marginal cost of generation, P_T = transmission fee, P_R = retail price and Q = transaction quantity of energy and ancillary services market, $P_R(P_W, P_T) = P_W + P_T + \alpha$ where α is profit margin for ED and P_{RPM} and Q_{new} is clearing price and quantity of capacity market respectively

First part of profit function is from the energy market and second term is from the capacity market. GOs get profits from wholesale market and capacity market and pay cost of generation. EDs pay wholesale price and transmission fee, and get profits from retail market. Additionally, as in forth assumption, part of the payment with a share of θ to generators in capacity market is paid by EDs. EUCs pay in retail market and in capacity market they pay with a share of $(1-\theta)$.

As RPM is for ensuring peak capacity, Q is a peak demand and Q_{new} is estimated additional peak capacity or target Installed Reserve Margin (IRM) which is set by PJM satisfying reliability requirements. Q_{new} is added to profits from energy market as well as from capacity market. Clearing price, P_{RPM}, is determined based on VRR curve. For example, if the supply bid is settled at PJM target plus 1% margin then the price would be at the same level as Net CONE or point b. If the total supply bid is less than the target, then generators would get paid by higher price based on VRR curve. Specifically, when the supply is less than the target by α%, the price would increase by α% times the slope of the VRR curve between point a and point b (figure 5). Accordingly, as the clearing price of the capacity market is a function of a, b and α, profit function can be represented as a function of a, b and α when supply bid is the same or less than the target IRM plus 1% margin.

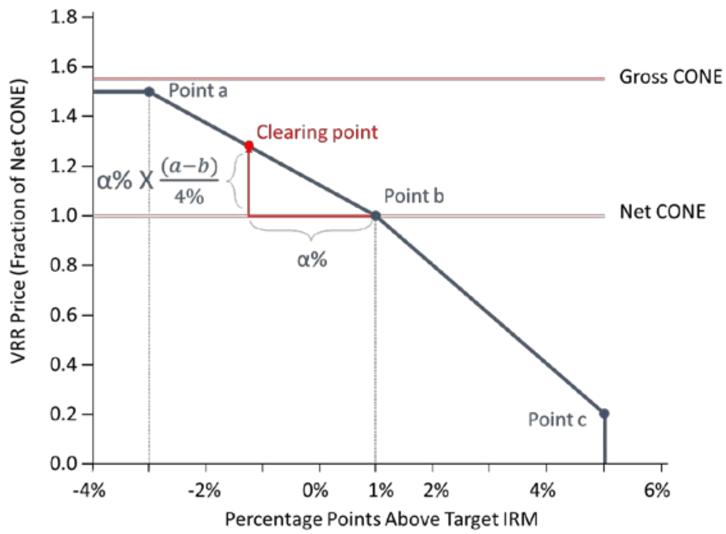

Figure 5. Capacity market price when the total supply bid is less than the target IRM by α%

$$\begin{aligned}
&\pi_{GO}(P_w, Q, C) = (P_w - C)\times(Q+Q_{new}) + b\times Q_{new}\\
&\pi_{ED}(P_w, Q, P_T, P_R) = (P_R - P_T - P_w)\times(Q+Q_{new}) - \theta\times(b\times Q_{new})\\
&\pi_{EUC}(P_R, Q) = -P_R\times(Q+Q_{new}) - (1-\theta)\times(b\times Q_{new})
\end{aligned} \tag{4}$$

Profit function when the supply bid is settled at PJM target plus 1% margin

$$\begin{aligned}
&\pi_{GO}(P_w, Q, C) = (P_w - C)\times(Q+Q_{new}) + \{b+\alpha\times\tfrac{(a-b)}{4}\}\times Q_{new}\\
&\pi_{ED}(P_w, Q, P_T, P_R) = (P_R - P_T - P_w)\times(Q+Q_{new}) - \theta\times\{b+\alpha\times\tfrac{(a-b)}{4}\}\times Q_{new}\\
&\pi_{EUC}(P_R, Q) = -P_R\times(Q+Q_{new}) - (1-\theta)\times\{b+\alpha\times\tfrac{(a-b)}{4}\}\times Q_{new}
\end{aligned} \tag{5}$$

Profit function when the total supply bid is less than the target IRM by α%

Depending on where the market clears, profit functions are different. Equation 4 is when the supply bid is settled at PJM target plus 1% margin thus the clearing price in the capacity market is b. Equation 5 is when the total supply bid is less than the target and the clearing is $\alpha\%$ times the slope, $\frac{(a-b)}{4\%}$. As mentioned, this study focuses on when the supply bid is the same or less than the target IRM plus margin because based on the voting results and the proposals, levels of points *a* and *b* are more critical.

4.4.2 GO, ED, and EUC + TO

Unlike GO, ED, and EUC, transmission owner group's payoff function is more complex to parameterize because TO firms tend to have multiple lines of business. There are 12 transmission owners in PJM MC and 11 of them own not only transmission but also generation and load server. This implies that their interest would be divergent depending on portfolio of assets. Therefore, TOs' payoff function would encompass GO and ED's payoff functions as well as its own payoff.

Consider a TO that have generation, transmission and load server and assume shares of each asset in the firm's portfolio to be γ_1, γ_2 and γ_3 respectively. Profits from receiving transmission fee is defined by multiplying transmission fee by transaction quantities from both energy market and capacity market.

$$\begin{aligned}(6) \quad & \pi_{TO}(P_w, C, Q, P_T, P_R) = \gamma_1 \left\{(P_w - C)\times(Q+Q_{new}) + b\times Q_{new}\right\} \\ & +\gamma_2 \left\{P_T \times (Q+Q_{new})\right\} + \gamma_3 \left\{(P_R - P_T - P_w)\times(Q+Q_{new}) - \theta\times b\times Q_{new}\right\}\end{aligned}$$

$$\begin{aligned}(7) \quad & \pi_{TO}(P_w, C, Q, P_T, P_R) = \gamma_1 \left\{(P_w - C)\times(Q+Q_{new}) + \{b+\alpha\times\tfrac{(a-b)}{4}\}\times Q_{new}\right\} \\ & +\gamma_2 \left\{P_T \times (Q+Q_{new})\right\} + \gamma_3 \left\{(P_R - P_T - P_w)\times(Q+Q_{new}) - \theta\times\{b+\alpha\times\tfrac{(a-b)}{4}\}\times Q_{new}\right\}\end{aligned}$$

Profit function of TO when the supply bid is settled at PJM target plus 1% margin (6) and when the total supply bid is less than the target IRM by α% (7). θ is ED's share of capacity market payment. γ_i is a share of asset i, where $0 < \gamma_i < 1,\ i = 1, 2, 3$ (generation, transmission, load server respectively) and $\gamma_1 + \gamma_2 + \gamma_3 = 1$

$$\begin{aligned}(8) \quad & \frac{\partial \pi}{\partial a} = \frac{\alpha}{4} Q_{new}\left(\gamma_1 - \theta\gamma_3\right) \\ & \frac{\partial \pi}{\partial b} = (1-\frac{\alpha}{4}) Q_{new}\left(\gamma_1 - \theta\gamma_3\right)\end{aligned}$$

Two equations in (8) are marginal profits from (7) with respect to the levels of points *a* and *b* respectively. Absence of γ_2 term in both equations implies that TOs' preference on capacity market reform proposals would not depend on ownership of transmission line but depend on ownership of power plants and load serving entities precisely on the sign of $\gamma_1 - \theta\gamma_3$. Since θ is between 0 and 1, if shares of generation and load are similar, having load serer has less influence on the sign than ownership of generators.

This aligns with the data. TOs who own greater size of generation than load server or large generation regardless of size of load server (9 among 12) showed same voting decision with majority of generators. On the other hand, TOs who own smaller size of generation than load server or small generation (3 among 12) have a voting pattern that is similar to ED or EUC. Besides relative size of generator and load server, size of generator itself affects more voting decision than that of load. 5 TOs have the same size of generation and load server. TOs who have large generation (3 among 5) voted with generator whereas TOs who have small generation (2 among 5) voted similar to ED and EUC.

4.4.3 GO, ED, and EUC + TO + CSP

Other supplier group is a big 'miscellaneous' group. There are 9 sub-sectors while the others have 3 or 4 sub-sectors such as Curtailment Service Providers, Transmission dependent utilities, financial players, etc. Accordingly, their interests are inevitably heterogeneous. Among various sectors, payoff of one sector named Curtailment Service Providers is relatively clear because as they are demand response companies[4], they can be considered as electric-sellers. Since both GOs and CSPs are both sellers in electricity market, CSP's payoff function is aligned with that of GOs.

$$\pi_{CSP}(P_w, Q, C) = (P_w - C) \times (Q + Q_{new}) + b \times Q_{new} \tag{9}$$

$$\pi_{CSP}(P_w, Q, C) = (P_w - C) \times (Q + Q_{new}) + \{b + \alpha \times \tfrac{(a-b)}{4}\} \times Q_{new} \tag{10}$$

Profit function of CSP when the supply bid is settled at PJM target plus 1% margin (6) and when the total supply bid is less than the target IRM by α% (7)

[4] Demand Response is a program that enables end-use customers to react electricity market price and pays customers not to use electricity during the peak time. If participating customers reduce their electricity usage during periods of high power prices or when the reliability of the grid is threatened, they get compensation.

In our data set, Curtailment Service Providers almost always voted with the generation owner group, so we model their payoff function as (ceteris paribus) increasing in the level of the clearing price in RPM.

4.5 Existence of an acceptable proposal?

$$(11)\qquad Ay=\begin{bmatrix} \lambda_1\frac{\partial U^{GO}}{\partial a} & \lambda_1\frac{\partial U^{GO}}{\partial b} \\ \lambda_2\frac{\partial U^{ED}}{\partial a} & \lambda_2\frac{\partial U^{ED}}{\partial b} \\ \lambda_3\frac{\partial U^{EUC}}{\partial a} & \lambda_3\frac{\partial U^{EUC}}{\partial b} \\ \lambda_4\frac{\partial U^{TO}}{\partial a} & \lambda_4\frac{\partial U^{TO}}{\partial b} \\ \lambda_5\frac{\partial U^{CSP}}{\partial a} & \lambda_5\frac{\partial U^{CSP}}{\partial b} \\ \lambda_6\frac{\partial U^{OS}}{\partial a} & \lambda_6\frac{\partial U^{OS}}{\partial b} \end{bmatrix}\begin{bmatrix} da \\ db \end{bmatrix}=\begin{bmatrix} \frac{\alpha}{4}Q_{new} & (1-\frac{\alpha}{4})Q_{new} \\ -\theta\frac{\alpha}{4}Q_{new} & -\theta(1-\frac{\alpha}{4})Q_{new} \\ -(1-\theta)\frac{\alpha}{4}Q_{new} & -(1-\theta)(1-\frac{\alpha}{4})Q_{new} \\ \frac{\alpha}{4}(\gamma_1-\theta\gamma_3)Q_{new} & (1-\frac{\alpha}{4})(\gamma_1-\theta\gamma_3)Q_{new} \\ \frac{\alpha}{4}Q_{new} & (1-\frac{\alpha}{4})Q_{new} \\ \frac{\partial\pi^{OS}}{\partial a} & \frac{\partial\pi^{OS}}{\partial b} \end{bmatrix}\begin{bmatrix} da \\ db \end{bmatrix}>0$$

Condition for acceptable proposal when the total supply bid is less than the target IRM by α%

$$(12)\qquad Ay=\begin{bmatrix} \lambda_1\frac{\partial U^{GO}}{\partial a} & \lambda_1\frac{\partial U^{GO}}{\partial b} \\ \lambda_2\frac{\partial U^{ED}}{\partial a} & \lambda_2\frac{\partial U^{ED}}{\partial b} \\ \lambda_3\frac{\partial U^{EUC}}{\partial a} & \lambda_3\frac{\partial U^{EUC}}{\partial b} \\ \lambda_4\frac{\partial U^{TO}}{\partial a} & \lambda_4\frac{\partial U^{TO}}{\partial b} \\ \lambda_5\frac{\partial U^{CSP}}{\partial a} & \lambda_5\frac{\partial U^{CSP}}{\partial b} \\ \lambda_6\frac{\partial U^{OS}}{\partial a} & \lambda_6\frac{\partial U^{OS}}{\partial b} \end{bmatrix}\begin{bmatrix} da \\ db \end{bmatrix}=\begin{bmatrix} 0 & Q_{new} \\ 0 & -\theta Q_{new} \\ 0 & -(1-\theta)Q_{new} \\ 0 & (\gamma_1-\theta\gamma_3)Q_{new} \\ 0 & Q_{new} \\ \frac{\partial\pi^{OS}}{\partial a} & \frac{\partial\pi^{OS}}{\partial b} \end{bmatrix}\begin{bmatrix} da \\ db \end{bmatrix}>0$$

Condition for acceptable proposal when the supply bid is settled at exactly what PJM targeted

Matrix A contains information of marginal payoff functions from section 4.4 representing approximation of marginal utilities matrix and vector y is the proposed small changes of variables in concern which are defined in previous chapter as the level of point a and b.

Note that when the supply bid matches with the target margin, the level of point a does not matter and only the level of b matters. This makes sense in that the capacity market price would only depend on the level of b where the market clears. As shown in the matrix, in our framework, Generation Owners and Curtailment Service Providers have aligned incentives and Electric Distributors and End Users are also aligned. Transmission Owners' alignment depends on the sign of $\gamma_1 - \theta\gamma_3$. Aligned payoffs imply that it is highly possible that they have the same opinion on capacity market revision issue. Payoff functions for other types of suppliers beyond CSPs are less clear, so we consider those to be potentially pivotal or swing voters.

If there is no solution to equation (11) or (12), that means there is no acceptable proposal satisfying all stakeholders[5]. Thus, to check the existence of acceptable proposal, we need to prove that the problem has a solution. As this problem can be considered as a simple linear programming problem, let's borrow linear programming scheme. In linear programming, there will always be a solution if a set of all constraints is a closed and nonempty set. When a set is empty, there is no overlapping area among constraints which makes it infeasible to get a solution. Also, closed set means the problem is bounded so that we can find extreme solution. Otherwise, the solution is either infinity or negative infinity. Considering this problem as utility maximization problem, equation (11) and (12) are constraints. Accordingly, what we need to prove here is whether **Ay** is nonempty and closed. Let's first consider the case when the supply bid is less than the target IRM. There is one constraint of each of the five types of stakeholders–GO, ED, EUC, TO, and CSP.

$$(13) \qquad \frac{\alpha}{4}Q_{new} \times da + (1-\frac{\alpha}{4})Q_{new} \times db > 0 \ \textit{(GO and CSP)}$$

[5] As mentioned in section 4.3.2 or page 14, in this section it is assumed that for a proposal to be passed, it needs to satisfy all stakeholders (unanimous rule) whereas in reality, two-thirds rule is applied. This supermajority rule case is shown in section 4.6

(14) $$-\theta\frac{\alpha}{4}Q_{new}\times da-\theta(1-\frac{\alpha}{4})Q_{new}\times db>0 \ \textit{(ED)}$$

(15) $$-(1-\theta)\frac{\alpha}{4}Q_{new}\times da-(1-\theta)(1-\frac{\alpha}{4})Q_{new}\times db>0 \ \textit{(EUC)}$$

(16) $$\left(\gamma_1-\theta\gamma_3\right)\left(\frac{\alpha}{4}Q_{new}\times da+(1-\frac{\alpha}{4})Q_{new}\times db\right)>0 \ \textit{(TO)}$$

Simplify above equations:

(17) $$db>-\frac{\alpha}{(4-\alpha)}\times da \ \textit{(GO and CSP)}$$

(18) $$db<-\frac{\alpha}{(4-\alpha)}\times da \ \textit{(ED and EUC)}$$

TO's constraint is simplified in two ways depending on the sign of $\gamma_1-\theta\gamma_3$

(19) when $\gamma_1-\theta\gamma_3>0$,

$$\frac{\alpha}{4}Q_{new}\times da+(1-\frac{\alpha}{4})Q_{new}\times db>0 \Rightarrow db>-\frac{\alpha}{(4-\alpha)}\times da \ \textit{(as in GO and CSP)}$$

(20) when $\gamma_1-\theta\gamma_3<0$,

$$\frac{\alpha}{4}Q_{new}\times da+(1-\frac{\alpha}{4})Q_{new}\times db<0 \Rightarrow db<-\frac{\alpha}{(4-\alpha)}\times da \ \textit{(as in ED and EUC)}$$

Equation (19) and (20) suggest that when TO has bigger generation than load server ($\gamma_1-\theta\gamma_3>0$) then its interest is aligned with GO and CSP while it has bigger load server ($\gamma_1-\theta\gamma_3<0$), its interest is in the same direction with ED and EUC. Therefore, TOs' decision depends on its portfolio over generation and load server and due to the coefficient θ, load server has less impact on their decision than generation. When the market clears at the target plus 1% margin, then the constraint is only a function of the level of point b. $db>0$ for GO and CSP and $db<0$ for ED and EUC. Similarly, TO's payoff is aligned with GO and CSP when $\gamma_1-\theta\gamma_3>0$ and with ED and EUC when $\gamma_1-\theta\gamma_3<0$.

All the constraints boil down to two constraints laying on the opposite sides of a linear function for both cases when the market clears at the target (figure 6 (a)) and below the target (figure 6 (b)). Consequently, since the set of constraints has no area shared by all stakeholders which means the set is an empty set, the conclusion would be that there is no acceptable proposal on reshaping VRR curve in this framework. Note that transmission owner is divided into two groups: one whose payoff is aligned with electric-seller side and the other whose payoff is similar to electric-buyer side. Even though this framework requires unanimity for a proposal to be passed, it still helps to clarify how opinions of stakeholder would be divided and eventually to predict whether measure pass or fail.

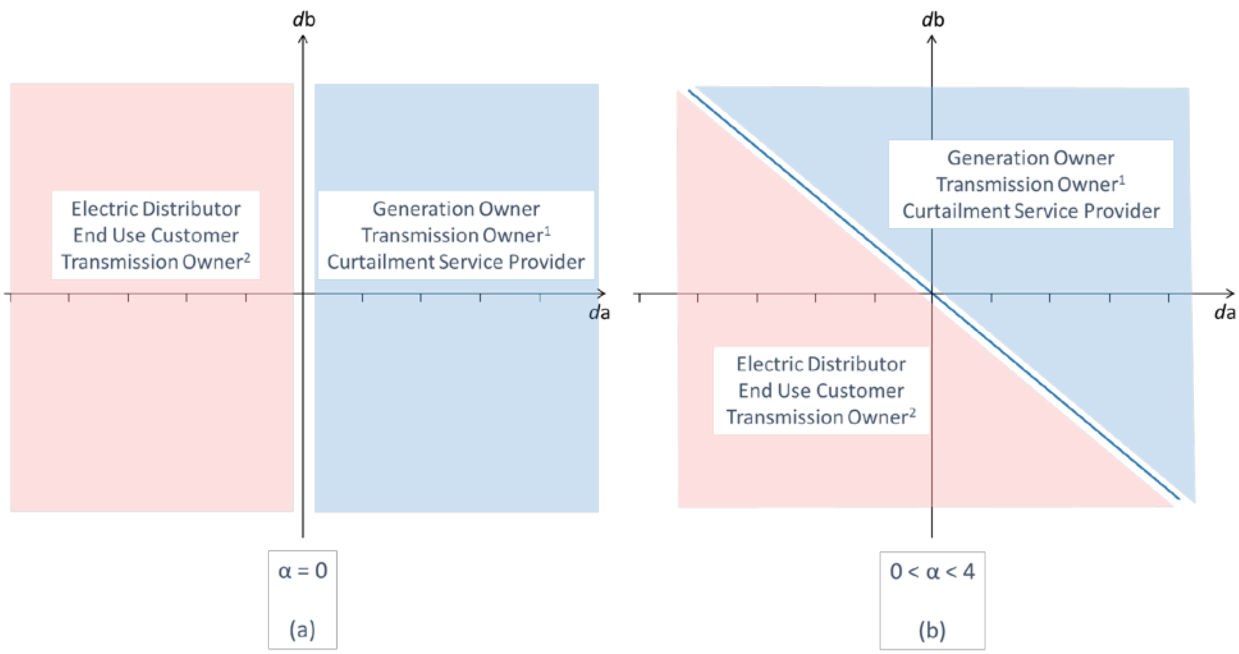

Figure 6. Geometry of the Constraints

For the case when α is 0 (that is when the market clears at the target IRM) VRR price curve becomes a vertical line and the price will solely depend on the level of point b (figure 6 (a)) as indicated from the marginal profit function. Furthermore, we could also get another implication from changes in graph depending on the changes in α. As α increases from 0 to 4, the line becomes closer to vertical axis which means since the clearing point becomes closer to point a, all the players become more sensitive to changes in the level of point a. Note that constraints of ED and EUC are, in fact, the same after θ and (1- θ) are ruled out.

Since it is assumed that one prefers a proposal when it strictly increases his/her utility, intersect of the two constraints is empty. This assumption seems legitimate when we look at the voting data (table 2) because percentage in favor for the status quo proposal is the lowest among all the proposal. Considering status quo is at (0, 0) because it suggests no change in any variable, it does make sense that a firm does not prefer a proposal that makes no changes in its utility. However, it is also possible that a firm did not want to vote yes for status quo because the other proposal sets more favorable environment for them. This strategic behavior is not considered in this study and remained for the future work.

4.6 RPM voting in theory and in practice

4.6.1 Pivotal coalitions in theory under Supermajority rule

In PJM MC, proposal **y** does not need to satisfy all individuals but only need to satisfy two-thirds of them because for an issue to be passed it only needs supermajority. Therefore, we need more relaxed condition. Consider a new matrix B which satisfies

(21) $$By > 0$$

where $$B = \begin{bmatrix} \vdots & \cdots & \vdots \\ \lambda_k \dfrac{\partial U^i}{\partial x_1} & & \lambda_k \dfrac{\partial U^i}{\partial x_n} \\ \vdots & \cdots & \vdots \end{bmatrix}$$

Let K be a set of individuals who satisfies inequality condition (21). As set K is a subset of M, a set of total voters, size of the set K is smaller than m, the size of the set M. A proposal would pass in PJM MC considering supermajority rule and sector-weighted voting if

(22) $\sum_{i \in K} w_i > 3.335$ where w_i is a sector weight of an individual i

Let's take an example with the same assumptions in section 4.4 except the first assumption. Instead, suppose there are all types of stakeholders and multiple firms exist within a sector. Also, assume Transmission Owners have generation, transmission and load server and shares of each asset are γ_1, γ_2 and γ_3 respectively. Now consider a proposal that is one of the red arrows in figure 7 and capacity market clears below the target IRM plus 1% margin. As it is located in electric-seller side, marginal profits of GOs, CSPs, and some TOs that has more generation than load server or large generation (TO^1) are positive (equation (23)). As GO, TO^1, and CSP's interests are aligned, they would naturally establish a coalition. On the other side, electric-seller such as EDs, EUCs, and some other TOs whose payoff is aligned with EDs and EUCs (TO^2), would collectively oppose this proposal as their marginal profit would decrease.

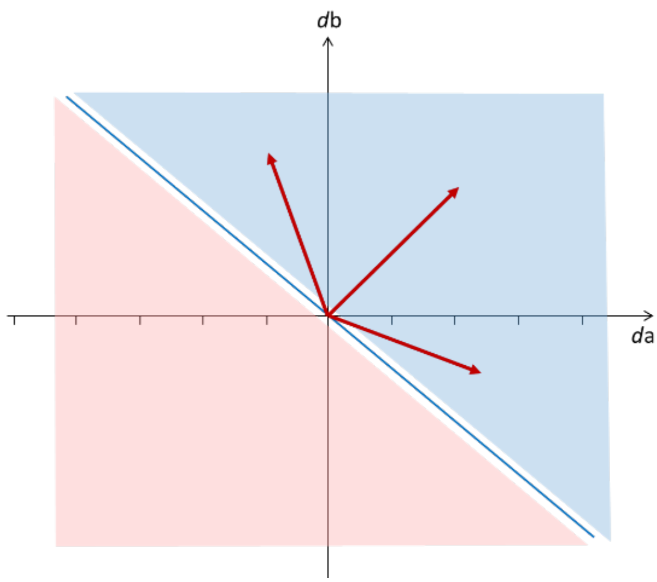

Figure 7. Example of a proposal that satisfies electric-sellers

$$My = \begin{bmatrix} m_{GO,a} & m_{GO,b} \\ m_{TO^1,a} & m_{TO^1,b} \\ m_{CSP,a} & m_{CSP,b} \end{bmatrix} \begin{bmatrix} da \\ db \end{bmatrix} = \begin{bmatrix} \frac{\alpha}{4} Q_{new} & (1-\frac{\alpha}{4}) Q_{new} \\ \frac{\alpha}{4}(\gamma_1 - \theta\gamma_3) Q_{new} & (1-\frac{\alpha}{4})(\gamma_1 - \theta\gamma_3) Q_{new} \\ \frac{\alpha}{4} Q_{new} & (1-\frac{\alpha}{4}) Q_{new} \end{bmatrix} \begin{bmatrix} da \\ db \end{bmatrix} > 0 \quad (23)$$

TABLE 3. Sector weights in PJM MC

	GO	TO		ED	EUC	OS	
		1	2			CSP	Other OS
w_i	1	0.75	0.25	1	1	0.2	0.8

Table 3 shows sector weights of stakeholders. Weight of GO, ED, and EUC is 1 as they have clear payoff functions and TO and OS's weight is set based on actual share in PJM MC. 75% of TO has more generation than load server or large generation (TO^1) and 25% has greater load server or small generation (TO^2). 20% of Other Suppliers are CSP so I divide OS into two groups: CSP with sector weight of 0.2 and the others of OS with weight of 0.8. Payoff functions of the others of OS remain unclear. Coalition formation in this setting would be

$$\boldsymbol{Z} = \{GO, TO^1, CSP\}, \qquad \boldsymbol{Z^c} = \{ED, EUC, TO^2\}, \qquad \mathbf{U}^{\boldsymbol{c}} = \{OS\}$$

Based on this coalition formation and sector weights, each coalition's sum of sector weight is

$$\sum_{i \in \boldsymbol{Z}} w_i = 1.95, \qquad \sum_{i \in \boldsymbol{Z^c}} w_i = 2.25, \qquad w_{\boldsymbol{U^c}} = 0.8$$

To have an effective veto power a coalition has to have more than 1.665[6] sector weight. As shown above, both buyer (Z^c) and seller (Z) coalition has more than 1.665 sector weight. Therefore, under PJM voting rules, electric-buyer coalition could have blocked this proposal from passing. On the other hand, if a proposal is placed in electric-buyer side, seller coalition could have blocked it, too. Hence, both coalitions are pivotal players with veto power.

4.6.2 Identifying pivotal coalitions in practice

After looking at individual firm's voting data, consistent defections from the electric-seller coalitions in theory are observed. Table 4 shows sector weights of stakeholders considering those defections. Some

[6] As threshold is 3.335 and maximum sum of scores is 5, if a coalition has 1.665 ($= 5 - 3.335$), it has an effective veto power.

GOs voted with electric-buyers and they take 27% of GOs. Also among CSPs, a few of them did not vote with electric-sellers. Reason for these defection is not identified and remained as a future work.

TABLE 4. Sector weights in PJM MC considering defection

	GO		TO		ED	EUC	OS	
	1	2	1	2			CSP	Other OS
w_i	0.73	0.27	0.75	0.25	1	1	0.178	0.822

Accordingly, coalition formation in practice would be

$$\boldsymbol{Z} = \{GO^1, TO^1, CSP\}, \qquad \boldsymbol{Z^c} = \{GO^2, ED, EUC, TO^2\}, \qquad \mathbf{U^c} = \{OS\}$$

And sum of sector weights in coalitions

$$\sum_{i \in \boldsymbol{Z}} w_i = 1.658, \qquad \sum_{i \in \boldsymbol{Z^c}} w_i = 2.52, \qquad w_{\boldsymbol{U^c}} = 0.822$$

Interestingly, seller coalition does not have veto power any more as the sum is less than 1.665. It needs 0.007 more and one vote from the U^c can make up the difference since one vote's weight from OS is 0.022[7]. Furthermore, buyer coalition needs 0.815 to ensure passage of a proposal which can also be satisfied by the others in OS group. Even though it needs most of votes in U^c, it is still possible to arrange an issue to pass whereas it is impossible in the case without defection. Accordingly, in reality, due to enough defections from coalitions, a small number of financial players are more likely to be pivotal than large coalitions.

5 CONCLUSION

Findings in this study can be summarized in three aspects. First, electric-buyers (electric distribution utilities and large direct-access customers) do appear to form a strong coalition both in theory and in practice whereas suppliers (generation firms and vertically-integrated generation owners) do not. Indeed, the

[7] There are 45 members in OS so one vote is counted for 1/45 which is 0.022

structure of the voting system in the PJM Members Committee does give some coalitions effective veto power over any proposed rule change. Although this study confirms the intuitive results that customers have opposite preference against suppliers, it gives clear implication that in current system, it is difficult to pass a proposal if it is not supported by ED and EUC coalition.

Second, our focused analysis of a series of votes on redesign of PJM's capacity market allows us to identify relevant parameters for the payoff functions for generation owners, large industrial customers and electric distribution utilities. With some additional assumptions and restrictions we can identify payoff functions for transmission owners and curtailment service providers (demand response companies). Our model of acceptable proposals based on identified payoffs suggests a geometry of voting on the capacity market in particular that is highly likely to lead to stakeholder deadlock. While the structure of the stakeholder process in the PJM is successful at moving many needed reforms through to acceptance by the Federal Energy Regulatory Commission and eventual implementation, This theoretical finding suggests that there may be limits to the degree to which organizations like RTOs can create mechanisms for heterogeneous stakeholders with opposing interests to develop passable market rules and protocols.

Third, our analysis of votes on capacity market redesign suggests that our theoretical framework is effective at predicting whether measures pass or fail, but is less effective at identifying the pivotal coalitions that lead to measures passing or failing. Our model correctly predicts some circumstances where distribution utilities and large industrial customers act as a voting coalition to keep some capacity market redesigns from passing. In other cases, however, that pivotal or swing voting power is held by a smaller number of financial market players.

While this analysis suggests possibility of stakeholder deadlock for some reforms, I would be cautious to make sweeping generalizations on stakeholder process. The model is limited to a specific data set and I have not yet extended this framework to other issues. Moreover, investigations on reasons for defections and other features influencing voting behavior beyond sector affiliation are required. Additional future work involves comparison between PJM another RTOs and using a dynamic or game-theoretic framework to model the repeated interactions of stakeholders in their decision making process.

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