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Producer heterogeneity and voting power in mandatory US agricultural marketing organisations

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1 Introduction

Mandatory marketing organizations (MMOs) have been an important agricultural policy tool in the United States for 80 years. These organizations include agricultural marketing orders, commissions, councils and check-off programs. They can serve many purposes, including supply control (for price stabilization), setting of quality and grading standards, market or production research, limiting of unfair trade practices and generic commodity promotion. The intended purposes differ across MMOs and are outlined in each organization's governing documents.

The creation of a MMO is a political process, and considerable discretion is given to the Secretary of Agriculture (state or federal, depending on the organization) in determining the value of these MMOs. In addition, many MMOs require approval through a vote of eligible producers for creation, continuation and termination. The outcome of this referendum then informs the Secretary's decision for the future for the organization, and, in some cases, may dictate it. Producer referenda are held at regular intervals for most MMOs to ensure they are continuing to provide positive net benefits to producers.

These referenda are the focus of our research. Specifically, we examine how market power among agricultural producers relates to voting power in a referendum to form, terminate or continue a MMO with a generic promotion provision. These referenda are interesting for several reasons. First, the voting rules used in determining the outcome of these referenda often depend on both the number of producers and the quantity of output they produce, suggesting that market structure matters in determining the outcome. Second, they provide an opportunity for us to study grower behavior regarding mandatory collective action organizations, which can shed light on the costs and benefits to growers of these organizations as well as on attitudes to collective action more broadly.

One of the most common types of MMOs is a marketing order. Although voting rules differ somewhat across MMOs, for the purposes of this paper, we consider voting rules for Federal marketing orders, as they are typical of the type of voting rule used by many MMOs. We model the supply side of the market for a homogeneous agricultural commodity as consisting of a single firm with a cost advantage and multiple firms with heterogeneous higher costs. This cost structure is intended to represent the supply environment in many industries, where there is an increasing gap between a few dominant producers and many smaller ones. We assume buyers of the commodity do not exercise market power. Finally, we focus on demand-increasing generic commodity promotion as the means by which an MMO benefits producers. Generic promotion is increasingly one of the primary roles of MMOs in the United States, in part due to the passage of the Research and Commodity Promotion Act of 1996, which created of a new category of federal check-off program with a major emphasis on generic promotion.[1]

We focus on a pair of voting rules commonly used together for Federal marketing orders and examine the voting power of the dominant and fringe firms. For this analysis, we consider what Felsenthal and Machover (2004) call "I-power." This class of power measure address a voter's influence over the decision to be made. The power measure we use is Banzhaf Power (Banzhaf, 1965). The Banzhaf Power Index is calculated by considering all possible "winning" coalitions of voters—those coalitions that could pass a proposed action if all members of the coalition favored it, given the voting rule. A voter is "critical" if the coalition would no longer pass the proposed action if the voter left that coalition. The Banzhaf Power Index is defined as the number of times a given voter is critical out of the total number of possible vote combinations in the industry. Running simulations of these markets under various assumptions about costs and market structure and industry-calibrated market parameters, we calculate the Banzhaf Power Index value and market share of each firm.

The Banzhaf Power Index assumes implicitly that voters vote for the action with a probability of 0.5. Some have challenged the usefulness of this type of measure given this naive assumption about voter behavior (see for example Gelman et al., 2004). However, developing a better model requires more information about voters, which can be hard to obtain. In most situations, voter preferences or correlations between preferences are difficult to measure and the factors that underly them may be challenging to identify. Our setting offers us an advantage because voters are profit-maximizing agricultural producers. This voter characteristic allows us to incorporate our knowledge of theory of the firm to better predict the voter behavior given cost and market parameters. Building on the probability theory approach to Banzhaf's index identified by Straffin (1977), and the behavior of profit-maximizing producers in the neoclassical theory of the firm to develop a second measure

[1]Of course, our methodology could also be applied to MMOs with other functions or multiple functions. Because of the variety among MMOs, developing a general framework for dealing with all MMOs would require modeling the many different effects an MMO might have on firm and market parameters, which is not within the scope of this article.

we call "Feasible" Banzhaf Power. To calculate this measure, we incorporate the information about each producer's profit-maximizing voting choice and then assume that a producer votes in accordance with his profit-maximizing choice with a randomly drawn idiosyncratic probability. This probability represents the probability that a producer is optimizing some objective function other than profit-maximization that yields him or her to a different voting choice. For example, the producer could have the objective of minimizing government intervention, regardless of its effect on his profits.

We find that market power and cost heterogeneity do indeed matter in determining the voting power of producers in MMO referenda, whether or not producer behavior is incorporated. Furthermore, incorporating information on producer behavior substantially affects our estimate of voting power. We also find that disparate preferences of firms with heterogeneous costs in situations where some producers wield market power can reduce the Feasible Banzhaf Power Index value for the low cost firm, even when the low cost firm produces a substantial share of industry output. Finally, we find that the different voting rules faced by producers in MMO referenda yield distinct differences in voting power in markets with heterogeneous producers.

Our contributions to the literature are threefold. First, we contribute to both the voting power and agricultural economics literature, as to the best of our knowledge we are the first authors to examine marketing order referenda through the lens of voting power. Second, we contribute to the voting power literature by connecting the work on voting preferences and empirical voting power measures to the neoclassical theory of the firm in the form of our Feasible Banzhaf Power Index. This index is useful in that it incorporates information about behavior to provide a more realistic measure of voting power in settings with firms in the role of voter. And finally, through the analysis of voting power measures, we provide new insights about the potential challenges agricultural producers face in adapting their MMOs in a rapidly changing economic landscape. As agricultural market structures have changed over time, agricultural economists have moved away from the long-held assumption of perfect competition in some agricultural settings. Our work shows how the marriage of voting power methodology and agricultural economics can shed new light on how market power and cost heterogeneity interact with agricultural institutions in changing markets.

The remainder of the paper proceeds as follows. In Section II, we give a brief history of MMOs and discuss the relevance of our work to agricultural policy. In Section III, we relate our work to the relevant literature in agricultural economics and political science. In Section IV, we present our theoretical model. In Section V, we discuss our simulations and calibration methodology. Section VI includes the presentation and discussion of our results, and Section VII concludes.

2 Background and policy relevance

MMOs were first authorized at the federal level by the Agricultural Adjustment Act of 1933 and the Agricultural Marketing Agreement Act of 1937. Initially, they were a policy response to ongoing low and volatile returns to agriculture in the 1920s and 1930s. Subsequent state and federal legislation has allowed for the formation of related types of organizations. MMOs were designed to mitigate the "disruption of the orderly exchange of commodities" and protect the "value of agricultural assets which support the national credit structure." (U.S. Code, 2014). The continued presence in today's U.S. Code of these justifications and others first voiced in the 1930s suggests that MMOs are still considered a valuable tool for meeting these objectives. However, the structure of agricultural production has changed considerably since the 1930s, suggesting that the value of MMOs may have changed as well.

When MMOs were introduced during the Great Depression, farms in the United States were relatively homogeneous compared to today. In 1934, 1.3% of farms were larger than 1000 acres and represented only 6.7% of harvested cropland. In contrast, in 2012, 8.2% of farms were larger than 1000 acres, representing 64.2% of harvested cropland. In 1934, 39.5% of farms were smaller than 50 acres, and represented 11.2% of harvested cropland. In 2012, 38.5% of farms were smaller than 50 acres, representing 1.40% of harvested cropland (NASS, 1935; NASS, 2014). In the 1930s, there were fewer large farms, and large farms represented a considerably lower percentage of the nation's harvested cropland. Thus, promoting the orderly exchange of commodities meant managing the interests of smaller farmers with negligible or nonexistent potential to affect the market individually. In contrast, there is considerable heterogeneity in farm size and revenues today. Of course, cost—which is an important factor in determining farm size and revenue—is only one of many dimensions of heterogeneity among producers. Producers may also be heterogeneous in terms of operator age, crop mix, land quality, or non-farm income sources. Nevertheless, for simplicity we limit our discussion of heterogeneity to farm sizes, which has changed considerably over time.

The implication of this increase in heterogeneity is that it could cause MMOs to yield an unequal distribution of benefits across farm sizes, even proving costly for some producers. In turn, these differences could cause producers in the same industry to disagree about the need for MMOs. This circumstance may explain why growers in industries covered by MMOs have been suing the U.S. government over issues related to their mandatory nature during the last several decades (Crespi 2003a). These differences of opinion suggest a need for MMOs to have a mechanism to adapt their functions and assessment rates over time... and they do. Producer referenda play an important role in determining whether organizations continue and in some cases whether major amendments that change the focus of activities conducted by the MMO should be passed. But, when disagreement occurs among producers because an MMO benefits some producers and not others, the scope for change using these referenda can be limited due to the requirements of the voting rule.

Voting rules are particular to each marketing order and are developed in collaboration between industry and the USDA or equivalent state-level department.[2] Voting rules may require a single, double or triple majority. An example of a single majority rule would be that the MMO would be formed if more than half of the producers voting favored formation. An example of a double majority rule would be the requirement that more than half of the producers voting *and* producers of more than half of the total output of those voting favor formation. Finally, an example of a triple majority rule would be the requirement that more than half of the producers voting *and* producers of more than half of the total output of those voting favor formation, with a quorum requirement of 50%.[3]

In this paper we consider the most common formation and termination rules for federal marketing orders. Formation of a federal marketing order requires approval by at least two thirds of those producers voting by number or producers of at least two thirds of the total output of those voting. Termination requires approval by more than half of those producers voting by number who must *also* produce more than half of the total production of those voting. These rules do not include a quorum requirement, although the Secretary of Agriculture has taken the participation rate into account on certain occasions. In our model we assume 100% participation.

[2]Much is at the discretion of the Secretary of Agriculture (or state equivalent), and for the formation of some state-level MMOs, legislative approval is also required.

[3]One interesting implication of a quorum rule is that by simply not participating, producers are effectively casting a “no” vote. This area remains a topic for future research.

Given these rules, if an industry comprised of homogenous producers desires to form or terminate a MMO, industry members have the ability to make those changes. This may not be the case in industries with heterogeneous firms where not all industry members are aligned in their profit-maximizing choices. In such cases, the question remains of whether heterogeneity among firms may lead to disproportionate voting power among firms, and how this affects an industry's ability to adapt and change its MMO to meet its needs. This question is the central topic of our paper.

3 Relevant literature

This work relates to veins of literature in agricultural economics and political science. Several recent studies have examined the distributional implications of generic commodity promotion programs, and there is a rich literature in coalition formation among agricultural producers. In the political science literature, the work on voting power indices stretches back to the 1940s. Although this literature has a large theoretical component, there is a spate of more recent applied work. Much of this work is focused on recent changes to member state representation on the Council of the European Union. There is also some work on the voting power of shareholders in large companies. Like our analysis, this work focuses on the importance of firms, (as opposed to nations or individual citizens) in the role of the voter.

Within the extensive literature regarding generic commodity promotion programs, three recent studies consider firm-level heterogeneity and its effects on the benefits firms obtain from MMOs. Chung and Kaiser (2000) showed that producers with a less elastic supply response capture more benefits per dollar of generic advertising expenditure than producers with a more elastic supply response. Building on this analysis, Chung and Kaiser (2003) suggest that producers with steeper marginal cost curves and fewer fixed factors have a lower marginal benefit per unit of generic advertising expenditure than producers with flatter marginal cost curves and more fixed factors. Crespi and Marette (2003) consider firm heterogeneity in output quality. They find that when a crop covered by a marketing order is horizontally differentiated, the benefits of a uniform assessment are not equitably distributed between the producers of the two different varieties. The newest papers in this vein consider the effects of market power. Crespi and Marette (2009) model an agricultural market as a monopoly with a potential entrant and consider a demand-enhancing check-off program. They find that generic promotion can be pro-competitive due to cost-sharing by firms and consumers' increased exposure to the product. This paper shows that relaxing the assumption of price-taking firms can alter conclusions regarding the effects of MMOs, a theme we continue.

Our work most closely relates to that of Zheng, Bar and Kaiser (2010). They consider how benefits of generic advertising vary with farm size (driven by heterogeneous costs) assuming an asymmetric oligopoly. In their work, they vary both the convexity of the demand curve and the type of demand shift and demonstrate that there are cases in which firms differentially benefit from generic advertising. Our work, like theirs, considers the implications of cost heterogeneity among farms and the implications of market power. However, we focus on the distribution of voting power. In addition, our work differs from theirs in other important ways. First, we consider heterogeneity in terms of costs and multiple market structure scenarios; they only consider cost heterogeneity under asymmetric oligopoly. Second, they only consider the distribution of the associated benefits of generic promotion compared to a counterfactual of no promotion and do not consider the referenda that lead to these generic promotion programs. Our work builds on theirs by considering how these differential benefits interact with the institutional framework of the MMO.

In addition to this work on generic promotion, there is a literature in agricultural economics related to coalition formation in the context of agricultural cooperatives stemming from Staatz (1983) and Sexton (1986) that draws on the methodology of cooperative game theory. While there are some strong parallels to this work, the nature of MMOs does not lend itself to this framework because of its disaggregated nature. Although we consider some strategic interactions among firms in the market, in the formation of MMOs, referenda are mandated by law and administered by the government, and therefore the type of producer interaction modeled in cooperative game theory is not necessary for an MMO to exist.[4] The sharing rule of the benefits stemming from the formation of the MMO is simply that each producer keeps his own profits. In addition, we must make an important distinction between the mandatory nature of MMOs and the voluntary nature of other types of organizations such as cartels, cooperatives, and strategic alliances. These organizations

[4]A notable exception to this statement is at the point of formation, when a subset of producers will petition the government to form the MMO, after which the government agency will hold a hearing and then an initial referendum vote. However, there are few requirements regarding the petition apart from being industry members, and much is at the discretion of the Secretary of the agency. Considering the aspects of power held by the key industry participants who participate in this initial conversation about the MMO is not within the scope of this paper. Once the referendum ballot arrives in the mailboxes of producers, it is a simple binary choice.

may form among firms that benefit from them within a larger industry. Thus, a dominant producer choosing not to participate is not necessarily a death knell for an agricultural cooperative. However, the vote of this producer in a MMO referendum could be vital.

To measure voting power, we use a metric developed by Banzhaf (1965) and also attributed to Penrose (1946) which measures the ability of each voter to cast a swing vote. Straffin (1977) characterized the Banzhaf Power measure and another well-known and oft-used voting power measure, the Shapley-Shubik Index, according to their assumptions about probabilities. Our Feasible Banzhaf Power Index follows Straffin as well as Laruelle and Valenciano (2005), who developed a unified approach to the Banzhaf Power Index and related voting power indices by providing a more general characterization of the probabilities underlying these measures. The voting power literature is expansive, and a number of academics have proposed new or related voting power indices throughout the 20th century (for a concise history of these different indices and their relationships, see Felsenthal and Machover (2005)).

In addition to theoretical work regarding voting power, there is considerable work applying these concepts to specific empirical contexts. Voting power indices have been utilized recently to examine the representation of nations on the Council of the European Union. Multiple majority rules for the Council were established by the Treaty of Nice and later amended in the Treaty of Lisbon, and political scientists have considered the implications of various voting rules implemented or under consideration by the Council at various points in time (e.g. Hosli, 1995; Laruelle and Widgrén, 1998). Our work is similar to theirs in that it deals with questions of changing relative size (in their work, the "size" is population, not share) and its effect on voting power, as well as what the optimal voting rules would be depending on the goal of policymakers.

While much of the applied focus has been on political representation in the EU, there have also been applications to other settings. Leech (1988, 2002) examines the validity of voting power measure among the shareholders of large British companies by calculating voting power based on the share of votes held by the largest shareholders and comparing the result to expert evidence regarding the level of control these shareholders exert on the companies they own shares of. This work is similar to our own in that it considers a context in which the goal of voters is likely to be profit-maximization. As Leech (2002) points out, in a vote that would yield an unambiguous increase in share value for all shareholders, under the assumption of profit-maximization, we would expect all shareholders to vote for the measure, making the context fairly uninteresting. However, this information can also be incredibly useful, as we show in this paper.

Finally, in addition to these applications, some authors have developed empirical voting power indices that incorporate information on voter preferences (e.g. Pajala and Widgrén, 2004; Badinger et al., 2014). In these empirical approaches, the authors propose rules that limit the number of winning coalitions by locating voting bodies relative to each other in a uni-dimensional policy space. Locations are defined by observed voting behavior. While incorporating information on voter preferences is appealing, determining voting bodies' relative positioning in policy space is mathematically intensive, and the resulting ordering does not provide an intuitive link to policy positions. We avoid some of these challenges by incorporating the accepted neoclassical theory of the profit-maximizing firm into our development of our Feasible Banzhaf Power Index.[5]

4 Model

The theoretical model has two components: the behavior of profit-maximizing firms under different market structures, and the characterization of voting power. We design our model to be as simple as possible while still allowing us to compare results across different market structures and different types of demand shifts.

4.1 Market structure and profit maximization

An industry consisting of N growers produces a homogeneous agricultural product for competitive buyers represented by the affine aggregate inverse demand function $P(Q) = A - BQ$. We consider three market structures: dominant firm/competitive fringe, competition, and Cournot oligopoly. One of the N firms in the market has a cost advantage and the remaining $N - 1$ firms have heterogeneous costs above a specified threshold value, ensuring that their costs are greater than those of the low cost firm. Assuming $i, j \in \{1, ..., N\}$, firm i has cost function $C_i(q_i) = \frac{aq_i^2}{2} - c_i q_i$,

[5]We readily acknowledge that some who study voting power take issue with the incorporation of preferences. Braham and Holler (2005) question whether empirical voting power indices are a valid measurement of power—in other words, whether it is "conceptually meaningful for *any* measure of power – not just voting power – to include the preferences of the player whose power is being measured" [authors' emphasis] (Braham and Holler, 2005: 138). They raise a valid criticism, but in turn we must ask the question of whether it is "conceptually meaningful" in the measurement of power to consider situations in which the player would never find herself. We do not attempt to resolve this theoretical argument, but we wish to acknowledge it as an important consideration in any discussion of empirical voting power measures.

and the low cost firm has cost parameter c_i such that $c_i < c_{j \neq i}$. The cost of operating the MMO is represented by t, the per-unit assessment on output. We do not allow entry or exit and, accordingly, normalize fixed costs to zero. Unlike the classical result of complete rent dissipation in the long run for homogeneous, perfectly competitive firms, firm heterogeneity and market power imply that even free entry may not dissipate the benefits of the MMO entirely, even in the long run.

We begin with the dominant firm/competitive fringe model in which the low cost firm is dominant and the high cost firms are a competitive fringe. Fringe firms maximize profit taking price as given, and the dominant firm maximizes profit taking its residual demand curve as given. This initial market equilibrium could be one with or without an MMO, although the values of parameters A, B, or both will be different in the formation and termination cases, depending on the type of demand shift caused by the MMO.

The fringe firm f's profit maximization problem (assuming $f \in \{1, ..., N-1\}$) is:

$$\max_{q_f} \ \Pi_f = Pq_f - \frac{aq_f^2}{2} - c_f q_f - tq_f. \tag{1}$$

The residual inverse demand faced by the dominant firm is:

$$P(q_D) = \frac{A - Bq_D + \frac{B}{a}\left(\Sigma_{f=1}^{N-1} c_f + (N-1)t\right)}{\frac{B}{a}(N-1)+1}, \tag{2}$$

so its profit maximization problem is:

$$\max_{q_D} \ \Pi_D = P(q_D)q_D - \frac{aq_D^2}{2} - c_D q_D - tq_D. \tag{3}$$

The optimal output for the dominant firm is thus:

$$q_D^* = \frac{A - c_D - t + \frac{B}{a}\left(\Sigma_{f=1}^{N-1} c_f - (N-1)c_D\right)}{B(N+1)+a}. \tag{4}$$

The equilibrium price is:

$$P^* = \frac{A + \frac{B}{a}\left(\Sigma_{f=1}^{N-1} c_f + (N-1)t\right)}{\frac{B}{a}(N-1)+1} - \frac{B}{\frac{B}{a}(N-1)+1}\left[\frac{A - c_D - t + \frac{B}{a}\left(\Sigma_{f=1}^{N-1} c_f - (N-1)c_D\right)}{B(N+1)+a}\right], \tag{5}$$

and fringe firm f produces:

$$q_f^* = \frac{P^* - c_f - t}{a}. \tag{6}$$

In the asymmetric oligopoly case, firm i's profit maximization problem (where $i, j \in \{1, ..., N\}$) is:

$$\max_{q_i} \ \Pi_i = P(q_1, ...q_N)q_i - \frac{aq_i^2}{2} - c_i q_i - tq_i. \tag{7}$$

The optimal output for firm i is thus:

$$q_i^* = \frac{(B+a)(A-t) - [B(N+1)+a]c_i + B\Sigma_{j=1}^N c_j}{(B+a)[B(N+1)+a]}, \tag{8}$$

and the equilibrium price is:

$$P^* = \frac{A(B+a) + B(\Sigma_{j=1}^N c_j + Nt)}{B(N+1)+a}. \tag{9}$$

In the asymmetric competition case, firm i's profit maximization problem (where again $i, j \in \{1, ..., N\}$) is:

$$\max_{q_i} \ \Pi_i = Pq_i - \frac{aq_i^2}{2} - c_i q_i - tq_i. \tag{10}$$

The optimal output for firm i is thus:

$$q_i^* = \frac{A - t + \frac{B}{a}\Sigma_{j=1}^N c_j - (\frac{BN+1}{a})c_i}{BN+a}, \tag{11}$$

and the equilibrium price is:

$$P^* = \frac{Aa + B(\Sigma_{j=1}^N c_j + Nt)}{BN+a}. \tag{12}$$

For each of these market structures, we consider what happens when the formation of the marketing order causes an increase in demand (or equivalently, if the termination of the marketing order causes a decrease in demand). Implicitly, $A = A(t)$ and $B = B(t)$. We suppress the t for notational clarity. When there is no MMO in place, t, the per-unit assessment, is equal to 0, and the slope and intercept of inverse demand are defined as the parameters $B = B_0$, and $A = A_0$. When an MMO is in place, all producers pay a per-unit output assessment of $t > 0$.[6] The benefit to producers of the presence of the MMO is higher demand, represented by the new demand parameters $B = B_1$, and $A = A_1$. We consider three of the four possible demand shift cases considered by Zheng et al. (2010): a parallel demand shift and elastic and inelastic demand rotations. Case 1 is an inelastic rotation in demand ($A_1 > A_0$ and $B_1 > B_0$ such that $\frac{A_1}{B_1} = \frac{A_0}{B_0}$). Case 2 is a parallel demand shift ($A_1 > A_0$). Case 3 is an elastic rotation of demand ($B_1 < B_0$). For all three cases, we assume that the percentage price increase is the same at the initial non-MO equilibrium quantity. Both the assessment and the benefits of the MMO are known by the producers when they vote. Consistent with the structure of the model producers assume there will be zero entry due to the formation of the MMO.

4.2 Voting power

We measure producers' voting power using the Banzhaf Power Index. The index value represents a voter's ability to change the outcome of an election or vote and is defined on the [0,1] interval (Banzhaf, 1965).[7] Assuming $i \in \{1, ..., N\}$, for any voter i, the Banzhaf Power Index is defined as:

$$BP_i = \frac{2 * Critical_i}{2^N} = \frac{Critical_i}{2^{N-1}}, \tag{13}$$

where 2^N is the number of possible voting configurations and $Critical_i$ is the number of times voter i casts a critical vote, given all possible winning coalitions. A winning coalition is any combination of voters that, given the voting rule, can pass the proposed action. For instance, for a simple

[6] In practice, the assessment is developed by a subset of producers, and the boards of existing organizations wield considerable power in driving organizational changes. Cave and Salant (1995) and others have considered the incentives facing this subgroup. We abstract away from this empirical regularity. For our purposes, this is a valid simplifying assumption because in our context the (generally substantial) majority of producers are made a take-it-or-leave-it offer.

[7] Another candidate index we could consider is the Shapley-Shubik Index. This index can be derived in two different ways. One way is through a probabilistic assumption of homogeneous voting probabilities (see Straffin, 1977), and the other utilizes cooperative game theory. The former approach assumes all voters have a homogeneous probability of voting for the measure, while the latter approach is based on the idea that there is a fixed prize that is divided among the "yes" voters in the event of a win and that the index represents an estimate of the voter's share of this payoff. The latter derivation is a poor fit with our context, and we believe the former derivation does not allow us to adequately address producer heterogeneity, which is the core focus of our paper. We therefore proceed using the Banzhaf Power Index alone for our analysis.

majority vote in a population of 10 voters, a coalition is any set of the 10 voters that has at least six voters in it. A voter is critical if without her vote, the coalition would no longer be a winning one. Implicit in the Banzhaf Power Index formulation is the assumption that *on average*, voters vote for the measure with a probability of 0.5 and vote against the measure with a probability of 0.5 (i.e., there are no abstentions). This assumption results in the condition that all voting configurations are equally likely.

To calculate the Feasible Banzhaf Power Index, we consider the same winning coalitions, but instead of assuming that all voting configurations are equally likely, we build on Straffin's (1977) probabilistic set-up to determine new probabilities of coalition formation based on expected producer behavior. For each combination of cost structure, market structure, and demand shift, each vote for an initiative has two sets of voters—those who benefit from the initiative and those who do not benefit from it given the assumption of profit-maximizing behavior. Assume there are m voters who benefit from the initiative and n voters who do not benefit from it. Now assume that voter k votes in accordance with his profit-maximizing choice with probability $1-\epsilon_k$ and votes for the opposite of his profit-maximizing choice with probability ϵ_k, assuming $\epsilon_k \sim i.i.d.(\bar{\epsilon}, \sigma)$. Then, the probability of a voter who does benefit from the initiative voting for it is: $p_k = 1-\epsilon_k$, and the probability of a voter who does not benefit from the initiative voting for it is $q_k = \epsilon_k$. Further assuming that $v_k = 1$ if voter k votes for the initiative and $v_k = 0$ if voter k votes against the initiative, where $k \in i, j$, we know that the probability, P, of a particular voting configuration, $S = \{v_1, ..., v_m; v_1, ..., v_n\}$ given $\{p_1, ..., p_m, q_1, ..., q_n\}$ is:

$$P(S) = \big[\prod_{j=1}^{m} p_j^{v_j}(1-p_j)^{1-v_j}\big]\big[\prod_{i=1}^{n} q_i^{v_i}(1-q_i)^{1-v_i}\big] = \big[\prod_{j=1}^{m}(1-\epsilon_j)^{v_j}(\epsilon_j)^{1-v_j}\big]\big[\prod_{i=1}^{n}\epsilon_i^{v_i}(1-\epsilon_i)^{1-v_i}\big]. \quad (14)$$

Following Laruelle and Valenciano (2005), we can then characterize the Feasible Banzhaf Index as:

$$FBP_i = \sum_{\substack{S: i \in S \in W \\ S \setminus i}} P(S) + \sum_{\substack{S: i \notin S \notin W \\ S \cup i \in W}} P(S), \quad (15)$$

where i is a voter, S is a coalition, W is the set of winning coalitions and $P(S)$ is as defined in equation (14). The first term is the sum of the probabilities of formation of the winning coalitions containing i which would not be winning if i was not in the coalition. The second term is the sum of the probabilities of formation of the losing coalitions not containing i which would be winning coalitions if i was in the coalition. Thus, if we assume $\epsilon_i = \epsilon_j = 0.5 \; \forall \; i, j$, we simply have the Banzhaf Power Index. All coalitions have an equal probability of formation ($P(S) = \frac{1}{2^{m+n}} \;\; \forall S$), so the expression in (15) simplifies very neatly to the more usual characterization of this index as written in equation (13). Or, if we instead assume $\epsilon_i = \epsilon_j = 0 \; \forall \; i, j$, then we are in a world of certainty, where one voting configuration occurs with probability one (the configuration in which all producers who benefit from the MMO vote for it and all those who don't benefit from the MMO vote against it) and all other voting configurations occur with probability zero.[8]

Although not a major departure from prior indices, this formulation is particularly important in that we incorporate producers' profit-maximizing behavior and then make an assumption about the importance of behavioral factors play (i.e. how much producers depart from profit-maximization) in their voting behavior. Anecdotal evidence from conversations with agricultural producers and MMO managers in California suggests that these behavioral factors are important. For instance, some producers who would appear to benefit financially from a MMO may oppose MMOs on ideological grounds. The Feasible Banzhaf Power Index incorporates the same information about critical voters as the Banzhaf Power Index but provides a revised estimation of the probability of the coalitions in which the critical votes occur based on the assumption of profit-maximizing behavior (or some small idiosyncratic departure from it).

Finally, any voting power measure depends fundamentally on the voting rules being considered. Assuming N producers vote in the referendum, the voting rule for formation is the union of two weighted majority games, and the termination rule is an intersection of two weighted majority games.[9] Assuming q^*_{0l} is the output of producer l prior to the formation of the MMO, the the formation rule can be expressed as $U \cup V$, where:

$$U = \left\{ \frac{2}{3}N; \underbrace{1, ..., 1}_{N} \right\} \text{ and } V = \left\{ \frac{2}{3} \sum_{i=1}^{N} q_{0i}; q_{01}, ..., q_{0N} \right\}. \tag{16}$$

Then a winning coalition of size $L \leq N$ is any coalition of members $l \in L$ that satisfies one of the

[8]Note that if we assumed $\epsilon_i = \epsilon^* \; \forall \; i$ and $\epsilon_j = \epsilon^{**} \; \forall \; j$, we would get the partial homogeneity model identified by Straffin (1977).

[9]We are grateful to an anonymous reviewer for pointing out this elegant way to characterize the voting rules.

following two conditions:

$$L \geq \frac{2N}{3}, \text{ or} \tag{17}$$

$$\Sigma_{l=1}^{L} q_{0l}^{*} \geq \frac{2\Sigma_{i=1}^{N} q_{0i}^{*}}{3}. \tag{18}$$

Since only one of inequalities 17 and 18 must hold for the coalition to be a winning coalition, it follows that a losing coalition is a coalition for which *neither* of the two inequalities holds. Thus, a firm is a critical voter if once it leaves the winning coalition, the coalition does not have a two-thirds majority of voters *and* the coalition does not produce a two-thirds majority of industry output. Similarly, assuming q_{1l}^{*} is the output of producer l after the formation of the MMO, the termination rule can be expressed as $Y \cap Z$, where:

$$Y = \left\{ \frac{1}{2}N; \underbrace{1, ..., 1}_{N} \right\} \text{ and } Z = \left\{ \frac{1}{2} \sum_{i=1}^{N} q_{1i}; q_{11}, ..., q_{1N} \right\}. \tag{19}$$

Then a winning coalition of size $L \leq N$ is any coalition of members $l \in L$ that satisfies the following two conditions:

$$L > \frac{N}{2}, \text{ and} \tag{20}$$

$$\Sigma_{l=1}^{L} q_{1l}^{*} > \frac{\Sigma_{i=1}^{N} q_{1i}^{*}}{2}. \tag{21}$$

This output of producer l after the formation of the MMO is the output given the MMO assessment, t, and the corresponding increase in demand due to the MMO.[10] A firm is a critical voter if when it leaves the winning coalition one of three outcomes occurs: the coalition no longer has a majority of voters, the coalition no longer produces a majority of industry output, or both.

5 Simulations

Given the double majority nature of Federal MMO voting rules and the consequent challenge of deriving analytical results regarding the relationship between market structure and voting power, we turn to numerical simulation to examine the distribution of voting power among firms in our

[10] It's important to note that a situation could exist in which a voter is critical in the case of formation but not in the case of termination because the producer's share of output may be different in the two cases.

setting. Where possible, our simulations are calibrated to the California almond industry and its Federal marketing order operated by the Almond Board of California (see ABC, 2015a), which has key characteristics to that we wish to examine. Among the functions of this marketing order is a provision for generic commodity promotion. In addition, the industry has a large agricultural cooperative, Blue Diamond Growers, which represents half of the state's growers and 80% of world almond production (Blue Diamond 2015). Almonds, of course, are a perennial tree crop. Our static model obviously ignores important dynamic aspects of this industry. It is thus most appropriate to think of our pre- and post-MMO equilibria as long-run equilibria given the dynamic adjustment process of both demand and supply rather than as immediate adjustments.

In describing our simulations, we refer to the model notation described in Section 4.1. We assume that the number of firms, N, is equal to 10. One of these is the low cost firm.[11] All firms have the same marginal cost slope, a, which is set equal to 3x10^{-9}. The intercept of marginal cost, c_i, varies across firms. We specify a cost advantage x, where $x \in \{1, 2, 3, 4, 5\}$. The process of selecting the marginal cost intercept parameters ensures the low cost firm has a lower intercept than the high cost firms and thus produces at lower cost at any give level of output. To select these parameters, we first draw a random vector of size $25N$ from an uniform (0.5,3) distribution to yield marginal cost figures consistent with the University of California Cooperative Extension's cost and return study for almond production in the Sacramento Valley of California (Connell et al., 2012). The smallest element is the low cost firm's marginal cost intercept parameter. Then we provide the low cost firm with a "cost advantage" by deleting all elements that are less than the magnitude of x multiplied by the intercept parameter of the low cost firm, where $x \in \{1, 2, 3, 4, 5\}$. We then take a random sample of size $N - 1$ from the remaining elements to get the intercept parameters of the high cost firms' marginal costs. The size of the original vector (25N) is chosen to be large enough to provide a pool of elements to draw from after the deletion of elements used to provide the cost advantage. For each set of firm costs, we consider three different market structures: dominant firm/competitive fringe, Cournot oligopoly, and competition.

We assume that pre-MO, the demand intercept, A, is equal to $A_0 = 9$ and the absolute value

[11] This assumption is the notably departs from the California almond industry. In fact, there are many more than 10 firms. It is not within the scope of this article to explore the implications of modeling this industry as an oceanic game, although we believe that would be an interesting extension. As Leech (2013) points out, the properties of voting power in large voting bodies is an under-explored area of the literature.

of the slope of demand, B, is equal to $B_0 = 3.3\text{x}10^{-9}$, which yield estimations of almond demand consistent with Crespi and Chacón-Cascante (2004) and Crespi and Sexton (2005). We simulate 500 markets for each cost level, measuring each firm's market share and Banzhaf Power Index value, the latter of which is independent of the producers' referendum decisions. Next we specify the costs and benefits of the MMO in order to calculate the Feasible Banzhaf Power. We assume the per-unit assessment, t, is 0.03, this 2014-2015 per-pound assessment levied on California almond growers by the Almond Board of California (ABC, 2015b). Following the general structure of federal requirements for MMOs, as described in Section 4.2, we assume the marketing order will be formed if at least two-thirds of producers *or* producers of at least two thirds of total output favor formation and we assume the marketing order will be terminated if more than half of producers *and* producers of more than half of total output favor termination.

We consider three possible ways that the formation of the MMO could affect demand. All three yield a 5% increase in the equilibrium price at the original equilibrium output, consistent with the estimation of ABC commodity promotion benefits by Crespi and Sexton (2005). Case 1 is an inelastic rotation of demand. The demand curve rotates upward, with the lower intercept unchanged. Case 2 is a parallel demand shift. Case 3 is an elastic rotation of demand. The demand curve rotates outward with no change in the upper intercept. In total, we evaluate 90 scenarios defined by cost advantages (5), market structures (3), demand shifts (3), and voting rules (2).

To calculate both indices, we simulate a market using the methods indicated above and construct all possible winning coalitions in MATLAB R2013b. To calculate the Banzhaf Power Index we then loop over the coalitions and sum the number of critical votes for each firm in each simulation. For the calculation of Feasible Banzhaf Power, we draw a parameter that represents the probability, ϵ_i, that producer i departs from profit-maximizing behavior. We draw these parameters from a uniform (0,0.5) distribution so that producers can range between near perfect profit-maximization to random voting. The consequence of this assumption is that on average producers depart from their profit-maximizing choice with probability 0.25 in our model. To calculate the index itself, we loop over each coalition and for each firm, we sum the probabilities of formation over all the coalitions in which that firm is critical.

6 Results and discussion

In Table 1 we report the pre-vote market shares and Banzhaf Power Index and Feasible Banzhaf Power Index values associated with formation for the low cost firm and average high cost firm. The Banzhaf Power Index incorporates no information about producer behavior—it is simply a product of the voting rule and is not affected by the demand shift that will occur in the event the proposed action is passed. We thus use pre-vote outputs to calculate it. On the other hand, the Feasible Banzhaf Power Index uses the additional information about whether or not producers benefit from the MMO, so its value depends on the resulting shift in demand if the proposed action is passed. The formation voting rule that we consider requires at least two thirds of producers *or* producers of two thirds of output to vote for the MMO for it to be formed. Thus, there are two ways for a firm to be a critical voter. In Tables 2 and 3, we report the pre-vote market shares and Banzhaf Power Index and Feasible Banzhaf Power Index values associated with termination for the low cost firm and average high cost firm, respectively. The termination voting rule that we consider requires more than half of producers *and* producers of more than half of output to vote against the MMO for it to be terminated. Now, we return to our research question and examine how market power and cost heterogeneity affect voting power as measured by these two indices.

6.1 Formation

In the case of formation, both the Banzhaf Power Index value and Feasible Banzhaf Power Index value of the low cost firm are highest under competition, followed by the dominant firm/competitive fringe market structure and then the Cournot market structure. As the market power of the low cost firm increases, the low cost firm restricts its output relative to the competitive case to maintain a higher price. Because the voting rule we consider is in part based on market share, this restriction of output causes the Banzhaf Power Index value to be smaller than it would be if the low cost firm (and other firms, in the Cournot case) did not have market power. This result holds under all cost advantages and can be seen in the first column labeled "BP" in Table 1 by comparing values for the three market structures for a given cost advantage.

Changes in voting power are driven by three related factors: market share of the firm, the number of critical votes of the firm, and the probability of formation of coalitions in which the firm is critical. In all cases, the market share of the low (average high) cost firm increases (decreases) as the low cost firm's cost advantage increases. Finally, for the Feasible Banzhaf Power Index case, the probability of formation of coalitions in which the firm is critical weakly decreases for both types of firms as the low cost firm's cost advantage increases. The patterns in voting power depend on which of these effects dominates.

Across all three market structures in the case of MMO formation, we see that at low cost advantages the effect of increasing market share and the resulting increase in the number of critical votes dominate for the low cost firm. As market share of the low cost firm increases, coalitions that were not previously winning coalitions can become winning coalitions, and firms that are critical in these new winning coalitions see an increase in the number of critical votes. We see this phenomenon for high cost firms as well because even though their market share is decreasing, they benefit from the increase in winning coalitions. While the reason for this increase is logical for the low cost firm, it is less obvious for the high cost firm. This result is due to the particular nature of the voting rule; it is a *union* of two weighted voted games rather than an *intersection*. When the market shares of all the high cost firms are relatively similar to that of the low cost firm, the only winning coalitions will be those who contain many voters. Thus, the coalitions meeting one of the quotas will also meet the other quota. However, as the market share of the low cost firm increases, the number of coalitions that only meet one of the two quotas will increase, increasing the number of critical votes for both low and high cost firms.[12] This effect drives the Banzhaf Power Index value of all firms upward as the low cost firm's cost advantage increases.

The probability of coalitions forming is a product of the probabilities that the firms in the coalition will vote for the proposed action. The probability of winning coalitions forming increases if more firms benefit from the MMO. In the case of MMO formation, as the cost advantage of the low cost firm increases we see increasing heterogeneity and thus disagreement among the producers, which drives the probability of winning coalitions forming downward.

In the dominant/competitive and competitive firm market structures in a vote for MMO formation, the critical vote effect dominates the probability effect at low cost advantages, but the

[12]An anonymous reviewer pointed out that this result could also be driven by the *paradox of redistribution*—a situation in a weighted voting game in which a voter's weight decreases whilst the voter's voting power increases (Felsenthal and Machover 1998). While we can't rule out this paradox as a possible mechanism for our results, the fact that we do not see this pattern in the Banzhaf Power Index in the case of termination suggests to us that the relationship between the Banzhaf Power Index and market share that we observe here is driven mainly by the structure of the voting rule for formation.

market share of the low cost firm builds quickly and the probability effect begins to outweigh the critical vote effect. However, we see the opposite in the case of Cournot. At low cost advantages, the probability effect outweighs the critical vote effect. This is due to the fact that the market share of the low cost firm is relatively low at this point and increases very slowly, since all firms are acting strategically. Thus, the increase in the number of critical votes that occurs with an increase in market share and the number of winning coalitions is smaller than in the other two market structures. These result hold for both low cost and high cost producers.

Comparing Feasible Banzhaf Power across demand shift scenarios, we see that for the dominant/competitive and competitive markets, both types of firms have weakly higher Feasible Banzhaf values with an inelastic demand shift compared to the other two types of shifts. This is due to the fact in the case of an inelastic demand shift, firms with low market share benefit more than those with high market share. In the case of Cournot, we see that the inelastic demand shift actually yields weakly lower Feasible Banzhaf Power as compared to the other two demand shifts across both firm types due to the smaller difference in market shares between the high and low cost firms.

[Table 1 goes here.]

6.2 Termination

Although the determining factors are the same, the voting power results for MMO termination are different from those for formation. The three related factors driving changes in voting power are: market share of the firm, the number of critical votes of the firm, and the probability of formation of the coalition in which a firm is critical. In all cases, the market share of the low (average high) cost firm increases (decreases) as the low cost firm's cost advantage increases. At the same time, the number of critical votes for the low cost firm increases as its cost advantage increases, but the number of critical votes for the high cost firms *decrease*, due to the nature of the voting rule as an *intersection* between two voting games, rather than a *union* like the formation rule. As the market share of low cost producers decreases, winning coalitions that once met the production and number requirements of the voting rule may only meet the number requirement and therefore are no longer winning. This pattern of critical votes is reflected in the three columns of Banzhaf Power Index values in each of Tables 2 and 3, labeled “BP.”

In looking at the Feasible Banzhaf Power Index, a first main difference to notice between Table 1 (values for MMO formation) and Tables 2 and 3 (values for MMO termination) is that the Feasible Banzhaf Power Index values in the latter two tables are an order of magnitude smaller. As indicated in the previous section, the probability of winning coalitions forming increases if more firms benefit from the MMO. We see relatively high values for Feasible Banzhaf Power for MMO formation as compared to MMO termination because more firms benefit from the MMO under the specified parameterization.

Examining the probability of coalition formation, the probability of formation of coalitions in which the low cost firm is critical weakly decreases as its cost advantage increases across all three market structures and all three demand shifts. This result is consistent with disagreement among firms becoming more common as the market share of the low cost firm increases. However, in contrast to the MMO formation case, for the high cost firms in the dominant/competitive and competitive market structures, the probability of formation of coalitions in which they are critical first decreases as the low cost firm's cost advantage increases, and then increases again at higher cost advantages. We again attribute this result to the more restrictive voting rule regarding termination. As the market share of the low cost firm increases, the market shares of the high cost firms necessarily decrease. Thus, at low cost advantages, as the cost advantage of the low cost firm increases, the winning coalitions in which the high cost firms are critical lose their ability to meet the production requirement of the voting rule and the winning coalitions that it remains in suffer from some disagreement. At higher cost advantages, as heterogeneity between the low cost and high cost producer increases, the high cost producers become critical in fewer winning coalitions due to this continued challenge of meeting the production requirement, but for those winning coalitions for which it is still critical, there is greater agreement among producers about the benefits of the MMO.

On the other hand, for the Cournot market structure, the number of critical votes decreases relatively slowly as cost advantage increases and the probability of coalition formation for the high cost producer decreases as well, so this effect seems to be driven by disagreement among producers as producer heterogeneity increases. However, despite these underlying differences across market structures, the net effect of these factors is that Feasible Banzhaf Power increases (decreases) for the low (average high) cost firm as the low cost firm's cost advantage increases, thus following the same pattern as the Banzhaf Power Index, as we see in Tables 2 and 3.

There are no apparent differences in Feasible Banzhaf Power across demand shift scenarios. This result is not surprising and is consistent with the voting power literature. Since the voting rule requirements prevent a few large producers or many small producers from effecting change, shifts that yield disproportionate benefits are unlikely to afford producers greater Feasible Banzhaf Power.

[Table 2 goes here.]

[Table 3 goes here.]

7 Conclusions

In this paper, we consider a simple model of MMO formation and termination. We assume all producers vote and do not consider the political aspects of MMO formation or termination within or outside the organization. We also assume there is no market power among buyers of agricultural output and restrict attention to affine demand functions. These are important aspects of MMOs and the markets they operate in and suggest multiple avenues for future work.

Even this simple theoretical setting generates several results. First, we find that market power and cost heterogeneity do matter in determining the voting power of producers in MMO referenda, whether or not producer behavior is incorporated. Banzhaf Power for the low cost firm is higher under competition than under alternative market structures, as is the low cost firm's higher market share under competition. This result is consistent with previous studies in the voting power literature that employ empirical data from weighted voting games, in which voters with larger weights tend to have higher voting power. So although this result is not new, this is the first time to the best of our knowledge that this relationship has been examined in the context of MMOs. Second, incorporating information on producer behavior substantially affects our estimate of voting power. For example, it gives us a very different picture of the ability of the low cost firm to effect change. For two out of the three market structures, the Banzhaf Power Index value of the low cost firm increases with cost heterogeneity in the case of MMO formation, but the Feasible Banzhaf Power

Index decreases with cost heterogeneity. This decrease in Feasible Banzhaf Power is driven by the lower probability of formation for those coalitions in which the low cost producer is critical, once we take into account producer behavior. This observed difference between the patterns in the Banzhaf Power Index and the Feasible Banzhaf Power Index also illustrates our third main result—that disparate preferences by firms with heterogeneous costs in situations where some producers wield market power can lead to a lower Feasible Banzhaf Power Index value for the low cost firm, even when the low cost firm produces a substantial share of industry output. Finally, we find that the different voting rules faced by producers in MMO termination and formation referenda yield distinct differences in voting power in markets with heterogeneous producers.

Overall, we find that there is a trade off between market power and voting power among agricultural producers facing the voting rules that we examine. If there are instances in which low cost producers are indeed exercising some amount of market power then there are two implications. First, low cost producers could potentially become trapped in MMOs that do not benefit them. This may explain why some large producers (who often have lower costs than smaller producers) have challenged MMOs in the court system over the mandatory nature of marketing orders. These producers may have turned to legal action because the referendum mechanisms put in place were did not allow them to adapt the MMO to better fit their needs. That said, high cost producers do not necessarily drive the decisions. They still have considerably less Banzhaf Power than the low cost firm in a number of settings. This latter result suggests that low cost forms could wield substantial voting power in some situations. As we show in our simulations, whether the low cost firm is entirely unable to wield power or wields considerable power depends on both the voting rule and the type of demand shift. Together these insights suggest that it is important for policymakers and government officials making MMO formation and termination decisions to consider the variability in firms' costs, industry structure and the nature of the MMO's effects on demand along with referenda outcomes. In addition, we must note that although we address voting power within MMO referenda, voting power is not the same as political power. This work tells us about the ability of heterogeneous firms to affect the outcome of referenda, but it does not tell us about firms' different abilities to affect MMOs through other political channels, which may also be important.

Finally, our work raises a broader philosophical and political question about whether MMO policies and voting rules in their current forms are appropriate for use in heterogeneous industries.

Differential benefits across producers may be considered acceptable, but our work suggests there are situations where some industry members could benefit at the expense of others due to the institutional framework of MMOs. These cases do not support the claim that MMOs provide industry-wide benefits, or that producers can terminate a MMO if it is no longer beneficial. A policy that would raise all boats (albeit to different sea levels) would require some form of compensation to the losing actors that is not currently addressed explicitly in policies regarding MMOs.

Table 1: Voting Power and MMO Formation

		Low cost firm					*Average for high cost firms*				
Market	*Cost*	*Share*	*BP*	FBP_I	FBP_P	FBP_E	*Share*	*BP*	FBP_I	FBP_P	FBP_E
Dominant/ competitive	1	0.230	0.341	0.530	0.515	0.515	0.086	0.229	0.375	0.371	0.371
	2	0.276	0.376	0.550	0.537	0.536	0.080	0.229	0.358	0.357	0.356
	3	0.329	0.424	0.543	0.532	0.532	0.075	0.236	0.339	0.337	0.337
	4	0.389	0.500	0.434	0.427	0.427	0.068	0.253	0.293	0.291	0.291
	5	0.441	0.609	0.374	0.374	0.374	0.062	0.272	0.258	0.258	0.258
Cournot	1	0.195	0.286	0.317	0.323	0.326	0.089	0.221	0.279	0.284	0.285
	2	0.217	0.291	0.293	0.297	0.299	0.087	0.221	0.260	0.263	0.264
	3	0.242	0.298	0.289	0.290	0.290	0.084	0.228	0.258	0.259	0.259
	4	0.270	0.316	0.298	0.298	0.298	0.081	0.243	0.266	0.266	0.266
	5	0.297	0.377	0.330	0.330	0.330	0.078	0.282	0.286	0.286	0.286
Competitive	1	0.250	0.357	0.555	0.535	0.535	0.083	0.229	0.372	0.369	0.369
	2	0.299	0.398	0.578	0.561	0.561	0.078	0.230	0.355	0.354	0.354
	3	0.356	0.457	0.569	0.555	0.554	0.072	0.239	0.336	0.335	0.335
	4	0.422	0.553	0.476	0.468	0.468	0.064	0.252	0.296	0.295	0.295
	5	0.480	0.686	0.383	0.383	0.383	0.058	0.257	0.248	0.248	0.248

Cost: Cost advantage of low-cost firm
Share: Pre-vote market share of firm
BP: Banzhaf Power Index value
FBP: Feasible Banzhaf Power Index value
I = inelastic, P = parallel, E = elastic

Table 2: Voting Power and MMO Termination – Low Cost Firm

Market	*Cost*	$Share_I$	BP_I	FBP_I	$Share_P$	BP_P	FBP_P	$Share_E$	BP_E	FBP_E
Dominant/ competitive	1	0.229	0.301	0.039	0.222	0.299	0.039	0.223	0.299	0.039
	2	0.274	0.338	0.042	0.267	0.334	0.042	0.267	0.334	0.042
	3	0.326	0.386	0.046	0.320	0.382	0.045	0.320	0.382	0.045
	4	0.384	0.442	0.048	0.383	0.440	0.048	0.383	0.440	0.048
	5	0.434	0.487	0.049	0.434	0.487	0.049	0.434	0.487	0.049
	1	0.191	0.288	0.041	0.193	0.289	0.040	0.194	0.290	0.040
Cournot	2	0.213	0.304	0.042	0.216	0.305	0.042	0.217	0.306	0.042
	3	0.237	0.318	0.043	0.240	0.321	0.043	0.241	0.323	0.043
	4	0.263	0.343	0.044	0.266	0.347	0.044	0.268	0.350	0.045
	5	0.289	0.398	0.047	0.293	0.401	0.047	0.296	0.402	0.048
	1	0.249	0.315	0.040	0.241	0.311	0.040	0.241	0.311	0.040
Competitive	2	0.297	0.356	0.043	0.288	0.351	0.043	0.288	0.351	0.043
	3	0.354	0.407	0.046	0.346	0.402	0.046	0.346	0.402	0.046
	4	0.417	0.463	0.049	0.415	0.462	0.049	0.415	0.462	0.049
	5	0.473	0.496	0.049	0.472	0.496	0.049	0.472	0.496	0.049

Cost: Cost advantage of low-cost firm
Share: Pre-vote market share of firm
BP: Banzhaf Power Index value
FBP: Feasible Banzhaf Power Index value
I = inelastic, P = parallel, E = elastic

Table 3: Voting Power and MMO Termination – Average High Cost Firm

$Market$	$Cost$	$Share_I$	BP_I	FBP_I	$Share_P$	BP_P	FBP_P	$Share_E$	BP_E	FBP_E
Dominant/ competitive	1	0.086	0.210	0.030	0.086	0.212	0.030	0.086	0.212	0.030
	2	0.081	0.204	0.029	0.081	0.206	0.029	0.081	0.206	0.029
	3	0.075	0.191	0.027	0.076	0.193	0.027	0.076	0.193	0.027
	4	0.068	0.170	0.024	0.069	0.170	0.024	0.069	0.170	0.024
	5	0.063	0.147	0.021	0.063	0.147	0.021	0.063	0.147	0.021
	1	0.090	0.226	0.033	0.090	0.225	0.033	0.090	0.225	0.033
Cournot	2	0.087	0.225	0.033	0.087	0.224	0.033	0.087	0.223	0.033
	3	0.085	0.221	0.032	0.084	0.220	0.032	0.084	0.220	0.032
	4	0.082	0.214	0.030	0.082	0.212	0.030	0.081	0.211	0.030
	5	0.079	0.195	0.025	0.079	0.194	0.025	0.078	0.194	0.025
	1	0.083	0.207	0.029	0.084	0.210	0.030	0.084	0.210	0.030
Competitive	2	0.078	0.199	0.028	0.079	0.201	0.029	0.079	0.201	0.029
	3	0.072	0.183	0.026	0.073	0.185	0.026	0.073	0.185	0.026
	4	0.065	0.159	0.023	0.065	0.160	0.023	0.065	0.160	0.023
	5	0.059	0.140	0.021	0.059	0.140	0.021	0.059	0.140	0.021

Cost: Cost advantage of low-cost firm
Share: Pre-vote market share of firm
BP: Banzhaf Power Index value
FBP: Feasible Banzhaf Power Index value
I = inelastic, P = parallel, E = elastic

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