A Group Rule–Utilitarian Approach to Voter Turnout: Theory and Evidence

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This paper explores a group rule–utilitarian approach to understanding voter turnout, inspired by the theoretical work of John C. Harsanyi (1980) and Timothy J. Feddersen and Alvaro Sandroni (2002). It develops a model based on this approach and studies its performance in explaining turnout in Texas liquor referenda. The results are encouraging: the comparative static predictions of the model are broadly consistent with the data, and a structurally estimated version of the model yields reasonable coefficient estimates and fits the data well. The structurally estimated model also outperforms a simple expressive voting model. (*JEL* D27)

Understanding voter turnout is a central problem in political economy. Turnout is sensitive to the specific characteristics of elections. Political parties understand this and fashion their policy stances to "bring out the base" or discourage the opposition's base. Accordingly, turnout not only determines which option wins but also shapes the policy options from which voters select. While turnout has attracted considerable academic attention, there is little consensus on how best to understand it.[1] This paper explores a *group rule–utilitarian approach* to the problem, inspired by the theoretical work of Harsanyi (1980) and Feddersen and Sandroni (2002). It develops a model based on this approach and studies its performance in explaining turnout in Texas liquor referenda.

The approach begins with the observation that any election naturally divides the electorate into distinct *groups.* In a referendum or ballot initiative, such as studied in this paper, these groups are the supporters and opposers of the proposal. In a candidate election, they are the supporters of the different candidates. Effectively, the election creates a *contest* between these different groups, the winner being the group delivering the most votes. The approach postulates that individual group members want to "do their part" to help their group win. This is not because they receive a transfer from other group members for doing so; they simply adhere to the belief that this is how a citizen should behave in a democracy. In the spirit of Harsanyi (1980) and Feddersen and Sandroni (2002), "doing their part" is understood to mean following the voting rule that, if followed by everyone else in their group, would maximize their group's aggregate utility. Thus, individuals are assumed to act as group rule–utilitarians, with their "groups" being those who share their views on which candidate or option is best.[2]

Each group's optimal voting rule specifies a

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[1] The reader is referred to John Aldrich (1993, 1997), Morris P. Fiorina (1997), Gene M. Grossman and Elhanan Helpman (2001), and John G. Matsusaka and Filip Palda (1993) for overviews and discussion of this literature.

[2] A rule-utilitarian follows the rule that if followed by all citizens would maximize aggregate utility. By analogy, a

critical cost level below which an individual should vote. A higher critical level creates more turnout and hence raises the probability of the group's preferred outcome. On the other hand, it increases the expected voting costs incurred by group members. Balancing these two considerations determines the optimal critical level. Obviously, the greater the turnout expected from opposing groups, the higher a group's critical level must be in order to ensure any given chance of success. Accordingly, it is natural to think of the voting rules as being determined in a game in which individuals from the various groups move simultaneously. In equilibrium, individuals in each group must be satisfied with their voting rule, given the rules they expect the other groups to choose. The equilibrium voting rules depend on election-specific characteristics like the relative sizes of the competing groups, how intensely they support their preferred candidate, and expected voting costs. Understanding these relationships yields predictions for how turnout should depend on election-specific characteristics.

The particular group rule–utilitarian model developed in the paper is designed to apply to a referendum.[3] It assumes that all supporters of the referendum enjoy the same benefit and all opposers incur the same cost if it passes. This sidesteps the question of how the burden of voting should be shared among group members with differing intensities of preference. In addition, the fraction of supporters is assumed to be the realization of a random variable with a Beta distribution. Individuals do not observe the realization but do know the parameters of the Beta distribution. This captures the idea that individuals will be aware of general characteristics of their fellow citizens that will influence the likely fraction of supporters. Finally, the cost of voting for each supporter and opposer is assumed to be the realization of an independent random variable uniformly distributed on an identical support. The model is therefore described by five parameters: the benefit of the proposed change to supporters; the cost to opposers; the two parameters of the Beta distribution; and the upper bound of the support of voting costs. The equilibrium voting rules for supporters and opposers depend on these parameters and they, together with the realization of the fraction of supporters, determine the turnout of supporters and opposers.

To evaluate the model empirically, we collected data on Texas liquor referenda. In Texas, a citizen wishing to change liquor regulations in his community can get the change voted on in a referendum. Such referenda are commonplace, with over 500 elections between 1976 and 1996. While not previously studied, these elections are particularly suitable for testing theories of turnout. First, turnout varies widely: in some communities over 75 percent of the voting-age population shows up to vote, in others less than 10 percent. Second, the issues decided by the referenda are basically the same across jurisdictions, since there is a limited set of regulations actually proposed. Third, the referenda are typically held separately from other elections, so that the only reason to go to the polls is to vote on the proposed change in liquor law.

Our data include information on the type of referendum, the votes for and against, and when the referendum was voted on. We also know the size of the voting population and many characteristics of the jurisdiction in question at the time of the election. This includes the religious affiliations of the county population and the liquor regulations in neighboring communities. Finally, we know weather conditions on the day of voting.

We begin our empirical analysis by regressing votes for and against on election and population characteristics in order to test the comparative static predictions of the model. While the results are broadly consistent with the model's predictions, they are by no means conclusive. One problem is that our group rule–utilitarian model does not yield particularly sharp comparative static predictions, making it difficult to assess its performance based on the coefficient estimates from the reduced form regressions. Moreover, the reduced form results

group rule–utilitarian follows the rule that if followed by all group members would maximize aggregate group utility.

[3] A referendum is equivalent to a two-candidate election in that it divides the electorate into two groups. Candidate elections with three or more candidates are complicated by the possibility that groups may decide to throw their support behind another candidate if they believe their own candidate has little chance of victory.

are also consistent with a much simpler expressive view of voting—the *intensity model*—which postulates that people are more likely to vote if they feel more strongly about the issue. These limitations motivate us to structurally estimate a parameterized version of our group rule–utilitarian model. The estimation yields reasonable parameter estimates and results in a better fit of the data than the reduced-form model. Moreover, the structurally estimated group rule–utilitarian model outperforms the intensity model.

Section I explains how the paper relates to previous work on voter turnout. Section II presents our group rule–utilitarian model. Section III describes the institutional details concerning the referenda that we study and presents the raw data. Section IV contains the reduced form empirical analysis and Section V the structural estimation. Section VI presents and estimates the intensity model and compares its performance with that of the group rule–utilitarian model. Section VII concludes with suggestions for further research.

I. Relationship to the Turnout Literature

The starting point for any theoretical discussion of turnout is the *calculus of voting model* (Anthony Downs, 1957; William H. Riker and Peter Ordeshook, 1968). This defines the benefits of voting as $pB + d$ where p is the probability of swinging the election, B is the gain from having one's preferred outcome, and d is the benefit a citizen feels from doing his civic duty or expressing his preference. A citizen votes if these benefits exceed the direct cost of voting, denoted c, which includes the time taken to get to the polls and so on. To get a useful theory of turnout, it is necessary to understand how these variables depend on election-specific characteristics.

Since the benefits from doing one's duty seem rather nebulous, it is tempting to look at the pB term to understand turnout. The *pivotal-voter model* of John O. Ledyard (1984) and Thomas Palfrey and Howard Rosenthal (1985) provides a natural way of endogenizing the probability that a voter will swing the election. The obvious problem with this approach, however, would seem to be that p is sufficiently small in any large election that changes in pB are likely to be minuscule across elections. Thus, many have questioned the fruitfulness of a theory of turnout based on minuscule changes in a minuscule number (see, for example, Donald P. Green and Ian Shapiro, 1994). Formal support for this concern is provided by Palfrey and Rosenthal's well-known result that in a sufficiently large electorate the only citizens who vote in equilibrium are those for whom d is no smaller than c.[4] Accordingly, significant variations in turnout in large elections must arise from variations in the fraction of the population for whom d is no smaller than c.

More recently, researchers have turned to the d term. An interesting line of work has assumed that this term can be influenced by leaders (see, for example, Ron Shachar and Barry Nalebuff, 1999). The idea of the *follow-the-leader model* is that in close elections or in elections where there is much at stake, community and political leaders put in more effort exhorting their fellows to vote, and this leads to higher turnout. The effort decisions of political leaders are rational because their efforts can sway large groups of voters. Exactly why such exhortions are successful is not clear, which is a basic difficulty with the approach.[5]

An alternative strategy is to think more deeply about individuals' notions of duty in the voting context. Harsanyi (1980) argues that voting may usefully be understood as individuals acting according to the dictates of *rule-utilitarianism*—individuals follow the voting rule that would maximize aggregate utility if everybody followed it. Harsanyi illustrates his argument by considering an environment in which a fixed number of votes is needed to pass a policy that would raise aggregate utility. Each citizen faces the same cost of voting and chooses a probability of voting that, if adopted by all, would

[4] Palfrey and Rosenthal's result is for symmetric equilibria in a model where voters are imperfectly informed about each others' voting costs and preferences.

[5] In one of the first papers stressing the importance of group leaders, Carole J. Uhlaner (1989) assumed that leaders offered transfers to group members in exchange for their votes. Even when transfers are interpreted most broadly, however, this practice does not seem particularly widespread in the United States.

maximize aggregate utility. The key insight is that the optimal probability is between zero and one. Not everybody should stay home, because that would mean the policy would not pass. But not everybody should vote because that would result in a surfeit of votes, imposing unnecessary costs on society. In this way, the logic of rule-utilitarianism yields an elegant theory of turnout. In terms of the calculus of voting model, Harsanyi effectively assumes that d is large enough so that everyone does their duty but *rejects the implicit assumption that doing one's duty always involves voting.*

Harsanyi's insight is developed much further by Feddersen and Sandroni (2002). They consider the more relevant environment of a two-candidate plurality-rule election in which citizens have heterogeneous voting costs. Feddersen and Sandroni first point out a problem with Harsanyi's argument in this context. With two candidates to select from, a rule-utilitarian has to choose not only whether to vote but also for whom to vote. All rule-utilitarians would vote for the candidate who maximizes aggregate utility and, accordingly, if only rule-utilitarians voted, the optimal voting rule would be such that turnout would be minimal. Since all voters would be voting for the same candidate, it is best for society as a whole to minimize the number of individuals incurring voting costs.

To deal with this problem, Feddersen and Sandroni introduce disagreement on which candidate maximizes aggregate utility. There are two groups of rule-utilitarians with opposing views. Individuals in each group follow a voting rule that they believe, if followed by all in their group, would maximize aggregate utility given the behavior of individuals in the opposing group. Feddersen and Sandroni show that the two groups' voting rules can be derived as the equilibrium of a game in which group members choose a rule for their group to maximize their conception of expected aggregate utility. While there are differences in the details, this game has the same basic structure as that studied in this paper.[6]

The key difference between Feddersen and Sandroni's rule-utilitarian model and our group rule-utilitarian model is that in the former individuals follow the voting rule that they believe maximizes aggregate utility, while in the latter they follow the voting rule that maximizes the payoff of those on their side of the issue. Using the terminology of social psychology, the distinction is one between "altruism" and "collectivism."[7] The merit of Feddersen and Sandroni's approach is that all behavior follows from the single postulate that citizens are rule-utilitarians. This has significant theoretical appeal. The social psychology literature stresses, however, the importance of group identity for cooperation in social dilemma–type situations (see, for example, Robyn Dawes et al., 1988; Henri Tajfel 1982; John Turner, 1987) and in contests, such as elections, being on the same side creates a natural group identity. Moreover, in the rule-utilitarian model, it is not clear why citizens should have different beliefs, nor what should determine the relative sizes of the two groups.[8]

Our group rule–utilitarian model is also related to the work of Rebecca B. Morton (1987, 1991). She studies a two-candidate election and assumes that the population is exogenously divided into groups with different policy preferences. Each group collectively and simultaneously decides how many of its members should vote in order to maximize the group's aggregate benefit. The choice trades off the policy benefit associated with changing the out-

[6] There are three main differences in the details. First, in the model of this paper, the two groups may differ in the intensity of their preference for their preferred candidates. Second, in Feddersen and Sandroni's model, the fraction of each group who behave "ethically" (i.e., as rule-utilitarians) is random. Nonethical voters abstain. Third, in Feddersen and Sandroni's model, ethical voters will follow the optimal rule only if their payoff from ethical behavior (the d term) exceeds their voting cost. As in Harsanyi (1980), the model of this paper implicitly assumes that d is sufficiently large that individuals always do their part.

[7] As defined by C. Daniel Batson (1994) in the *Handbook of Social Psychology*, "Collectivism involves motivation to benefit a particular group as a whole. The ultimate goal is not one's own welfare or the welfare of the specific others who are benefited; the ultimate goal is the welfare of the group" (p. 303).

[8] These problems make it difficult to use our data to test directly between the rule-utilitarian and group rule–utilitarian models. Nonetheless, it is possible to estimate a version of the rule-utilitarian model with our data and we have done so. The details are available on request.

come of the election with the cost to members of voting. In Coasian fashion, Morton is not specific on why the groups behave in this way: "The model assumes that groups invest resources (financial or otherwise) which provide group members with the individualized incentives necessary to vote. These resources are then transformed into votes by the groups" (Morton, 1987). This paper's approach may be considered as a special case of Morton in which there are only two groups—supporters and opposers.[9] While we prefer our group rule–utilitarian interpretation, there is nothing in the empirical work to distinguish it from a story where supporters and opposers collectively determine which of their members should vote.[10]

There is a vast empirical literature on turnout in both U.S. and international elections.[11] The bulk of this studies reduced-form regressions of turnout on characteristics of the eligible voting population and the election. There are very few papers that attempt to structurally estimate models of turnout. Stephen Hansen et al. (1987) use data on school-budget referenda to structurally estimate a pivotal-voter model. Given its complexity, they must make strong assumptions to undertake the estimation. In particular, they assume that the population is equally divided between supporters and opposers and that supporters and opposers have identical benefits from their preferred outcomes. They then estimate the parameters of the distribution of voting costs. Our simpler model permits estimation of the distribution of supporters and opposers, the benefits of supporters and opposers, and the distribution of voting costs.

Shachar and Nalebuff (1999) use state-level voting in U.S. presidential elections to structurally estimate a model based on the follow-the-leader approach. Their model assumes that Democratic and Republican leaders in each state expend effort to have an impact on the outcome of the presidential election.[12] Leaders' ability to have an impact depends on how followers respond and on the expected closeness of the race (at both state and national levels). The former is a parameter of the model to be estimated and the latter depends on the distribution of Democrats and Republicans in the population, which is estimated from past election outcomes. The authors conclude that voters do respond to effort and that effort is higher in races that are predicted to be closer. Shachar and Nalebuff's model is an equilibrium model in that the leaders from the two parties in each state choose their effort levels simultaneously. This gives it a similar flavor to our model.

II. A Group Rule–Utilitarian Model

Consider a community that is holding a referendum on some proposed policy change. For analytical tractability, we adopt the fiction that the community has a continuum of citizens. These citizens are divided into supporters and opposers of the change. Each supporter is willing to pay b for the change, while each opposer is willing to pay x to avoid it.

Each citizen knows whether he is a supporter or an opposer, but not the fraction of citizens in each category. All citizens know, however, that the fraction of supporters in the population, denoted μ, is the realization of a random variable with range [0, 1] distributed according to the Beta Distribution.[13] Thus, the probability density function of the random variable is

[9] A minor difference is that Morton assumes that groups are of fixed size, while our analysis assumes that the size of the two groups is ex ante uncertain. The assumption of fixed group size creates potential difficulties for the existence of equilibrium which Morton overcomes by assuming that the total votes a candidate receives equals the amount provided by the groups who support him plus an error term.

[10] Morton (1987) endogenizes the policy choices office-seeking candidates would make given this group voting behavior. Building on this work, John Filer et al. (1993) present a group voting model where candidates propose tax schemes that differ in the degree of progressiveness. The paper empirically tests the model's qualitative predictions using county-level turnouts in the 1948, 1960, 1968, and 1980 presidential elections.

[11] Arend Lijphart (1997) and John G. Matsusaka and Filip Palda (1999) provide useful surveys.

[12] One drawback with the study is that, in reality, voters are voting on many other issues at the same time as they are casting their presidential ballot.

[13] Shachar and Nalebuff (1999) model uncertainty in the fraction of the population who are Democrats in a similar way. They assume, however, that the fraction of Democrats is the realization of a random variable with a normal distri-

$$h(\mu;\ \nu, \omega) = \mu^{\nu-1}(1-\mu)^{\omega-1}/B(\nu, \omega)$$

where ν and ω are parameters known by the citizens and $B(\nu, \omega)$ is the Beta function

$$B(\nu, \omega) = \int_0^1 \mu^{\nu-1}(1-\mu)^{\omega-1}\, d\mu.$$

The expected fraction of supporters under this distributional assumption is $\nu/(\nu + \omega)$.

Citizens must decide whether or not to vote in the referendum. If they do, supporters vote in favor and opposers vote against. Voting is costly, with each citizen i facing a cost of voting c_i which is the realization of a random variable uniformly distributed on $[0, c]$. Citizens do not observe the voting costs of their fellows but do know the distribution from which they are drawn. We assume that individuals follow the voting rule that, if followed by everyone else on their side, would maximize their side's aggregate utility. Each side's optimal voting rule specifies a critical cost level below which an individual should vote.

Letting the critical voting costs for the two groups be denoted by γ_s and γ_o, if citizen i is a supporter he votes if c_i is less than γ_s, and if he is an opposer he votes if c_i is less than γ_o. Thus, if citizen i is a supporter his *expected voting cost* is $\gamma_s^2/2c$, while if he is an opposer it is $\gamma_o^2/2c$.[14] The probability that a supporter votes is the probability that γ_s exceeds c_i, which is γ_s/c. Similarly, the probability that an opposer votes is γ_o/c. The referendum passes when $\mu\gamma_s/c$ exceeds $(1-\mu)\gamma_o/c$ or, equivalently, when μ exceeds $\gamma_o/(\gamma_s + \gamma_o)$.

Conditional on μ, the aggregate expected payoff of supporters is $\mu(b - \gamma_s^2/2c)$ if μ exceeds $\gamma_o/(\gamma_s + \gamma_o)$ and $-\mu\gamma_s^2/2c$ otherwise. Taking expectations over μ, the aggregate expected utility of supporters is

$$U_s(\gamma_s, \gamma_o) = \int_{\gamma_o/(\gamma_s+\gamma_o)}^1 \mu b h(\mu;\ \nu, \omega)\, d\mu - \frac{\nu}{\nu+\omega}\frac{\gamma_s^2}{2c}.$$

The first term represents the expected policy benefits and the second the expected voting costs. Similarly, conditional on μ, the aggregate expected payoff of opposers is $-(1-\mu)(x + \gamma_o^2/2c)$ if μ exceeds $\gamma_o/(\gamma_s + \gamma_o)$ and $-(1-\mu)\gamma_o^2/2c$ otherwise. Taking expectations over μ, the aggregate expected utility of opposers is

$$U_o(\gamma_s, \gamma_o) = -\int_{\gamma_o/(\gamma_s+\gamma_o)}^1 (1-\mu)xh(\mu;\ \nu, \omega)\, d\mu - \frac{\omega}{\nu+\omega}\frac{\gamma_o^2}{2c}.$$

Accordingly, we define a pair of critical levels (γ_s^*, γ_o^*) to be an *equilibrium* if γ_s^* maximizes $U_s(\gamma_s, \gamma_o^*)$ subject to the constraint that $\gamma_s \in [0, c]$ and γ_o^* maximizes $U_o(\gamma_s^*, \gamma_o)$ subject to the constraint that $\gamma_o \in [0, c]$. We say that (γ_s^*, γ_o^*) is an *interior equilibrium* if both γ_s^* and γ_o^* are between 0 and c.

We are now able to establish the following result.[15]

PROPOSITION 1: *If (γ_s^*, γ_o^*) is an interior equilibrium, then*

$$\gamma_s^* = \left(\frac{c(\nu+\omega)(\nu x)^{(\nu+1)/3}(\omega b)^{(\omega+3)/3}}{\nu\omega[(\omega b)^{1/3} + (\nu x)^{1/3}]^{\nu+\omega+1}B(\nu, \omega)}\right)^{1/2}$$

and

$$\gamma_o^* = \left(\frac{c(\nu+\omega)(\nu x)^{(\nu+3)/3}(\omega b)^{(\omega+1)/3}}{\nu\omega[(\omega b)^{1/3} + (\nu x)^{1/3}]^{\nu+\omega+1}B(\nu, \omega)}\right)^{1/2}.$$

This proposition shows that, if there exists an interior equilibrium, it is unique and, moreover,

bution. This has the obvious drawback that it can take on values outside the interval [0, 1].

[14] Given that a supporter will vote if and only if his voting cost is less than γ_s, his expected voting costs are $\int_0^{\gamma_s} c_i\,(dc_i/c) + \int_{\gamma_s}^c 0\,(dc_i/c)$ which equals $\gamma_s^2/2c$.

[15] The proofs of Propositions 1 and 2, together with a derivation of the comparative static predictions of the model, are in the Appendix.

the equilibrium critical levels are related to the parameters in a relatively straightforward way.

The characterization in Proposition 1 can be used to derive predictions for how turnout should depend upon the exogenous variables $\{b, x, c, v, \omega\}$. Let V_s be the fraction of the population voting in support of the referendum and V_o the fraction voting in opposition. According to the model, $V_s = \mu\gamma_s^*/c$ and $V_o = (1 - \mu)\gamma_o^*/c$. Thus, the *expected* fraction voting in support is $\bar{V}_s = \nu\gamma_s^*/c(\nu + \omega)$ and the *expected* fraction voting in opposition is $\bar{V}_o = \omega\gamma_o^*/c(\nu + \omega)$. If (γ_s^*, γ_o^*) is an interior equilibrium, then we can use Proposition 1 to show that

$$\frac{\partial \bar{V}_s}{\partial b} \geq 0, \qquad \frac{\partial \bar{V}_s}{\partial c} < 0,$$

$$\frac{\partial \bar{V}_s}{\partial x} \gtrless 0 \quad \text{as} \quad x \lessgtr b\,\frac{(\nu + 1)^3}{\nu\omega^2}$$

and that

$$\frac{\partial \bar{V}_o}{\partial x} \geq 0, \qquad \frac{\partial \bar{V}_o}{\partial c} < 0,$$

$$\frac{\partial \bar{V}_o}{\partial b} \gtrless 0 \quad \text{as} \quad b \lessgtr x\,\frac{(\omega + 1)^3}{\nu^2\omega}.$$

Thus, the expected fraction voting in support (opposition) is increasing in b (x) and decreasing in c. The effect of an increase in x (b) is ambiguous. At first, increasing x (b) raises $\bar{V}_s$ ($\bar{V}_o$) as the contest becomes more competitive. After some point, however, x (b) becomes so large that turnout among supporters (opposers) decreases.

The comparative static results involving the parameters describing the distribution of supporters in the voting population are more complicated. Consider raising ν, holding constant ω, which serves to increase the expected fraction of supporters. Simulations reveal that both $\bar{V}_s$ and $\bar{V}_o$ initially increase. The expected fraction voting in opposition increases, despite the smaller fraction of opposers, because opposers are induced to vote with higher probability to deal with the greater competition. As ν is further increased, $\bar{V}_o$ starts to decrease as the effect arising from a reduction in the fraction of opposers offsets any increase in the probability of voting. Furthermore, at some higher value of ν, $\bar{V}_s$ starts to decrease as the election becomes sufficiently one-sided that supporters can reduce the rate at which they vote. The only possibility ruled out is that $\partial\bar{V}_s/\partial\nu < 0$ while $\partial\bar{V}_o/\partial\nu > 0$.

It is important to note that there is no general guarantee that an equilibrium will exist. The payoff functions of supporters and opposers are not quasi-concave functions of their own critical cost levels. Indeed, it is not difficult to find parameter values for which no equilibrium exists.[16] In such circumstances, one of the critical levels described in the proposition is not a best response for the group in question. This is typically because it would be better for that group not to vote at all than to vote at cost levels below the critical level identified in the proposition. This arises, for example, when one group (say, supporters) is expected to be much smaller than the other (i.e., $\nu/(\nu + \omega)$ is small). While the cost level in the proposition is always positive and implies a positive level of turnout, if supporters are very unlikely to win they may be better off just giving up and staying home. But if supporters are staying home, the optimal critical cost for opposers becomes very small, which then provides supporters an incentive to vote.

When we structurally estimate the model, we estimate the exogenous variables $\{b, x, c, \nu, \omega\}$ assuming that supporters and opposers use the critical levels described in Proposition 1. Of course, this is only legitimate if these are indeed equilibrium-critical levels. When can we be sure that a pair of critical cost levels satisfying the conditions of Proposition 1 is actually an

[16] Feddersen and Sandroni (2002) deal with this existence problem in their model by assuming that the fraction of individuals in each group who behave "ethically" (i.e., according to the dictates of rule-utilitarianism) is uncertain. Under the assumption that the two groups care equally intensely about the election, Feddersen and Sandroni show that an equilibrium exists and is unique if the fraction of "ethicals" in each group is uncertain, independent, and uniformly distributed.

equilibrium? Our next proposition provides some useful sufficient conditions.

PROPOSITION 2: *Suppose that* $(\gamma_s^*, \gamma_o^*) \in (0, c]^2$ *satisfies (i) the conditions of Proposition 1, (ii) the "second order" conditions*

$$(\nu + 3)\gamma_s^* > (\omega - 2)\gamma_o^* \quad \text{and}$$

$$(\omega + 3)\gamma_o^* > (\nu - 2)\gamma_s^*,$$

and (iii) the "better than staying home" conditions

$$U_s(\gamma_s^*, \gamma_o^*) \geq 0 \quad \text{and} \quad U_o(\gamma_s^*, \gamma_o^*) \geq -x.$$

Then (γ_s^*, γ_o^*) *is an equilibrium.*

The second order conditions in (ii), together with the conditions of Proposition 1, imply that the payoff functions of supporters and opposers are locally strictly concave at (γ_s^*, γ_o^*). The better-than-staying-home conditions in (iii) ensure that at (γ_s^*, γ_o^*) the payoffs of supporters and opposers are at least as high as if they simply choose not to vote. The proof of the proposition amounts to showing that the payoff functions can have at most one interior local maximum, in which case these three conditions are sufficient to imply that γ_s^* is a best response to γ_o^* and vice versa.

We will use the sufficient conditions in Proposition 2 to check the validity of our structural estimation procedure. Our estimates will imply values of the exogenous variables $\{b, x, c, \nu, \omega\}$ for each jurisdiction which, in turn, imply values of the critical costs (γ_s^*, γ_o^*) via the equations of Proposition 1. If these implied values satisfy the second-order conditions and the better-than-staying-home conditions of Proposition 2, then we know that (γ_s^*, γ_o^*) really are equilibrium-critical costs given $\{b, x, c, \nu, \omega\}$.

III. Texas Liquor Elections

A. *Institutional Background*

Chapter 251 of the Texas Alcoholic Beverage Code states, "On proper petition by the required number of voters of a county, or of a justice precinct or incorporated city or town in the county, the Commissioners' Court shall order a local election in the political subdivision to determine whether or not the sale of alcoholic beverages of one or more of the various types and alcoholic contents shall be prohibited or legalized in the county, justice precinct, or incorporated city or town." Thus, citizens can propose changes in the liquor laws of their communities and have their proposals directly voted on in referenda. Such direct democracy has a long history in Texas liquor regulation, with local liquor elections dating back to the mid 1800s.[17]

The process by which citizens may propose a change for their jurisdiction is relatively straightforward. The first step involves applying to the Registrar of Voters for a petition. This requires the signatures of only ten or more registered voters in the jurisdiction. The hard work comes after receipt of the petition. The applicants must get it signed by at least 35 percent of the registered voters in the jurisdiction and must do this within thirty days.[18] If this hurdle is successfully completed, the Commissioners' Court of the county to which the jurisdiction belongs must order a referendum be held. This order must be issued at its first regular session following the completion of the petition, and the referendum must be held between 20 and 30 days from the time of the order. All registered voters can vote, and if the proposed change receives at least as many affirmative as negative votes, it is approved.

Citizens may propose changes for their entire county, their justice precinct, or the city or town in which they reside. The state is divided into 254 counties and each county is divided into justice precincts.[19] Accordingly, a justice precinct lies within the county to which it belongs. By contrast, a city may spill over into two or more justice precincts. If only part of a city

[17] From 1919 to 1935, these elections were abolished as a result of prohibition. Since 1935, the process of citizen-democracy has been governed by the procedures described in Chapter 251 of the Texas Alcoholic Beverage Code.

[18] Prior to 1993, the number of signatures needed was 35 percent of the total number of votes cast in the preceding gubernatorial election.

[19] The number of justice precincts in a county ranges from one to eight.

belongs to a particular justice precinct that has approved a change, then that part must abide by the new regulations. If, however, the city subsequently approved a different set of regulations, they would also be binding on the part contained in the justice precinct in question. Effectively, current regulations are determined by the most recently approved referendum. Over our data period, citizens almost always choose to propose changes at the city or justice precinct level rather than at the county level.

Importantly for the purposes of our study, liquor referenda are typically held separately from other elections. Section 41.01 of the Texas Election Laws sets aside four dates each year as uniform election dates.[20] These are the dates when presidential, gubernatorial, and congressional elections are held. In addition, other issues are often decided on these days, such as the election of aldermen and the approval of the sale of public land and bond issuances. Elections pertaining to these other issues may occur, but rarely do, on dates other than uniform election days. Liquor referenda, in contrast, do not typically occur on uniform election dates. This reflects the tight restrictions placed by Chapter 251 on the timing of elections.[21]

B. *Data*

We assembled data on 363 local liquor elections in Texas between 1976 and 1996 where prior to the election the voting jurisdictions prohibited the retail sale of all alcohol.[22] Information on these elections was obtained from the annual reports of the Texas Alcoholic Beverage Commission (TABC). These reports contain the county, justice precinct, city, or town voting on the referendum, the date of the election, the proposed change, and the number of votes cast for and against. As indicated in Table 1, the elections differed in the degree to which restrictions were relaxed: 147 proposed permitting the selling of beer only or beer and wine; 144 proposed permitting the sale of all alcoholic beverages for off-premise consumption only (i.e., liquor stores); and 72 proposed not only that all beverages be sold but also that they could be consumed off- and on-premise (i.e., bars as well as liquor stores). Of these 363 elections, 2 were at the county level, 133 were at the justice precinct level, and 228 were at the city or town level. At least one election occurred in 125 different counties. Approximately two-thirds of the 363 elections involved jurisdictions that account for a single election. For those jurisdictions that had multiple elections, these often occured a number of years apart.[23]

We supplemented our election data with information on county-, city-, and town-level populations, by age, obtained from the U.S. Census. Using this information, we estimated the voting-age population at the time of an election. Table 1 indicates that the mean voting-age population in the 363 jurisdictions was 4,415 at the time of the elections.

We also attempted to find information that might tell us about the attitudes of citizens toward the selling of alcohol. Using county-level information from the census, we constructed estimates of the fractions of the county population that are over the age of 50, single and male, black, and neither black nor white at the time of the election.[24] We also used the county-level information to construct estimates of the fraction of houses that are owner-occupied and the median price of an owner-occupied house. Finally, using county-level information on the number of adherents to Baptist denominations from *Churches & Church Membership in the U.S.*, we constructed estimates of the fraction of the county population that was Baptist at the time of an election. We use these estimates as proxies for the demographic and housing char-

[20] These are the third Saturday in January, the first Saturday in May, the second Saturday in August, and the first Tuesday after the first Monday in November.

[21] Interestingly, the Texas state government voted in 2001 to require liquor law referendum votes to occur on one of the four uniform election dates. This was to avoid the costs of holding referenda separately.

[22] See the appendix for a description of this data-collection process. The appendix also contains a detailed explanation of how certain variables are created.

[23] The empirical results do not change appreciably if our estimation is based only on observations where the jurisdiction voting did not have another liquor law election within five years.

[24] Asians, American Indians, Hispanics, Latinos, and many other ethnicities are included in the "neither black nor white" category.

TABLE 1—SUMMARY STATISTICS FOR THE 363 ELECTIONS

Fraction of referenda involving only beer/wine	0.40 (147 Elections)
Fraction of referenda involving off-premise consumption	0.40 (144 Elections)
Fraction of referenda involving off- and on-premise consumption	0.20 (72 Elections)
Fraction of referenda involving an entire county	0.01 (2 Elections)
Fraction of referenda involving a justice precinct	0.37 (133 Elections)
Fraction of referenda involving an incorporated town or city	0.63 (228 Elections)
Voting-age population in jurisdiction	Mean = 4,145 (SD = 7,464)
Fraction of county voting-age population over the age of 50	Mean = 0.40 (SD = 0.10)
Fraction of county population that is single and male	Mean = 0.09 (SD = 0.02)
Fraction of county population that is black	Mean = 0.09 (SD = 0.08)
Fraction of county population that is neither black nor white	Mean = 0.07 (SD = 0.07)
Fraction of houses in county that are owner occupied	Mean = 0.66 (SD = 0.07)
Median price of owner-occupied houses in county (2000 dollars)	Mean = 68,572 (SD = 27,656)
Fraction of county population that is Baptist	Mean = 0.48 (SD = 0.13)
Fraction of referenda involving more liberal policy than county	0.33 (121 Elections)
Number of alcohol-related accidents in county divided by county population (1,000) in past 12 months	Mean = 2.04 (SD = 0.71)
Fraction of jurisdiction located in an MSA	0.44 (158 Elections)
Average temperature on day of election (Fahrenheit)	Mean = 65.2 (SD = 16.0)
Rainfall on day of election (tenths of inches)	Mean = 0.96 (SD = 3.10)
Snowfall on day of election (tenths of inches)	Mean = 0.06 (SD = 1.05)
Fraction of referenda that occurred on Saturday or Sunday	0.70 (255 Elections)
Fraction of referenda that occurred in summer	0.27 (97 jurisdictions)
Fraction of referenda that pass	0.41 (150 Elections)
Fraction of voting-age population voting for referendum	Mean = 0.17 (SD = 0.12)
Fraction of voting-age population voting against referendum	Mean = 0.19 (SD = 0.13)
Turnout (# of votes/voting-age population)	Mean = 0.36 (SD = 0.22)
Closeness (difference between votes for and against divided by total votes cast)	Mean = 0.25 (SD = 0.19)

Note: SD denotes standard deviation.

acteristics in each of the 363 jurisdictions, thereby implicitly assuming that these individual and housing characteristics are uniformly distributed throughout each county. The means and standard deviations of these variables are provided in Table 1.

To construct a proxy of whether the alcohol policy being voted on was more liberal than the policy in neighbouring communities, we used the annual reports of the TABC to obtain information on liquor regulations elsewhere in the county. We also obtained monthly information from the Texas Department of Public Safety on the number of alcohol-related road accidents in each county. Finally, we used classifications from the 1996 U.S. Census to determine whether the jurisdiction was located in a Metropolitan Statistical Area (MSA).

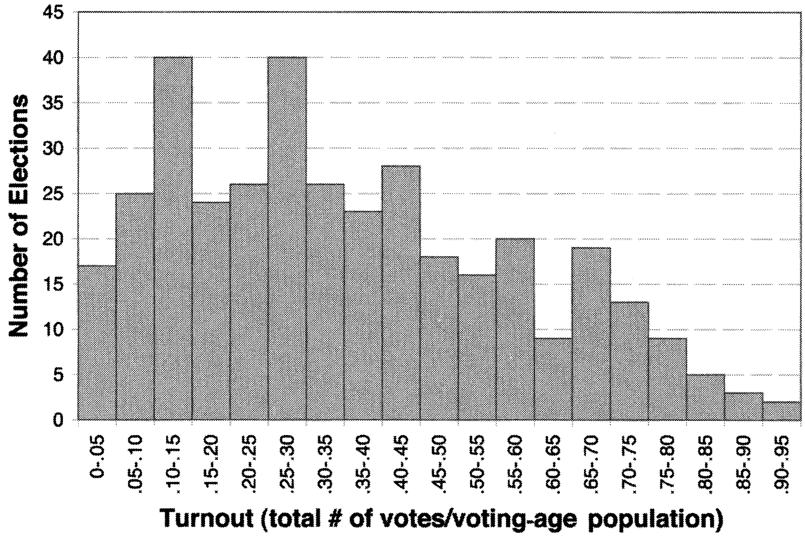

FIGURE 1. TURNOUT HISTOGRAM

In an attempt to get information about the costs of voting, we obtained daily weather conditions at 44 weather stations in Texas from the U.S. Carbon Dioxide Information Analysis Center. The weather conditions on the day of each election are taken to be the same as those measured at a weather station in close proximity to the voting jurisdiction. We also collected information on whether the election occurred on a weekend and/or in the summer, since this seemed likely to affect the costs of voting.

C. *Some Basic Facts*

Of our 363 referenda, 150 were approved and 213 were rejected by the voters. The percentage of the voting population that voted for the referendum averaged 17 percent across the 363 elections, while the percentage voting against averaged 19 percent. The average turnout in these elections (calculated by dividing total votes by voting-age population) is 36 percent but there is substantial variation across elections. Figure 1 presents the turnout information in a histogram where the vertical axis measures the number of elections in each turnout category. While a number of elections had turnout rates over 75 percent, the majority had less than a third of the voting-age population participate.

The elections tend to be close. When closeness is defined as the difference between votes for and against divided by total votes, the average closeness is 0.25. The histogram of this measure is depicted in Figure 2 and demonstrates that while the majority of the elections are relatively close, there are outliers. It is natural to ask whether the data support the familiar idea that turnout is higher in close elections. This all depends on how we measure closeness. Proceeding as in Figure 2, there is a slight positive relationship (correlation coefficient of 0.12). This positive relationship is stronger if closeness is defined as the difference between votes for and against divided by the voting-age population (correlation coefficient of 0.58). There is a negative relationship, however, between turnout and closeness when closeness is defined as the difference between votes for and against (correlation coefficient of −0.11).

IV. Reduced-Form Regressions

We begin the empirical analysis by regressing the fractions voting in support and opposition on the election-specific variables. This provides information on the basic correlations in the data as well as a check on the comparative

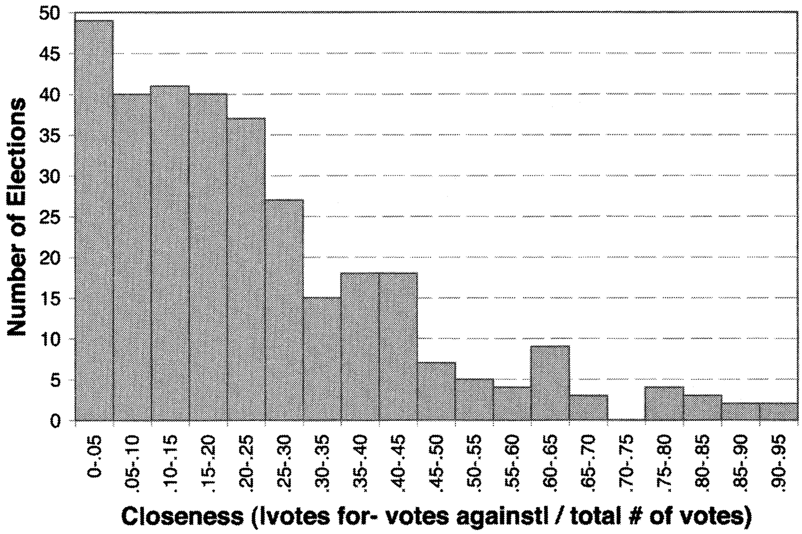

FIGURE 2. CLOSENESS HISTOGRAM

static predictions of the group rule–utilitarian model. The model we estimate is

$$V_{sj} = \boldsymbol{\beta}_{sp} \cdot \mathbf{z}_{pj} + \boldsymbol{\beta}_{sc} \cdot \mathbf{z}_{cj} + \boldsymbol{\beta}_{sv} \cdot \mathbf{z}_{vj} + \beta_{sn}(\text{pop}_j) + \varepsilon_{sj}$$

$$V_{oj} = \boldsymbol{\beta}_{op} \cdot \mathbf{z}_{pj} + \boldsymbol{\beta}_{oc} \cdot \mathbf{z}_{cj} + \boldsymbol{\beta}_{ov} \cdot \mathbf{z}_{vj} + \beta_{on}(\text{pop}_j) + \varepsilon_{oj}$$

where the fraction of the population voting in support of the referendum is V_{sj}, the fraction voting in opposition is V_{oj}, and $(\varepsilon_{sj}, \varepsilon_{oj})$ are random variables drawn from a bivariate normal distribution. The set of regressors is grouped into three main categories: those we thought likely to affect supporters' and opposers' willingness to pay ($\mathbf{z}_{pj}$); the cost of voting ($\mathbf{z}_{cj}$); and the fraction of supporters in the population ($\mathbf{z}_{vj}$). While it is not included in the theoretical model, we also included voting-age population.[25] The coefficient estimates from this seemingly unrelated regression are presented in Table 2.

Intuitively, we thought that both supporters' and opposers' willingness to pay (b and x) would be higher (i) the more permissive the proposed relaxation, and (ii) if the referendum proposed a more liberal alcohol policy than elsewhere in the county. We also expected b and x to be higher if the jurisdiction voting is a city, because residents in more densely populated areas are more likely to feel the impact of an alcohol policy liberalization. If these expectations are correct, the signs of the coefficient estimates are largely consistent with the comparative static predictions of the group rule–utilitarian model. The only exceptions are the negative coefficients on the indicator variable for off- and on-premise consumption of alcohol, which were unexpected because this is the most permissive regulation. The large and statistically significant coefficients associated with the city indicator variable suggest that the most important influence on willingness to pay is whether the jurisdiction is a city.

With respect to the cost of voting, we thought that average voting costs might be higher if the election were held on the weekend (perhaps because the polling location is on the way to

[25] The group rule–utilitarian model assumes a continuum of voters and hence offers no prediction concerning the impact of population size. While it is possible to develop the model for a finite population, computing the probability that the referendum passes or fails becomes considerably more complicated and the model becomes much less tractable.

TABLE 2—SEEMINGLY UNRELATED REGRESSION RESULTS
(N = 363, log likelihood = 662.90, correlation coefficient = 0.2005)

	Fraction for	Fraction against
$\mathbf{z}_{pj}$:		
Indicator variable for off-premise consumption of alcohol	0.008	0.003
	(0.012)	(0.013)
Indicator variable for off- and on-premise consumption of alcohol	−0.022	−0.052**
	(0.015)	(0.015)
Indicator variable for town or city referendum	0.116**	0.101**
	(0.011)	(0.012)
Indicator variable for most liberal policy in county	0.003	0.045**
	(0.012)	(0.012)
$\mathbf{z}_{cj}$:		
Indicator variable for election on weekend	−0.025**	−0.014
	(0.011)	(0.012)
Rainfall on day of election (tenths of inches)	−0.0002	0.0001
	(0.0002)	(0.0002)
Snowfall on day of election (tenths of inches)	−0.004	−0.004
	(0.005)	(0.005)
Average temperature on day of election (Fahrenheit)	0.001	−0.002
	(0.002)	(0.002)
Average temperature squared	−0.00002	0.00002
	(0.00002)	(0.00002)
Indicator variable for election in summer	0.005	0.002
	(0.016)	(0.017)
$\mathbf{z}_{vj}$:		
Fraction of county population that is Baptist	0.112*	0.085
	(0.059)	(0.061)
Fraction of county voting-age population over the age of 50	−0.042	0.129
	(0.094)	(0.098)
Fraction of county population that is single and male	−0.404	−0.478
	(0.319)	(0.332)
Fraction of county population that is black	−0.047	−0.262**
	(0.072)	(0.075)
Fraction of county population that is neither black nor white	−0.129	−0.215**
	(0.101)	(0.106)
Fraction of houses in county that are owner occupied	−0.123	−0.134
	(0.090)	(0.094)
Median price of owner-occupied houses in county (2000 dollars, $1,000)	−0.0007**	−0.0007*
	(0.0003)	(0.0003)
Alcohol-related accidents in county in prior year	0.002	−0.012
	(0.008)	(0.008)
Indicator variable for jurisdiction being located in an MSA	−0.034**	0.034**
	(0.016)	(0.017)
Voting-age population (1,000)	−0.0023**	−0.0031**
	(0.0008)	(0.0008)
Constant	0.267**	0.344**
	(0.123)	(0.128)

Notes: Standard errors are in parentheses. * Statistically significant at the 0.10 level; ** statistically significant at the 0.05 level.

work) and if the weather were bad. If this is true, the negative coefficients associated with the weekend, rainfall, and snowfall variables are consistent with the comparative static predictions of the model. Only the weekend coefficient in the fraction for regression, however, is statistically significant. We were agnostic concerning the effect of the other three variables on voting costs and, indeed, they do not have large effects.

We thought that citizens would be less likely to be supporters if they were Baptists, over the age of 50, or homeowners. We also expected that single males were more likely to be supporters and that citizens of different races might have different attitudes. Finally, we thought that the fraction of citizens who were supporters might be influenced by the number of alcohol-related accidents in the prior year and on whether the jurisdiction was located in an MSA.[26] As we noted in Section II, the group rule–utilitarian model does not yield sharp predictions concerning the effect of a change in the fraction of supporters. The only possibility ruled out by the model is that an increase in the fraction of supporters will reduce the fraction voting in support and increase the fraction voting in opposition.

While many of the coefficient estimates are not statistically significant, their signs are consistent with this prediction, under the assumptions that a greater number of alcohol-related accidents increases support, and location in an MSA reduces it. Both assumptions seem reasonable. The former is suggested by the finding of Reagan Baughman et al. (2001) that alcohol-related accidents in Texas counties may actually decline with a less restrictive alcohol policy.[27] The latter might be justified by the idea that a jurisdiction that allows the sale of alcohol attracts more outsiders if it is in an urban rather than rural area. While some residents may perceive this as a benefit, others may be concerned about the type of people the alcohol would attract.

Voting-age population has a large and statistically significant effect on the fraction voting both in favor and against. Specifically, increasing the voting-age population by 1,000 decreases the fraction voting in support by 0.23 percentage points and the fraction voting in opposition by 0.31 percentage points.

While the results in Table 2 are broadly consistent with the predictions from the group rule–utilitarian model, they are by no means conclusive. One problem is that the group rule–utilitarian model does not yield very sharp comparative static predictions. This makes it difficult to assess its performance from the reduced-form regressions. Moreover, the results are also consistent with other simpler models explaining voter turnout. As we argue below, the *intensity model*—which assumes that people's payoff from voting depends on how strongly they feel about the issue—yields comparative statics that are consistent with the results in Table 2. Thus, to investigate further the performance of the group rule–utilitarian model, we structurally estimate a parameterized version. This allows us to compare formally its performance with the intensity model. We will also be able to test whether the structural group rule–utilitarian model results in a better fit of the data than the reduced-form model above.

V. Structural Estimation

A. *Method*

To structurally estimate the group rule–utilitarian model, we assume that for each jurisdiction j, $\nu_j = \exp(\boldsymbol{\beta}_\nu \cdot \mathbf{z}_{\nu j})$ and $\omega_j = \exp(\beta_\omega)$ where $\boldsymbol{\beta}_\nu$ is a vector of parameters to be estimated, $\mathbf{z}_{\nu j}$ are the variables likely to affect the fraction of supporters, and β_ω is a parameter to be estimated. We further assume that $x_j = \exp(\boldsymbol{\beta}_x \cdot \mathbf{z}_{pj} + \varepsilon_j)$ and $b_j = \exp(\boldsymbol{\beta}_b \cdot \mathbf{z}_{pj} + \varepsilon_j)$ where $\boldsymbol{\beta}_x$ and $\boldsymbol{\beta}_b$ are vectors of parameters to be estimated, $\mathbf{z}_{pj}$ are the variables likely to affect supporters' and opposers' willingness to pay, and ε_j is the realization of a random variable distributed according to the standard normal distribution. The shock term ε_j reflects unobserved district-specific characteristics, like population tastes for liquor consumption, that might have an impact on the benefits and costs to supporters and opposers. The assumption that ε_j is a common shock to benefits and costs is key to deriving the likelihood function. Finally, we assume that $c_j = \exp(\boldsymbol{\beta}_c \cdot \mathbf{z}_{cj})$ where $\boldsymbol{\beta}_c$ is a

[26] The fact that most of the demographic and housing variables are measured at the county level only in 1970, 1980, and 1990 makes these noisy measures. This may explain why many of these coefficients are not statistically significant.

[27] While these law changes decrease the implicit price of alcohol for the jurisdiction, they also reduce the travel distance required to obtain the alcohol. Baughman et al. (2001) find that for certain alcohol-policy liberalizations, this second effect dominates in regards to alcohol-related accidents.

vector of parameters to be estimated and $\mathbf{z}_{cj}$ are the variables that may impact voting costs. The functional forms are selected to ensure that ν_j, ω_j, x_j, b_j, and c_j are non-negative.

The task is to estimate the parameters $\boldsymbol{\Omega} = \{\boldsymbol{\beta}_\nu, \beta_\omega, \boldsymbol{\beta}_x, \boldsymbol{\beta}_b, \boldsymbol{\beta}_c\}$. To construct the likelihood function, fix $\boldsymbol{\Omega}$ and consider a particular jurisdiction j. We observe the fractions voting in support and opposition—V_{sj} and V_{oj}. According to the model, $V_{sj} = \mu_j\gamma^*_{sj}/c_j$ and $V_{oj} = (1 - \mu_j)\gamma^*_{oj}/c_j$ where μ_j is the fraction of the voting population who are supporters, and γ^*_{sj} and γ^*_{oj} are the equilibrium-critical cost levels for supporters and opposers. Using the formulas presented in Proposition 1, it follows that

$$V_{sj} = \frac{\mu_j}{c_j} \cdot \left(\frac{c_j(\nu_j + \omega_j)(\nu_j x_j)^{(\nu_j+1)/3}(\omega_j b_j)^{(\omega_j+3)/3}}{\nu_j\omega_j[(\omega_j b_j)^{1/3} + (\nu_j x_j)^{1/3}]^{\nu_j+\omega_j+1}B(\nu_j, \omega_j)} \right)^{1/2}$$

and that

$$V_{oj} = \frac{(1 - \mu_j)}{c_j} \cdot \left(\frac{c_j(\nu_j + \omega_j)(\nu_j x_j)^{(\nu_j+3)/3}(\omega_j b_j)^{(\omega_j+1)/3}}{\nu_j\omega_j[(\omega_j b_j)^{1/3} + (\nu_j x_j)^{1/3}]^{\nu_j+\omega_j+1}B(\nu_j, \omega_j)} \right)^{1/2}.$$

Substituting in our functional forms and rearranging, we can write these as

$$V_{sj} = \mu_j \sqrt{\exp \varepsilon_j K_j}$$

and

$$V_{oj} = (1 - \mu_j) \sqrt{\exp \varepsilon_j K_j}\, \frac{(\nu_j\hat{x}_j)^{1/3}}{(\omega_j\hat{b}_j)^{1/3}}$$

where $\hat{b}_j = \exp(\boldsymbol{\beta}_b \cdot \mathbf{z}_{bj})$, $\hat{x}_j = \exp(\boldsymbol{\beta}_x \cdot \mathbf{z}_{xj})$, and

$$K_j = \left(\frac{(\nu_j + \omega_j)(\nu_j\hat{x}_j)^{(\nu_j+1)/3}(\omega_j\hat{b}_j)^{(\omega_j+3)/3}}{\nu_j\omega_j c_j[(\omega_j\hat{b}_j)^{1/3} + (\nu_j\hat{x}_j)^{1/3}]^{\nu_j+\omega_j+1}B(\nu_j, \omega_j)} \right)^{1/2}.$$

We can now solve these two equations for the realizations of μ_j and ε_j implied by any given choice of parameters $\boldsymbol{\Omega}$. In this way, we obtain

$$\mu_j = \frac{V_{sj}(\nu_j\hat{x}_j)^{1/3}}{V_{oj}(\omega_j\hat{b}_j)^{1/3} + V_{sj}(\nu_j\hat{x}_j)^{1/3}}$$

and

$$\varepsilon_j = 2 \ln[V_{oj}(\omega_j\hat{b}_j)^{1/3} + V_{sj}(\nu_j\hat{x}_j)^{1/3}] - 2 \ln[K_j(\nu_j\hat{x}_j)^{1/3}].$$

These equations define μ_j and ε_j as functions of the turnouts (V_{sj}, V_{oj}). Using the distributions of μ_j and ε_j, we can now compute the probability of observing any pair of turnouts.[28] Letting $\mathbf{Z_j} = (\mathbf{z}_{pj}, \mathbf{z}_{\nu j}, \mathbf{z}_{cj})$, the probability density function for (V_{sj}, V_{oj}) is

$$g_j(V_{sj}, V_{oj}|\boldsymbol{\Omega}, \mathbf{Z_j}) = \frac{2(\nu_j\hat{x}_j)^{\nu_j/3}(V_{sj})^{\nu_j-1}(\omega_j\hat{b}_j)^{\omega_j/3}(V_{oj})^{\omega_j-1}}{[V_{oj}(\omega_j\hat{b}_j)^{1/3} + V_{sj}(\nu_j\hat{x}_j)^{1/3}]^{\nu_j+\omega_j}B(\nu_j, \omega_j)} \cdot \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{\zeta_j^2}{2}\right)$$

where

$$\zeta_j = \ln c_j + (\nu_j + \omega_j + 1)\ln[(\omega_j\hat{b}_j)^{1/3} + (\nu_j\hat{x}_j)^{1/3}] + \ln B(\nu_j, \omega_j) + 2 \ln[V_{oj}(\omega_j\hat{b}_j)^{1/3} + V_{sj}(\nu_j\hat{x}_j)^{1/3}] - \ln(\nu_j + \omega_j) - \frac{\nu_j}{3}\ln(\nu_j) - \frac{\omega_j}{3}\ln(\omega_j) - \frac{\nu_j + 3}{3}\ln(\hat{x}_j) - \frac{\omega_j + 3}{3}\ln(\hat{b}_j).$$

Accordingly, our *likelihood function* is

$$L(\boldsymbol{\Omega}) = \prod_{j=1}^{J} g(V_{sj}, V_{oj}|\boldsymbol{\Omega}, \mathbf{Z_j}). \quad (1)$$

Any given estimate of the parameters $\boldsymbol{\Omega} = \{\boldsymbol{\beta}_\nu, \beta_\omega, \boldsymbol{\beta}_x, \boldsymbol{\beta}_b, \boldsymbol{\beta}_c\}$ implies values of the

[28] The derivation is available from the authors on request.

exogenous variables for each jurisdiction j.[29] These, in turn, imply values of the critical costs via the equations of Proposition 1. Unconstrained maximization of the likelihood function generates parameter estimates which, for some jurisdictions, imply values of the critical costs that exceed the maximum possible cost. Since this is clearly inconsistent with the model, we must maximize the likelihood function subject to the feasibility constraints that γ_{sj}^* and γ_{oj}^* are less than c_j for each jurisdiction j.[30]

To see how to impose these constraints, observe that for each jurisdiction j

$$\frac{\gamma_{sj}^*}{c_j} = \frac{V_{sj}}{\mu_j} = \frac{V_{oj}(\omega_j \hat{b}_j)^{1/3} + V_{sj}(\nu_j \hat{x}_j)^{1/3}}{(\nu_j \hat{x}_j)^{1/3}}$$

and that

$$\frac{\gamma_{oj}^*}{c_j} = \frac{V_{oj}}{1 - \mu_j} = \frac{V_{oj}(\omega_j \hat{b}_j)^{1/3} + V_{sj}(\nu_j \hat{x}_j)^{1/3}}{(\omega_j \hat{b}_j)^{1/3}}.$$

Using these, the feasibility constraint for jurisdiction j can be written as

$$\left(\frac{V_{sj}}{1 - V_{oj}}\right)^3 \leq \frac{\omega_j \hat{b}_j}{\nu_j \hat{x}_j} \leq \left(\frac{1 - V_{sj}}{V_{oj}}\right)^3.$$

Substituting in for $\omega_j \hat{b}_j$ and $\nu_j \hat{x}_j$, yields

$$(2) \quad \left(\frac{V_{sj}}{1 - V_{oj}}\right)^3 \leq \frac{(\exp \beta_\omega)\exp \boldsymbol{\beta}_b \cdot \mathbf{z}_{pj}}{(\exp \boldsymbol{\beta}_\nu \cdot \mathbf{z}_{\nu j})\exp \boldsymbol{\beta}_x \cdot \mathbf{z}_{pj}} \leq \left(\frac{1 - V_{sj}}{V_{oj}}\right)^3.$$

We can now solve for the parameters that maximize the likelihood function subject to these constraints. As noted in Section II, we may then use Proposition 2 to check whether the estimated critical cost levels are actually an equilibrium given the values of the exogenous variables. Happily, this is the case for every jurisdiction.

B. *Parameter Estimates*

The empirical results of the group rule–utilitarian model are shown in Tables 3 and 4. Table 3 presents the parameter estimates that maximize the likelihood function (1) subject to the constraints specified in (2). Using the estimates in Table 3, Table 4 presents some aggregate information about the implied values of the model's exogenous variables for the 363 jurisdictions.

The estimates in Table 3 for $\boldsymbol{\beta}_\nu$ and β_ω imply that the average expected percentage of supporters across the 363 jurisdictions is 54 percent (see Table 4). The coefficient estimate associated with the fraction of Baptists is statistically significant and implies that increasing by 10 percent the fraction of Baptists decreases supporters by approximately 3 percent, suggesting that baptists are 30 percent more likely to oppose the referendum. The only other statistically significant coefficient is that associated with the MSA variable and it implies that the fraction of supporters is 11 percent less, on average, if the jurisdiction is located in an MSA. While the other coefficient estimates are not statistically significant, they suggest that people over the age of 50 who are neither black nor white are slightly less likely to support the referendum, while single males are more likely to. The estimates also suggest that support is greater in jurisdictions with a larger fraction of owner-occupied housing and increasing in the number of prior year's alcohol-related accidents in the county.

The coefficient estimates in Table 3 for $\boldsymbol{\beta}_b$ and $\boldsymbol{\beta}_x$ suggest that benefits and costs are greater when the vote pertains to off-premise consumption of all alcohol than when it involves just beer and wine. The average marginal effects are to increase the supporters' benefit by 0.28 and the opposers' cost by 0.02. While the positive

[29] Thus, $\nu_j = \exp(\boldsymbol{\beta}_\nu \cdot \mathbf{z}_{\nu j})$, $\omega_j = \exp(\beta_\omega)$, and $c_j = \exp(\boldsymbol{\beta}_c \cdot \mathbf{z}_{cj})$. Moreover, $x_j = \exp(\boldsymbol{\beta}_x \cdot \mathbf{z}_{pj} + \varepsilon_j)$ and $b_j = \exp(\boldsymbol{\beta}_b \cdot \mathbf{z}_{pj} + \varepsilon_j)$ where $\varepsilon_j = 2 \ln[V_{oj}(\omega_j \hat{b}_j)^{1/3} + V_{sj}(\nu_j \hat{x}_j)^{1/3}] - 2 \ln[K_j(\nu_j \hat{x}_j)^{1/3}]$.

[30] By imposing these feasibility constraints, we are requiring that the choice of parameters must satisfy the conditions of Proposition 1 when either γ_{sj}^* and γ_{oj}^* equals c_j. This restricts the choice of parameters in a marginally tighter way than is implied by the model. This is because the conditions of Proposition 1 need not be satisfied if either group's critical cost level is at the boundary. In the boundary case, the first order conditions are in the form of weak inequalities rather than equalities. Since this dampens the ability of the model to fit the data, it will in no way compromise our conclusions about the relative performance of the model.

TABLE 3—GROUP RULE–UTILITARIAN
(N = 363, log likelihood = 748.59)

	Coefficients		Coefficients
v:		*x*:	
Fraction of county population that is Baptist	−1.213* (0.627)	Indicator variable for off-premise consumption of alcohol	0.021 (0.193)
Fraction of county voting-age population over the age of 50	−0.078 (0.777)	Indicator variable for off- and on-premise consumption of alcohol	−1.119** (0.220)
Fraction of county population that is single and male	1.629 (2.734)	Indicator variable for town or city referendum	1.372** (0.118)
Fraction of county population that is black	−0.046 (0.600)	Indicator variable for most liberal policy in county	0.697** (0.135)
Fraction of county population that is neither black nor white	−1.202 (0.897)	Constant	−1.675** (0.719)
Fraction of houses in county that are owner occupied	0.589 (0.741)	*c*:	
Median price of owner-occupied houses in county (2000 dollars, $1,000)	−0.002 (0.003)	Indicator variable for election on weekend	0.276** (0.117)
Alcohol-related accidents in county in prior year	0.029 (0.063)	Rainfall on day of election (tenths of inches)	0.002 (0.002)
Indicator variable for jurisdiction being located in an MSA	−0.367** (0.132)	Snowfall on day of election (tenths of inches)	0.065 (0.052)
Constant	2.015** (0.824)	Average temperature on day of election (Fahrenheit)	0.010 (0.024)
ω:		Average temperature squared	0.00001 (0.0002)
Constant	1.419 (0.077)	Indicator variable for election in summer	−0.101 (0.162)
b:			
Indicator variable for off-premise consumption of alcohol	0.469** (0.151)		
Indicator variable for off- and on-premise consumption of alcohol	−0.474** (0.204)		
Indicator variable for town or city referendum	1.951** (0.115)		
Indicator variable for most liberal policy in county	0.520** (0.125)		
Constant	−2.865** (0.704)		

Notes: Standard errors are in parentheses. * Statistically significant at the 0.10 level; ** statistically significant at the 0.05 level.

TABLE 4—ESTIMATED VALUES FROM GROUP RULE–UTILITARIAN MODEL

Model parameters	Mean estimates
v	5.09 (1.24)
ω	4.13 (0)
x	0.95 (0.99)
b	0.59 (0.65)
c	2.44 (0.55)

Note: Standard deviations are in parentheses.

coefficients associated with off-premise consumption were expected, the negative and statistically significant coefficients associated with off- and on-premise consumption of all alcohol were not. This is in line with the results from the reduced-form regressions. Finally, the estimates suggest that benefits and costs are higher when the jurisdiction in question is a city and when the proposal would result in a more liberal policy than exists in the rest of the county. The average marginal effects of these two variables are 0.87 and 0.33 for the supporters' benefit and 1.12 and 0.74 for the opposers' costs, respectively.

Consistent with the reduced-form results, the estimates of β_c indicate that while the cost of voting does depend on whether the election is held on the weekend, the weather conditions on the day of the election and summer-time elections do not significantly affect the cost of voting. The positive and statistically significant coefficient of 0.276 associated with the weekend indicator variable implies a marginal effect of 0.64 on the upper support of the voting cost distribution.

The average values of b_j and x_j in Table 4 indicate that opposers feel more intensely about the issue than do supporters. This greater intensity translates into opposers voting with higher probability: the average critical cost level is 0.76 for supporters and 0.96 for opposers. These yield average turnout rates of 32 percent for supporters and 40 percent for opposers.

It is important to note that the values in Table 4 are in relative terms and the absolute levels have no significance.[31] A feel for the numbers in dollar terms, however, can be obtained by assigning a value to the cost of voting. For example, suppose that the average voting cost across all districts is \$15. This implies that $c/2 = 2.44/2 = \$15$. This ties down the units in dollar terms since $2.44 = \$30$ or $1 = \$30/(2.44) = \$12.30$. It follows that the average value of x is $\$12.30(0.95) = \$11.68$, while the average value of b is $\$12.30(0.59) = \$7.26$. These numbers suggest that the proposed regulatory changes are of very minor importance to citizens' welfare.

The predictions of the model's exogenous variables and reasonable cost levels imply a value of μ_j for each district. This can be combined with b_j and x_j to provide a measure of the average net benefit of the proposed change $\mu_j b_j - (1 - \mu_j)x_j$. The change passes a standard cost-benefit test if and only if this average net benefit is positive. Of the 363 referenda, 96 had a positive net benefit. While 93 of these did pass, 57 of the referenda with a negative net benefit also passed. This shows that there is no reason to believe that group rule–utilitarian voting implies surplus-maximizing outcomes.

A proposed change with a positive net benefit does not imply that holding a referendum is desirable because of the transaction costs associated with voting. Holding the referendum passes a cost-benefit test if and only if $\mu_j(b_j - (\gamma_{sj}^*)^2/2c_j) - (1 - \mu_j)(x_j + (\gamma_{oj}^*)^2/2c_j)$ is positive. Only 46 referenda had a positive net benefit when voting costs were included.[32] This suggests that the case for this form of direct democracy is weak when evaluated on conventional cost-benefit grounds.

C. *Fit*

To give a sense of the fit of the model, Figure 3 contains a scatterplot depicting how actual turnout compares to predicted turnout for our jurisdictions. Predicted turnout in district j is that which would arise if the actual fraction of supporters equalled the expected (i.e., $\mu_j = \nu_j/(\nu_j + \omega_j)$) and if the actual values of the supporters' benefit and the opposers' cost equalled the fitted values (i.e., $b_j = \hat{b}_j$ and $x_j = \hat{x}_j$). If predicted turnout equalled actual turnout in all cases, all observations in Figure 3 would lie along the 45° line. Figure 3 shows that predicted turnout is strongly correlated with actual. The scatterplot also indicates that predicted turnout is more likely to exceed actual when actual is relatively low, and visa-versa when actual is relatively high. For a more formal test of the fit, note that the model explains 45 percent of the variation in turnout for the referenda and 51 percent of the variation in turnout against the referenda.

[31] Note from Table 3 that there is no constant term in the cost of voting function. By not including a constant term we are setting the maximal voting cost equal to one for elections held on a non-summer weekday where there is no rain or snow and the temperature is zero degrees Fahrenheit. The normalization is required because we cannot infer benefits and costs from the number of people who vote for and against the referendum. Instead, we can only infer relative benefits and costs.

[32] The Texas state government's recent move to require that liquor referenda be held on uniform election dates should help in this respect by spreading the transaction costs over a number of ballot issues. Since it will also have an impact on the likely turnout pattern, however, it may increase the set of referenda with negative net benefits that pass.

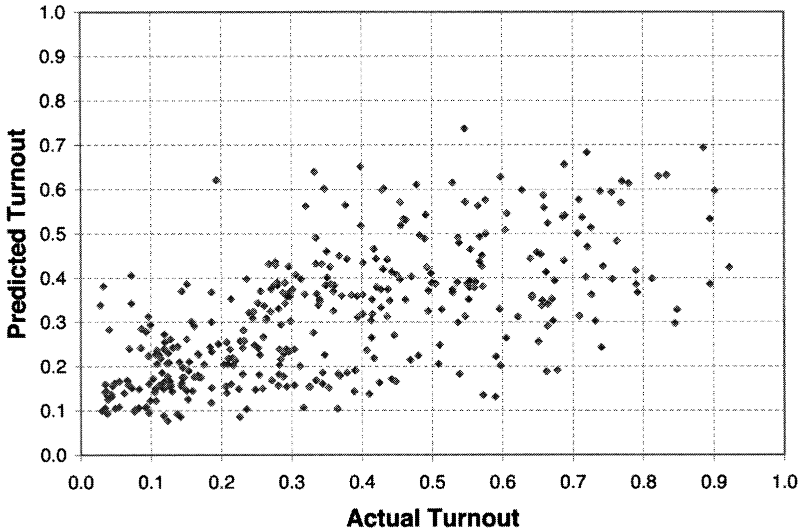

FIGURE 3. ACTUAL TURNOUT VERSUS PREDICTED TURNOUT FOR GROUP RULE–UTILITARIAN MODEL

Also of interest as regards fit is the *relative* performance of the structural and reduced-form models. The maximum log-likelihood value is 748.59 for the structural model and 662.90 for the reduced-form model. More rigorously, we can compare the performance of these two models using the directional test for non-nested models proposed by Quang H. Vuong (1989). Vuong proposes a likelihood ratio–based statistic to test the null hypothesis that two competing models are equally close to the true data-generating process against the alternative hypothesis that one model is closer. He proves that the difference between the maximum log-likelihood values of Model A and Model B divided by the product of the standard deviation of the difference in the log likelihood value for each observation and the square root of the number of observations has a standard normal distribution if the two models are equivalent. Vuong also demonstrates that the null hypothesis that Models A and B are equivalent can be rejected when the alternative hypothesis is that Model A (B) is better than Model B (A) if the test statistic above is greater (less) than the critical value obtained from the standard normal distribution for some significance level. Vuong's test statistic for the null hypothesis that the structural model is equivalent to the reduced form model is 3.17 and, thus, can be rejected at the 5-percent significance level when the alternative hypothesis is that the structural model is better.

VI. Comparison with the Intensity Model

In this section, to assess further the performance of the group rule–utilitarian model, we compare it with a simple, but plausible, alternative: the *intensity* model. This assumes that people get a higher payoff from voting the more intensely they feel about an issue. This is consistent with an *expressive* view of voting (see, for example, Geoffrey Brennan and Loren Lomasky, 1993). Voting is like cheering at a football game and you are more likely to cheer the more you care about the outcome. Formally, the intensity model assumes that supporters vote if their voting cost is less than $\gamma_s = \alpha b$, while opposers vote if their voting cost is less than $\gamma_o = \alpha x$. The parameter α measures the strength of citizens' desire to express themselves through voting. While this may vary across jurisdictions, the key restriction is that both supporters and opponents share the same α. Under this specification, the probability that a supporter votes is the probability that γ_s exceeds his voting cost, which is $\gamma_s/c = \alpha b/c$. Similarly, the probability that an opposer votes is $\gamma_o/c = \alpha x/c$.

The comparative static predictions of this model are perfectly consistent with the results from the reduced form regressions in Section IV if we allow α to depend upon population characteristics. For example, both the fractions of votes in support and opposition could be increasing in the fraction of Baptists if citizens in jurisdictions with more Baptists have a higher desire to express themselves. Thus, to test between the intensity and group rule–utilitarian models, we structurally estimate the intensity model and use Vuong's test.

To estimate the intensity model, we assume (as for the group rule–utilitarian model) that for each jurisdiction, j, $\nu_j = \exp(\boldsymbol{\beta}_\nu \cdot \mathbf{z}_{\nu j})$, $\omega_j = \exp(\beta_\omega)$, $x_j = \exp(\boldsymbol{\beta}_x \cdot \mathbf{z}_{pj} + \varepsilon_j)$, $b_j = \exp(\boldsymbol{\beta}_b \cdot \mathbf{z}_{pj} + \varepsilon_j)$, and $c_j = \exp(\boldsymbol{\beta}_c \cdot \mathbf{z}_{cj})$ where ε_j is the realization of a random variable distributed according to the standard normal distribution. We further assume that $\alpha_j = \exp(\boldsymbol{\beta}_\alpha \cdot \mathbf{z}_{\alpha j})$ where $\boldsymbol{\beta}_\alpha$ is a vector of parameters to be estimated and $\mathbf{z}_{\alpha j}$ is a vector of jurisdiction-specific characteristics that we thought might affect citizens' desires to express themselves. The parameters to be estimated are $\{\boldsymbol{\beta}_\nu, \beta_\omega, \boldsymbol{\beta}_b, \boldsymbol{\beta}_x, \boldsymbol{\beta}_\alpha, \boldsymbol{\beta}_c\}$. The procedure for constructing the likelihood function is similar to that for the group rule–utilitarian model. Table 5 shows the parameter values that maximize the likelihood function subject to the constraints that $\gamma_{sj} \leq c_j$ and $\gamma_{oj} \leq c_j$ for each jurisdiction j and Table 6 contains average implied values of the exogenous variables (ν_j, ω_j, α_j, b_j, x_j, c_j) based on the parameter estimates.

In contrast to the group rule–utilitarian model, the positive coefficients in Table 5 associated with the race variables provide limited evidence that minorities are more likely to support the referendum. These coefficient estimates are not statistically significant, however, in either model. Furthermore, the effects of the other factors on the fraction of supporters are similar to those in the group rule–utilitarian model. As for the cost of voting, the only coefficient estimate that is appreciably different is that associated with the weekend indicator variable, the predicted effect being smaller than for the group rule–utilitarian model. As indicated by the implied values in Table 6, the average percentage of supporters predicted by the intensity model is almost identical to that in the group rule–utilitarian model (both approximately 54 percent). While it is impossible to compare directly levels across models, note that while in both models the implied value of the opposers' willingness to pay is greater than the supporters', on average this difference is much larger in the group rule–utilitarian model.

We allow the strength of citizens' desire to express themselves through voting to vary across jurisdictions depending on the jurisdiction's religious composition, age distribution, marital composition, racial composition, and voting-age population.[33] The estimates suggest that individuals in smaller communities have a stronger desire to express themselves. While only voting-age population is statistically significant, the other coefficients in Table 5 suggest that individuals in communities with a larger proportion of individuals who are Baptist, over the age of 50, nonsingle males, or white, have a stronger desire to express themselves.

The maximum log-likelihood value for the intensity model is 706.41, which lies between the values for the group rule–utilitarian and reduced-form models. Vuong's test statistic for the null hypothesis that the group rule–utilitarian model is equivalent to the intensity model is 2.07, and hence can be rejected at the 5-percent significance level when the alternative hypothesis is that the group rule–utilitarian model is better.

VII. Conclusion

This paper has explored a group rule–utilitarian approach to understanding voter turnout. It has presented a model based on this approach and studied its performance in explaining turnout in Texas liquor referenda. The results are encouraging. The reduced-form regressions are broadly consistent with the comparative static predictions of the model. Moreover, the structurally estimated version of the model yields reasonable coefficient estimates and fits the data better than the reduced-form model. In addition, it outperforms a structurally

[33] Note that population is not included in the structural estimation of the group rule–utilitarian model.

TABLE 5—INTENSITY MODEL
(N = 363, log likelihood = 706.41)

	Coefficients		Coefficients
v:		b:	
Fraction of county population that is Baptist	−0.536 (0.375)	Indicator variable for off-premise consumption of alcohol	0.077 (0.132)
Fraction of county voting-age population over the age of 50	−0.084 (0.586)	Indicator variable for off- and on-premise consumption of alcohol	−0.144 (0.157)
Fraction of county population that is single and male	1.331 (1.720)	Indicator variable for town or city referendum	0.869** (0.118)
Fraction of county population that is black	0.633 (0.458)	Indicator variable for most liberal policy in county	0.170 (0.125)
Fraction of county population that is neither black nor white	0.299 (0.604)	Constant	−2.006** (0.864)
Fraction of houses in county that are owner occupied	0.287 (0.547)	x:	
Median price of owner-occupied houses in county (2000 dollars, $1,000)	0.001 (0.002)	Indicator variable for off-premise consumption of alcohol	−0.022 (0.134)
Alcohol-related accidents in county in prior year	0.063 (0.047)	Indicator variable for off- and on-premise consumption of alcohol	−0.324** (0.160)
Indicator variable for jurisdiction being located in an MSA	−0.295** (0.100)	Indicator variable for town or city referendum	0.674** (0.118)
Constant	1.417** (0.606)	Indicator variable for most liberal policy in county	0.225* (0.127)
ω:		Constant	−1.603* (0.864)
Constant	1.438** (0.784)	c:	
α:		Indicator variable for election on weekend	0.137 (0.117)
Fraction of county population that is Baptist	0.773 (0.584)	Rainfall on day of election (tenths of inches)	0.001 (0.002)
Fraction of county voting-age population over the age of 50	0.840 (0.716)	Snowfall on day of election (tenths of inches)	0.012 (0.053)
Fraction of county population that is single and male	−2.058 (3.026)	Average temperature on day of election (Fahrenheit)	0.003 (0.024)
Fraction of county population that is black	−0.627 (0.737)	Average temperature squared	0.000003 (0.0002)
Fraction of county population that is neither black nor white	−0.893 (0.915)	Indicator variable for election in summer	−0.064 (0.163)
Voting-age population (1,000)	−0.021** (0.008)		

Notes: Standard errors are in parentheses. * Statistically significant at the 0.10 level; ** statistically significant at the 0.05 level.

estimated version of a simple expressive voting model. This suggests that the approach to thinking about turnout that underlies the model deserves serious consideration.

There are many different directions for future research on the general approach (see also Feddersen and Sandroni, 2002). From an empirical perspective, it would be worth comparing the performance of the group rule–utilitarian and pivotal-voter models. While there are good reasons to be skeptical about the pivotal-voter model's ability to explain turnout, it represents in many respects the simplest way of thinking about voting behavior. Thus, it should be rejected only if it can be shown to be outperformed by some coherent alternative. This has yet to be demonstrated. The data set used in this paper is appropriate for studying the pivotal-voter model, and the group rule–utilitarian model is a coherent alternative. It remains to estimate structurally the pivotal-voter model and compare its performance. Given its greater complexity, this will be a challenging task.

With our data, it is difficult to compare di-

TABLE 6—ESTIMATED VALUES FROM INTENSITY MODEL

Model parameters	Mean estimates
v	5.00
	(0.83)
ω	4.21
	(0)
α	1.44
	(0.37)
x	0.37
	(0.22)
b	0.30
	(0.20)
c	1.38
	(0.12)

Note: Standard deviations are in parentheses.

rectly the performance of our group rule–utilitarian model and the rule-utilitarian model of Feddersen and Sandroni (2002). Future research might try to distinguish between these models in experiments. It would seem possible to set up an experiment where participants are assigned to two groups whose members must participate in an election. The two groups could be assigned different private benefits from the election outcome, as well as different beliefs concerning aggregate benefits. Individuals could then be assigned different voting costs and one could see which model best describes their voting behavior.

From a theoretical perspective, it would be interesting to incorporate the decision to acquire information about the election. Casual empiricism suggests that many citizens view thinking through the issues as part of their civic duty. One could imagine a two-stage procedure in which citizens first decide to become informed and then decide whether to vote. One advantage of such an extension is that, under the assumption that more educated citizens have a lower cost of acquiring information, it might yield theoretical insights into the empirical relationship between education and turnout (see, for example, Norman H. Nie et al., 1996). The extension would also allow study of the impact of media and campaigning on turnout.

It would also be interesting to think through the implications of heterogeneity in supporters' and opposers' preferences. It seems likely that, within groups, those voters who care less intensely about an issue will have lower critical-cost levels. This may reflect considerations of equity in the allocation of the costs of voting. Another interesting topic is how to think about elections with three or more candidates. While such elections naturally divide the population into groups of supporters, it is no longer obvious how supporters of an underdog candidate should vote. This is particularly the case when there are differences among group members in their second-choice candidate. Finally, more thought should be given to the justification of the behavior postulated here. Why should we expect citizens to behave as group rule–utilitarians in elections?

APPENDIX

Information on the Data

A total of 526 local liquor elections are identified in the annual reports of the Texas Alcoholic Beverage Commission between 1976 and 1996. We use 363 of these in our estimation. Of the 163 elections we do not use, 64 were missing critical information[34] and 43 involved elections where other items seem likely to have been voted on at the same time.[35] To keep the basic issue constant across

[34] Specifically, 12 observations did not identify the precise nature of the changes proposed by the referendum, 15 elections occurred in cities not identified in the U.S. Census, and 37 occurred in justice precincts where the precise number of justice precincts in the county could not be identified with confidence.

[35] We sent letters to the clerks of the 180 counties that had liquor elections over the period, requesting information on whether other issues were being voted on at the same time. Almost half sent copies of the notes from the Commissioners Court's meeting or a copy of the official document containing the results of the election. Both of these identified all items that were voted on at the same time as the local liquor referendum. Most of the other county clerks sent letters indicating whether the liquor law referendum was the only item on the ballot. A few county clerks either did not respond or could not determine

elections, we focus on proposals to move from a completely "dry" status where the selling of any alcohol is prohibited at the retail level.[36] Therefore, we eliminate the 53 elections where the jurisdiction was not "dry" prior to the election. Finally, in order to estimate structurally our model, we drop three elections where zero votes were cast against the referendum.[37]

The United States Census Bureau provides annual county-level populations by age. This information allows us to determine the voting-age population at the time of the election when the jurisdiction voting is either an entire county or a justice precinct. The voting-age population of a justice precinct at the time of an election is estimated by dividing the county voting-age population by the number of justice precincts in the county. We expect this to be a relatively good approximation based on information provided by the Texas Legislative Council indicating that justice precincts are selected so that each in a particular county has roughly the same number of residents. The fraction of the population of a justice precinct or county over the age of 50 can also be constructed from this annual county-level census information. The 1970, 1980, 1990, and 2000 Censuses provide county-level information on racial composition, marital status, and housing characteristics. By linearly interpolating this census information, we construct estimates of the fractions of a jurisdiction's population that is single and male, black, and neither black nor white, as well as the fraction of houses that are owner occupied and the median price of an owner-occupied house. For justice precincts, cities, and towns, we are implicitly assuming that these demographic and housing characteristics are uniform across the county.

In addition to the county-level information, the 1970, 1980, and 1990 Censuses provide the total population of many cities and towns. For cities and towns, the voting-age population is estimated at the time of an election by linearly interpolating and extrapolating the information provided by the Census Bureau. Consider the city of Novice in Coleman County, which had an election on January 6, 1987. Novice had a voting-age population of 129 in 1980 and 140 in 1990. By linearly interpolating this information, we estimate Novice's voting-age population to be 136.7 at the time of the election. If the election occurred in 1993, we would estimate the population by using Novice's voting-age population in 1990 and assuming that this population grew at the same rate as the county's voting-age population between 1990 and 1993. Because Coleman's voting-age population grew −1.56 percent from 1990 to 1993, we would estimate the voting-age population in Novice in 1993 to be 137.8. A similar extrapolation is used for elections prior to 1980 in cities and towns whose populations were not reported by the 1970 Census (but were reported in 1980 and 1990). As with the justice precincts, the fraction of a city's or town's population over the age of 50 is assumed to be the same as in the county.

Churches & Church Membership in the United States provides county-level information on the number of adherents to Baptist denominations. It is published every ten years (in 1970, 1980, and 1990). The total number of Baptists in a county at the time of an election is estimated by linearly interpolating and extrapolating this information. By dividing this number by the county population, we obtain an estimate of the fraction of the county population that is Baptist. We use this fraction as a proxy for the fraction of Baptists in each of the 363 jurisdictions, thereby implicitly assuming that Baptists are uniformly distributed throughout each county.

The United States Carbon Dioxide Information Analysis Center collects daily observations of maximum temperature, minimum temperature, precipitation, and snowfall from 1,062 weather stations (of which 44 are located in Texas) comprising the United States Historical Climatology

all items on the ballot. Of the 43 elections we suspect might have been held with other issues, 24 were ones for which we could not get a response from the relevant county clerk and which were held on uniform election days. The remaining 19 were ones that we knew for certain were held with other issues. Of these, 16 were held on uniform election dates.

[36] A jurisdiction can prohibit the retail sale of all alcohol while still allowing private clubs (including the VFW, American Legion, and other fraternal organizations) to serve alcohol.

[37] All of these elections had at least one vote for the referendum.

Network. We calculate the midpoint of the maximum and minimum temperature at each weather station on the day of an election and use this measure of temperature in our specification.

Proofs

PROOF OF PROPOSITION 1:

Let (γ_s^*, γ_o^*) be an interior equilibrium. Then, (γ_s^*, γ_o^*) must satisfy the pair of first-order conditions:

$$h\left(\frac{\gamma_o^*}{\gamma_o^* + \gamma_s^*}; \nu, \omega\right) \frac{(\gamma_o^*)^2}{(\gamma_o^* + \gamma_s^*)^3} b = \frac{\nu \gamma_s^*}{(\nu + \omega)c}$$

and

$$h\left(\frac{\gamma_o^*}{\gamma_o^* + \gamma_s^*}; \nu, \omega\right) \frac{(\gamma_s^*)^2}{(\gamma_o^* + \gamma_s^*)^3} x = \frac{\omega \gamma_o^*}{(\nu + \omega)c}.$$

The two first-order conditions imply that

$$\gamma_s^* = \frac{(\omega b)^{1/3}}{(\nu x)^{1/3}} \gamma_o^*.$$

Substituting this into the first of the two first-order conditions, we find that

$$(\gamma_o^*)^2 = h\left(\frac{(\nu x)^{1/3}}{(\omega b)^{1/3} + (\nu x)^{1/3}}; \nu, \omega\right) \frac{c(\nu + \omega)(\nu x)^{4/3}(\omega b)^{2/3}}{\nu\omega[(\nu x)^{1/3} + (\omega b)^{1/3}]^3}$$

which implies that

$$(\gamma_s^*)^2 = h\left(\frac{(\nu x)^{1/3}}{(\omega b)^{1/3} + (\nu x)^{1/3}}; \nu, \omega\right) \frac{c(\nu + \omega)(\nu x)^{2/3}(\omega b)^{4/3}}{\nu\omega[(\nu x)^{1/3} + (\omega b)^{1/3}]^3}.$$

Thus,

$$\gamma_o^* = \left(h\left(\frac{(\nu x)^{1/3}}{(\omega b)^{1/3} + (\nu x)^{1/3}}; \nu, \omega\right) \frac{c(\nu + \omega)(\nu x)^{4/3}(\omega b)^{2/3}}{\nu\omega[(\nu x)^{1/3} + (\omega b)^{1/3}]^3}\right)^{1/2}$$

and

$$\gamma_s^* = \left(h\left(\frac{(\nu x)^{1/3}}{(\omega b)^{1/3} + (\nu x)^{1/3}}; \nu, \omega\right) \frac{c(\nu + \omega)(\nu x)^{2/3}(\omega b)^{4/3}}{\nu\omega((\nu x)^{1/3} + (\omega b)^{1/3})^3}\right)^{1/2}.$$

For the Beta distribution, we have that

$$h\left(\frac{(\nu x)^{1/3}}{(\omega b)^{1/3} + (\upsilon x)^{1/3}}; \nu, \omega\right) = \frac{(\upsilon x)^{(\nu - 1)/3}(\omega b)^{(\omega - 1)/3}}{[(\omega b)^{1/3} + (\upsilon x)^{1/3}]^{\nu + \omega - 2}B(\nu, \omega)}$$

and substituting this into the above formulas yields the characterization stated in the proposition. QED

Comparative Static Results: By Proposition 1, we have that

$$\bar{V}_s = \frac{\nu\gamma_s^*}{(\nu+\omega)c} = \left(\frac{\nu(\nu x)^{(\nu+1)/3}(\omega b)^{(\omega+3)/3}}{(\nu+\omega)c\omega[(\omega b)^{1/3}+(\nu x)^{1/3}]^{\nu+\omega+1}B(\nu,\omega)}\right)^{1/2},$$

and

$$\bar{V}_o = \frac{\omega\gamma_o^*}{(\nu+\omega)c} = \left(\frac{\omega(\nu x)^{(\nu+3)/3}(\omega b)^{(\omega+1)/3}}{(\nu+\omega)c\nu[(\omega b)^{1/3}+(\nu x)^{1/3}]^{\nu+\omega+1}B(\nu,\omega)}\right)^{1/2}.$$

Claim 1: Let (γ_s^*, γ_o^*) be an interior equilibrium. Then,

$$\frac{\partial\bar{V}_s}{\partial b} \geq 0, \qquad \frac{\partial\bar{V}_s}{\partial c} < 0, \qquad \frac{\partial\bar{V}_s}{\partial x} \gtrless 0 \quad \text{as} \quad x \lessgtr b\frac{(\nu+1)^3}{\nu\omega^2}.$$

PROOF:

Since $\bar{V}_s > 0$, it must be the case that $sgn\partial\bar{V}_s/\partial b = sgn\partial \ln \bar{V}_s/\partial b$ and similarly for all the other parameters. We have that

$$\ln\bar{V}_s = \frac{1}{2}\left\{\ln\nu + \frac{\nu+1}{3}\ln(\nu x) + \frac{\omega+3}{3}\ln(\omega b)\right.$$

$$\left. - \ln(\nu+\omega) - \ln c\omega - (\nu+\omega+1)\ln[(\omega b)^{1/3}+(\nu x)^{1/3}] - \ln B(\nu,\omega)\right\}$$

so that

$$\frac{\partial\ln\bar{V}_s}{\partial b} = \frac{1}{6b\left(1+\frac{(\nu x)^{1/3}}{(\omega b)^{1/3}}\right)}\left\{2+[\omega+3]\frac{(\nu x)^{1/3}}{(\omega b)^{1/3}} - \nu\right\}.$$

It follows that

$$\frac{\partial\bar{V}_s}{\partial b} \geq 0 \Leftrightarrow [\omega+3]\frac{(\nu x)^{1/3}}{(\omega b)^{1/3}} \geq \nu - 2.$$

Since (γ_s^*, γ_o^*) is an interior equilibrium, then it must satisfy the second-order condition that $(\omega + 3)\gamma_o^* \geq (\nu - 2)\gamma_s^*$ (see the proof of Proposition 2). We also know from the proof of Proposition 1 that $\gamma_o^*/\gamma_s^* = (\nu x)^{1/3}/(\omega b)^{1/3}$. Thus, we may conclude that $\partial\bar{V}_s/\partial b \geq 0$.

We also have that

$$\frac{\partial\ln\bar{V}_s}{\partial c} = -\frac{1}{2c} < 0.$$

Finally, we have

$$\frac{\partial \ln \bar{V}_s}{\partial x} = \frac{1}{6x\left(1 + \frac{(\omega b)^{1/3}}{(\nu x)^{1/3}}\right)} \left\{[\nu + 1]\frac{(\omega b)^{1/3}}{(\nu x)^{1/3}} - \omega\right\}.$$

Thus, we have that

$$\frac{\partial \bar{V}_s}{\partial x} \gtreqless 0 \qquad \text{as} \qquad [\nu + 1]\frac{(\omega b)^{1/3}}{(\nu x)^{1/3}} \gtreqless \omega.$$

Manipulating this condition, we see that

$$\frac{\partial \bar{V}_s}{\partial x} \gtreqless 0 \qquad \text{as} \qquad x \lesseqgtr b\frac{(\nu + 1)^3}{\nu\omega^2}$$

as claimed. QED

Claim 2: Let (γ_s^*, γ_o^*) be an interior equilibrium. Then,

$$\frac{\partial \bar{V}_o}{\partial x} \geq 0, \qquad \frac{\partial \bar{V}_o}{\partial c} < 0, \qquad \frac{\partial \bar{V}_o}{\partial b} \gtreqless 0 \qquad \text{as} \qquad b \lesseqgtr x\frac{(\omega + 1)^3}{\nu^2\omega}.$$

PROOF:

This is similar to the proof of Claim 1 and hence omitted. QED

Claim 3: Let (γ_s^*, γ_o^*) be an interior equilibrium. Then,

$$\frac{\partial \bar{V}_s}{\partial \nu} < 0 \qquad \text{implies that} \qquad \frac{\partial \bar{V}_o}{\partial \nu} < 0.$$

PROOF:

Differentiating the expression for $\ln \bar{V}_s$ derived above, yields

$$\frac{\partial \ln \bar{V}_s}{\partial \nu} = \frac{1}{2}\left\{\frac{1}{\nu} + \frac{\nu + 1}{3\nu} + \frac{1}{3}\ln(\nu x) - \frac{1}{v + \omega} - \ln[(\omega b)^{1/3} + (\nu x)^{1/3}]\right.$$

$$\left. - \frac{\nu + \omega + 1}{(\omega b)^{1/3} + (\nu x)^{1/3}}\frac{1}{3}(\nu x)^{-2/3}x - \frac{\partial B/\partial v}{B(\nu, \omega)}\right\}.$$

We have that

$$\ln \bar{V}_o = \frac{1}{2}\left\{\ln \omega + \frac{\nu + 3}{3}\ln(\nu x) + \frac{\omega + 1}{3}\ln(\omega b)\right.$$

$$\left. - \ln(\nu + \omega) - \ln c\nu - (\nu + \omega + 1)\ln[(\omega b)^{1/3} + (\nu x)^{1/3}] - \ln B(\nu, \omega)\right\}$$

so that

$$\frac{\partial \ln \bar{V}_o}{\partial \nu} = \frac{1}{2}\left\{\frac{\nu+1}{3\nu} + \frac{1}{3}\ln(\nu x) - \frac{1}{\nu+\omega} - \frac{1}{\nu} - \ln[(\omega b)^{1/3} + (\upsilon x)^{1/3}]\right.$$

$$\left. - \frac{\nu+\omega+1}{(\omega b)^{1/3} + (\nu x)^{1/3}}\frac{1}{3}(\upsilon x)^{-2/3}x - \frac{\partial B/\partial \upsilon}{B(\nu, \omega)}\right\}.$$

Since $\partial \ln \bar{V}_o/\partial \nu < \partial \ln \bar{V}_s/\partial \nu$ the result follows. QED

PROOF OF PROPOSITION 2:

We need to show that γ_s^* maximizes the supporters' payoff $U_s(\gamma_s, \gamma_o^*)$ subject to the constraint that $\gamma_s \in [0, c]$ and that γ_o^* maximizes the opposers' payoff $U_o(\gamma_s^*, \gamma_o)$ subject to the constraint that $\gamma_o \in [0, c]$. We prove only the former claim, since the argument for the latter is analogous.

If γ_s^* did not maximize the supporters' payoff, there must exist some $\hat{\gamma}_s$ that would yield a higher payoff. By condition (iii) of the Proposition, we know that $\hat{\gamma}_s \neq 0$. Define the function $\varphi : [0, c] \rightarrow \mathfrak{R}$ as follows:

$$\varphi(\gamma_s) = U_s(\gamma_s, \gamma_o^*) = b\int_{\gamma_o^*/(\gamma_s+\gamma_o^*)}^{1} \mu h \, d\mu - \frac{\nu}{\nu+\omega}\frac{\gamma_s^2}{2c}.$$

Note first the following important claim.

Claim: Suppose that $\varphi'(\tilde{\gamma}_s) = 0$ for some $\tilde{\gamma}_s \in (0, c]$. Then, $\varphi''(\tilde{\gamma}_s)$ has the opposite sign from $(\nu + 3)\tilde{\gamma}_s - (\omega - 2)\gamma_o^*$.

PROOF:

We have that

$$\varphi'(\gamma_s) = h\frac{(\gamma_o^*)^2}{(\gamma_o^* + \gamma_s)^3}b - \frac{\nu\gamma_s}{(\nu+\omega)c}$$

and that

$$\varphi''(\gamma_s) = -b\left[3h + \frac{\gamma_o^*}{\gamma_o^* + \gamma_s}h_\mu\right]\frac{\gamma_o^{*2}}{(\gamma_o^* + \gamma_s)^4} - \frac{\nu}{(\nu+\omega)c}.$$

For the Beta distribution, for all (γ_s, γ_o) we have that

$$h = \frac{\gamma_o^{\nu-1}\gamma_s^{\omega-1}}{(\gamma_o + \gamma_s)^{\nu+\omega-2}B(\nu, \omega)}$$

and

$$h_\mu = \frac{\gamma_o^{\nu-2}\gamma_s^{\omega-2}}{(\gamma_o + \gamma_s)^{\nu+\omega-3}B(\nu, \omega)}[(\nu-1)\gamma_s - (\omega-1)\gamma_o]$$

so we may write

$$h_\mu = \frac{[(\nu-1)\gamma_s - (\omega-1)\gamma_o](\gamma_o + \gamma_s)h}{\gamma_o\gamma_s}.$$

Moreover, the fact that $\varphi'(\tilde{\gamma}_s) = 0$ implies that

$$h \frac{(\gamma_o^*)^2}{\tilde{\gamma}_s(\gamma_o^* + \tilde{\gamma}_s)^3} b = \frac{\nu}{(\nu + \omega)c}.$$

It follows that

$$\varphi''(\tilde{\gamma}_s) = -bh \frac{\gamma_o^{*2}}{(\gamma_o^* + \tilde{\gamma}_s)^3} \left(\frac{3}{(\gamma_o^* + \tilde{\gamma}_s)} + \frac{[(\nu - 1)\tilde{\gamma}_s - (\omega - 1)\gamma_o^*]}{\tilde{\gamma}_s(\gamma_o^* + \tilde{\gamma}_s)} + \frac{1}{\tilde{\gamma}_s} \right).$$

Since $\gamma_o^* > 0$, the sign of $\varphi''(\tilde{\gamma}_s)$ is the opposite of the sign of

$$\frac{[(\nu - 1)\tilde{\gamma}_s - (\omega - 1)\gamma_o^*]}{\tilde{\gamma}_s(\tilde{\gamma}_s + \gamma_o^*)} + \frac{3}{(\tilde{\gamma}_s + \gamma_o^*)} + \frac{1}{\tilde{\gamma}_s}.$$

This is positive if $(\nu + 3)\tilde{\gamma}_s > (\omega - 2)\gamma_o^*$ and negative if $(\nu + 3)\tilde{\gamma}_s < (\omega - 2)\gamma_o^*$. The Claim now follows. QED

Suppose first that $\hat{\gamma}_s > \gamma_s^*$. Consider the problem

$$\min\{\varphi(\gamma_s) : \gamma_s \in [\gamma_s^*, \hat{\gamma}_s]\}.$$

Since φ is continuous and the constraint set is compact, the problem has a solution which we denote by $\tilde{\gamma}_s$. Note that the solution must lie in the interior of $[\gamma_s^*, \hat{\gamma}_s]$. To see this note that $\tilde{\gamma}_s$ must be less than $\hat{\gamma}_s$ since $\varphi(\hat{\gamma}_s) > \varphi(\gamma_s^*)$. In addition, we know that by condition (i) $\varphi'(\gamma_s^*) = 0$, and by condition (ii) and the Claim, $\varphi''(\gamma_s^*) < 0$. This means that for γ_s slightly larger than γ_s^* that $\varphi(\gamma_s) < \varphi(\gamma_s^*)$. Since φ is smooth, it follows that $\varphi'(\tilde{\gamma}_s) = 0$ and $\varphi''(\tilde{\gamma}_s) \geq 0$. By the Claim, we have that $\varphi''(\tilde{\gamma}_s) \geq 0$ if and only if $(\nu + 3)\tilde{\gamma}_s \leq (\omega - 2)\gamma_o^*$. But we know from condition (ii) and the fact that $\hat{\gamma}_s > \gamma_s^*$ that $(\nu + 3)\tilde{\gamma}_s > (\nu + 3)\gamma_s^* > (\omega - 2)\gamma_o^*$ so this is impossible. Thus, $\hat{\gamma}_s$ cannot be greater than γ_s^*.

Now suppose that $\hat{\gamma}_s < \gamma_s^*$. Without loss of generality, we may assume that $\hat{\gamma}_s$ solves the problem:

$$\max\{\varphi(\gamma_s) : \gamma_s \in [0, \gamma_s^*]\}.$$

Since $\hat{\gamma}_s \in (0, \gamma_s^*)$, we know that $\varphi'(\hat{\gamma}_s) = 0$ and $\varphi''(\hat{\gamma}_s) \leq 0$. By the Claim, we know that $(\nu + 3)\hat{\gamma}_s \geq (\omega - 2)\gamma_o^*$. Now consider the problem

$$\min\{\varphi(\gamma_s) : \gamma_s \in [\hat{\gamma}_s, \gamma_s^*]\}.$$

The problem has a solution which we denote by $\tilde{\gamma}_s$. Note that the solution must lie in the interior of $[\hat{\gamma}_s, \gamma_s^*]$. To see this note that $\tilde{\gamma}_s$ must be greater than $\hat{\gamma}_s$ since $\varphi(\hat{\gamma}_s) > \varphi(\gamma_s^*)$. In addition, we know that by conditions (i) and (ii) and the Claim, $\varphi'(\gamma_s^*) = 0$ and $\varphi''(\gamma_s^*) < 0$. This implies that for γ_s slightly smaller than γ_s^* that $\varphi(\gamma_s) < \varphi(\gamma_s^*)$. Since φ is smooth, it follows that $\varphi'(\tilde{\gamma}_s) = 0$ and $\varphi''(\tilde{\gamma}_s) \geq 0$. By the Claim, we have that $\varphi''(\tilde{\gamma}_s) \geq 0$ if and only if $(\nu + 3)\tilde{\gamma}_s \leq (\omega - 2)\gamma_o^*$. But we know that $(\nu + 3)\tilde{\gamma}_s > (\nu + 3)\hat{\gamma}_s > (\omega - 2)\gamma_o^*$ so this is impossible. Thus, $\hat{\gamma}_s$ cannot be smaller than γ_s^*. QED

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