AN EXAMINATION OF THE MARKET FOR FAVORS AND VOTES IN CONGRESS

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This paper examines the strategies that "horse traders" and "power brokers" adopt in trading favors to pass legislation. Although the favors that they trade are generally impossible to observe, the paper develops a model that allows tests of favor trading. With data from the Senate vote on the Byrd Amendment to the 1990 Clean Air Act I conduct such a test. The test provides evidence that on this vote (i) favor trading occurred, (ii) the coalition leaders practiced price discrimination, and (iii) the coalition leaders did not collude with each another.

I. INTRODUCTION

At least since classic works such as Black [1958], Riker [1962], and Buchanan and Tullock [1962], social scientists have recognized the importance of side payments in legislatures.[1] Although actual money transfers between members of a legislature are probably rare—in fact, usually they are illegal—various transfers in kind may occur often in the process of law making. For instance, leaders in Congress have been known to give endorsement speeches or sponsor special hearings in return for support on key bills and amendments. Similarly, presidents have been known to give patronage appointments, VIP tours of the White House, contract awards for constituents, and other favors to members of Congress in return for votes. In fact, at least two presidents, Kennedy and Johnson, kept detailed records of such favors in a Congressional Favors File (Covington [1992]). The possibilities for such favor trading are large, and a rich array of terms has arisen to describe it. These terms include "horse trading," "logrolling," "arm twisting," "influence peddling," "back scratching," and "power broking."

This paper examines the strategies that such back scratchers and power brokers adopt in passing legislation. I propose a model in which coalition leaders try to pass legislation while paying as few favors as possible. Legislators weigh their preferences for the legislation against their preferences for favors to decide how to vote. I derive theoretical implications of the model and use these implications with data from a vote in the U.S. Senate to test theories of favor trading.

A primary question that I consider is whether coalition leaders practice price discrimination. That is, in promising favors for votes do they offer different amounts to different legislators? Intuition suggests that they would, most likely by offering smaller amounts to legislators already inclined toward voting their way.

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1. Although Black does not explicitly discuss side payments in the sense of resources traded in a quid pro quo, he does discuss the possibility of one legislator using his or her influence to induce another legislator to vote as if his or her ideal point has shifted. See Black [1958], chapter 14.

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However, at least two reasons suggest that price discrimination might not occur in practice. The first is institutional, involving the possibility that vote markets are not nearly as complex or developed as the typical economic market. Namely, suppose that when a coalition leader asks a legislator for a vote, he or she does not state an explicit price. Instead, the leader and the legislator only come to a vague understanding that the leader will owe "one chit" if the legislator votes his or her way. The understanding over what exactly one chit constitutes may be imprecise, but as long as it does not vary systematically with the initial preferences of the legislators, the market will look very much like one where favors are explicit, but the same favor is offered uniformly to each legislator.

Another reason involves the bargaining power of a coalition leader vis-à-vis the legislators. If the market is structured so that a coalition leader makes take-it-or-leave-it offers to legislators—that is, he or she has complete bargaining power relative to legislators—then, of course, his or her best strategy is to offer different prices to different legislators. However, suppose instead that *legislators* have complete bargaining power. Specifically, suppose each legislator makes a take-it-or-leave-it offer, which is a contract forcing himself or herself to vote against the coalition leader unless the leader pays a specified price. Under this structure all legislators who end up selling their vote will charge the same price. To see this, suppose that a coalition leader needs to buy m votes. Then each legislator whose reservation price is less than the $m + 1$ cheapest legislator will optimally offer a price just below the reservation price of this legislator. Most importantly, each legislator offers the same price, and the coalition leader ends up not practicing price discrimination.

Thus, while plausible theoretical reasons suggest that coalition leaders should practice price discrimination, other reasons suggest that they might not. This ambiguity is mirrored in the theoretical research on vote buying, which has failed to reach a consensus on the appropriate assumption to make regarding price discrimination. While several models assume that vote buyers practice price discrimination (e.g., Buchanan and Lee [1986]; Koford [1982]; and Denzau and Munger [1986], others (e.g., Wilson [1969] and Grier and Munger [1991]) do not. Still another (Snyder [1996]) considers both assumptions.

A second question that I consider is whether opposing coalition leaders collude with each other. That their collective gains are maximized when they do collude suggests that collusion might be common. Furthermore, at least one theoretical examination (Snyder [1991]) assumes they act in this manner.[2] My model, in contrast, assumes that coalition leaders do not collude, and in section V I present evidence from a vote in Congress that supports this assumption.

A third question is whether optimal strategies of favor trading involve minimal winning coalitions. Early work in formal models of politics (primarily, Riker [1962]) has suggested they do. The reason, in brief, is that favors traded to gain more votes than are constitutionally necessary to win are wasted resources. However, this proposition is not true once the threat of a competing coalition leader is considered. A result of my model, as well as other recent work (Baron and Ferejohn [1989]; Groseclose and Snyder [1996]), is that rational coalition leaders sometimes choose greater than minimal winning coalition strategies.

A fourth question is the extent to which favor trading can cause roll-call votes to distort apparent preferences of legislators.

2. However, an earlier, unpublished version of the paper does not assume this. It only assumes that coalition leaders on the *same* side of an issue collude with each other.

For instance, it is reasonable to suspect that a coalition leader announcing that he or she will grant a large favor for a bill will cause some legislators to vote for the bill who would not have otherwise. More fundamentally, however, when price discrimination is allowed, favor trading can distort even relative preferences of legislators. That is, one legislator can prefer a bill more than another, yet once final votes are taken, the first legislator could vote against the bill while the second votes for it. Informally, the former situation causes members' positions to shift, while the latter situation causes positions also to flip. This idea is formalized in section III with the notion of a cut point. Briefly, a roll-call vote produces a cut point if it perfectly partitions supporters and opponents of a measure by ideal points. A theoretical result of this paper is that when price discrimination is not allowed, a cut point is guaranteed, however when price discrimination *is* allowed, a cut point sometimes will not occur.

The result implies potential problems for the use of roll-call votes as data for legislative preferences. For instance, when a cut point does not exist, probit and logit techniques using votes as the dependent variable will not produce consistent estimates. Another consequence is that when interest groups, such as the Americans for Democratic Action, rate legislators according to past votes, the scores can become imperfect indicators of even relative preferences. This causes an errors-in-variables problem when the scores are used as independent variables in a regression, as they are used, for instance, in several studies that test for ideology in voting records.[3]

However, while this result can cause problems for studies using votes as data for preferences, at the same time it provides a method for testing for price discrimination. Namely, if a cut point does not occur on a vote, one can conclude that price discrimination must have been exercised. Such a test, which does not require direct observation of the actual favors traded, is crucial for gaining empirical knowledge about legislative favor trading, since legislators themselves are often reluctant to reveal information about favors.

3. E.g., see Kalt and Zupan [1984], Kau and Rubin [1979], and Peltzman [1984]. For a review see Goff and Grier [1990].

II. PREVIOUS STUDIES OF SIDE PAYMENTS IN LEGISLATURES

Evidence of favor trading appears in many scholarly and popular accounts of legislative activities. Scholarly work includes Covington's [1992], Kelley's [1969], and Sullivan's [1990] examinations of presidential favor trading with Congress. Other scholarly work includes Manley's [1969] analysis of favor trading within the House Ways and Means Committee.

In the latter study members of the committee were asked to estimate their bargaining position with the committee's chairman, Wilbur Mills. Almost all gave an answer within the specified choices: "Mills has done more for me," "I have done more for Mills," or "We are about even." An important aspect of this anecdote is that members keep at least a rough tally of favors they owe and are owed. Consequently, favors need not be traded directly for votes, but instead could serve as a form of currency within a legislature, in which only the remainder of favors not traded for votes are ever executed. For example, suppose Chairman Mills owes several favors to a member who wants to pass a public works project in her district. Rather than asking Mills to pay back the favors, she instead could ask him to pay up by garnering the votes necessary to pass the project. Mills would then debit favors from her account, while crediting the accounts of other members who vote for the bill. Mills would thus serve as a clearinghouse within the legislature for favors. Snyder [1991] has suggested that even PACs could perform such a clearinghouse function. For instance, a legislator who is scheduled to receive a large campaign contribution from a PAC could instead trade part of his scheduled contribution in return for a vote from a fellow legislator. The PAC would then debit the contributions it had scheduled to give to the first legislator and credit the account of the second legislator. In a legislature scarce on loyalty, or perhaps one in which legislative lives are too short to generate loyalty, such clearinghouses might be expected to arise.[4,5] In fact, such clearinghouses could decrease the transactions costs that Weingast and Marshall [1988] have suggested occur in legislatures.

My model assumes that coalition leaders, such as Mills or the type of PAC suggested by Snyder, can credibly promise future favors in return for votes delivered today. Although legislatures typically have no mechanism to enforce these promises, I assume that coalition leaders are sufficiently concerned about their reputations that upholding these commitments is optimal for them. Thus, although as it is often claimed, "in Congress loyalty is everything," I only require that for *some* members of the law-making process loyalty is everything.

III. ASSUMPTIONS AND DEFINITIONS

The model contains a finite set of legislators $N = \{1,2, ..., m\}$, who must choose between two policies by majority rule. The policies are the status quo x_0 and a proposed change to the status quo x_b both existing within the one-dimensional policy space $X \subset R$. Without loss of generality assume $x_0 < x_b$. Also, assume legislators have single-peaked preferences, where $y_i \in X$ is defined as legislator i's *ideal point*.[6] Legislators also derive utility from favors they receive from two coalition leaders L and R. Legislative preferences for receiving favors $z \in [0, \infty)$ and voting for a policy $x \in X$ are represented by the additively separable utility function

$$U(x, z; y_i) = u(x - y_i) + v(z),$$

where $u()$ is strictly concave and $v()$ is strictly increasing, continuous, and unbounded. Finally, assume that $u()$ reaches a maximum at zero. This and the strict concavity of $u()$ imply that y_i is i's most preferred policy, holding the level of favors constant.[7]

The two coalition leaders have preferences defined by the following von Neumann-Morgenstern utility functions.

$$U^j(x, Z^j; y^j) = u^j(x - y^j) - v^j(Z^j);\ j = L, R,$$

where Z^j represents the total amount of favors coalition leader j pays, and y^j represents the most preferred policy of coalition leader j.[8] Assume $u^j()$ is strictly concave

4. See Kreps [1990a] in which firms, like clearinghouses in this example, arise to facilitate cooperation among short-lived actors.

5. This has possible consequences for term limits in Congress. Term limits would cause legislative lives to become even shorter, causing even greater obstacles for loyalty among members. Term limits thus should cause the clearinghouse role of PACs and presidents to expand, while diminishing this role for powerful members of Congress.

6. The assumption that policies and ideal points are described by only one dimension can be relaxed. For instance, instead let x_0, x_b, and ideal points lie in R^n, and define the policy space by extending a line through x_0 and x_b. (That is, let $X = \{\lambda x_0 + (1 - \lambda)x_b: \lambda \in R\}$.) Next, project ideal points from the many-dimensional space to the one-dimensional space to create induced preferences along the one-dimensional space. As long as utility functions in the many-dimensional space are strictly concave, then induced utility functions in the one-dimensional space also will be strictly concave. Hence, they will also be single-peaked, and ideal points will be well-defined.

7. It should be emphasized that legislators do not have preferences for the policy adopted per se. Instead they only have preferences over the policy they vote for. Thus their preferences are similar to the "position-taking" legislators of Mayhew [1974]. This distinction is important, since if instead their preferences were only over the policy per se, then if they are not a decisive voter, their vote could be bought for free.

8. Unlike legislators, coalition leaders have preferences defined over policy per se.

and $v^i()$ is strictly increasing, continuous, and unbounded. Also assume that for a given level of favors, L prefers x_0 to x_b and that R has opposite preferences. That is, assume $u^R(x_b - y^R) > u^R(x_0 - y^R)$ and $u^L(x_0 - y^L) > u^L(x_b - y^L)$. For convenience define α^R and α^L as R and L's *degree of preference for* x_b.

DEFINITION. $\alpha^R = u^R(x_b - y^R) - u^R(x_0 - y^R)$.

$$\alpha^L = u^L(x_b - y^L) - u^L(x_0 - y^L)\,.$$

Since L prefers x_0 to win, her *degree of preference for* x_b is negative. These terms are similar to reservation prices. For instance, R desires x_b to win, but only if he can achieve this by paying favors worth less in utility than α^R.

Next, the model includes a game that contains three periods. In the first R names a set of favors $\{z_i^R\}_{i=1}^m$ that he promises to pay to legislators who vote for x_b.[9,10] For the case in which price discrimination is not allowed, R is restricted such that z_i^R is the same for each legislator. Accordingly, I drop subscripts and write z^R as the favor R is willing to pay for a vote. In the second period L names a set of counter offers $\{z_i^L\}_{i=1}^m$ that she will pay to any legislator who votes for x_0. Similar to R, in the one-price case z^L represents her offer. In the final period legislators note the corresponding offers and vote for the bill that maximizes their utility.[11]

Assume that any legislator indifferent between x_0 and x_b votes for x_0. Then, once the final period is reached, and offers have been announced, i votes for x_0 if and only if

$$(1)\qquad u(x_0 - y_i) + v(z_i^L) \geq u(x_b - y_i) + v(z_i^R).$$

Similarly, assume that if L is indifferent between the option of losing the vote and paying zero favors and the option of winning the vote but paying positive favors, she chooses the former option. Both of these assumptions are technical in nature. I make them to ensure a closed solution set for the game.

Next, similar to coalition leaders, define α_i as legislator i's *degree of preference for* x_b.

DEFINITION. $\alpha_i = u(x_b - y_i) - u(x_0 - y_i)$.

Note that if i prefers x_0 to x_b, then this term is negative. Substitution into (1) gives

$$(2)\qquad i \text{ votes for } x_0 \Leftrightarrow v(z_i^L) \geq \alpha_i + v(z_i^R).$$

I assume the game is one of perfect information. That is, each player knows

9. I assume that favors, like currency, are infinitely divisible. Of course, this is doubtfully true in practice; however, the assumption closely approximates actual vote markets if (i) coalition leaders can dole out very small favors, or (ii) they can assemble packages of favors such that the value of the packages differ by very small amounts. Patrick Moynihan's (D-NY) description of the approach to favor trading by Chief of Staff Mack McLarty is instructive: "McLarty had tried to ingratiate himself with one of Moynihan's aides by announcing that someone who Moynihan had routinely recommended for a midlevel government job had been given the post. At heart, Moynihan concluded, McLarty still acted at times as if he were running the Little Rock Ford dealership, trying to make a sale by throwing in free floor mats" (Woodward [1994, 221]).

10. Another assumption I make about the structure of favor trading is that legislators treat offers from coalition leaders like options contracts as opposed to securities. For instance, although R may offer a favor to legislator i, this does not mean that she is committed to vote with R. Instead, she will wait to see L's counteroffer.

11. In the game I assume x_0 and x_b are exogenous; however, the game could easily be extended to allow x_b to be endogenous. Namely, a prior period could be added in which R chooses x_b, then the game proceeds exactly as before. In fact, in the case I analyze, the Byrd Amendment to the 1990 Clean Air Act, this is exactly what happened. Twice Byrd scaled back his amendment (which in a speech on the Senate floor he called "negotiating with himself" (Hager [1990]). However, even in such an extended game, once x_b is chosen, its value is exogenous for decisions in subsequent periods. As a consequence, the game I analyze would simply be a subgame of this extended game, and the computation of its equilibrium would precisely follow the analysis I conduct here.

with certainty the choices made by other players in previous periods. However, I do not assume the game is one of complete information. That is, players might not know with certainty the preference parameters of the other players. Instead, coalition leaders possess a probability density $f_i(\alpha)$ of each legislator's preference parameter α_i, and similarly a probability density $f^j()$ of the other coalition leader's preference parameter α^k. Thus, for instance, L's belief about α^R is represented by the density function $f^L(\alpha^R)$.

The equilibrium concept I adopt is subgame-perfect Nash. Solutions can thus be computed by backward induction. Many of the results I derive involve whether the final vote produces a *cut point*. A cut point occurs if the respective votes of the legislators can be listed as $(x_0, x_0, ..., x_0, x_b, x_b, ..., x_b)$ when legislators are aligned according to their ideal points. This is defined formally as follows.

DEFINITION. *A cut point exists if and only if* $\forall\ i, j \in N$, *if* $y_i < y_j$ *and i votes for* x_b, *then j votes for* x_b.

IV. SOLUTIONS AND RESULTS

An equivalent way to define a cut point can be accomplished by substituting α_i for y_i above. This is shown formally with the following lemma. (The proof for this lemma and other results is in the appendix.)

LEMMA. $y_i < y_j \Leftrightarrow \alpha_i < \alpha_j$.

Before considering more general results, I first consider two examples.

Example 1

Let the legislature contain seven members (viz., $N = \{1,2,3,4,5,6,7\}$) and let the degrees of preference for x_b be $(\alpha_1, ..., \alpha_7) = (-7,-5,-3,-1,1,3,5)$. Also let $-\alpha^L = 8$ and $\alpha^R = 30$, and assume $v(z) = z$. Substituting this parameterization of $v(z)$ into (2) implies that legislator i votes for x_0 if, and only if, $z_i^L - z_i^R \geq \alpha_i$. Next assume actors in this example have complete information about the preference parameters of the other actors.

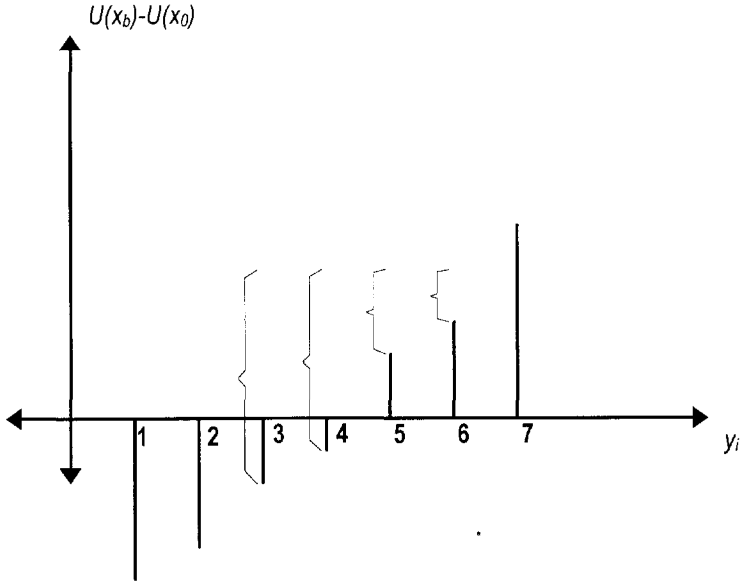
Consider first the one-price case—that is, the lack of price discrimination case. Here it is easily shown that the solution to the game is $z^{R*} = 3$ and $z^{L*} = 0$. For these values legislators 4, 5, 6, and 7 vote for x_b, and accordingly receive three favors from R. Legislators 1, 2, and 3 vote for x_0 and receive no favors. To see why this is an equilibrium, note that at the price R offers, the cheapest way for L to buy a majority is to set $z^L = 2$. At this price four legislators vote for x_0, which would cost L a total of eight favors. Since this value is not less than $-\alpha^L$, she prefers to concede the vote and pay no favors.

Computing the solution to the price-discrimination case is slightly more difficult, but it can be verified that $(z_1^{R*}, ..., z_7^{R*}) = (0,0,7,5,3,1,0)$ and $(z_1^{L*}, ..., z_7^{L*}) = (0,0,0,0,0,0,0)$ are equilibrium strategies for L and R.[12] These values are represented in Figure 1, where straight lines represent values of α_i, and braces represent the favors promised by R. To see why this is an equilibrium, note first that R's coalition consists of five members: legislators 3, 4, 5, 6, and 7. To buy back any of these members, L must respectively pay four, four, four, four, or five favors. If L were to attack successfully, she would need to buy at least two of these members, and thus, the cheapest way to achieve a victory would cost a total of eight favors. Since this is not less than $-\alpha^L$, L prefers to concede.

Note that in this solution R's coalition is larger than minimal winning. To see that

12. There are other, trivial equilibria. For instance, L could instead set $z_7^L = ½$. Since legislator 7 would not accept L's offer, L would still end up paying legislator 7 zero favors. L is thus indifferent between this strategy and setting $z_7^L = 0$.

FIGURE 1
Preferences and Equilibrium Payments of Example 1



Key: Straight lines represent legislators' initial preferences for voting for x_b. Braces represent R's equilibrium payments for a vote for x_b.

this is optimal, consider the vector of payments he would offer if instead he adopted a minimal-winning coalition. In this case *R*'s coalition would consist of legislators 4, 5, 6, and 7, and *L* would need to buy only one member to gain victory. To prevent this, *R* needs to make all members of his coalition cost at least eight favors for *L* to buy back. The cheapest way to do this is to set $(z_1^R, \ldots, z_7^R) = (0,0,0,0,9,7,5,3)$. This vector of payments costs *R* a total of twenty-four favors, which is more expensive than the five-member strategy. Similarly, it can be shown that the six- and seven-member strategies are also more expensive than the five-member strategy.

The solution to this game offers some intuition why it is possible for cut points not to occur once price discrimination is allowed. Note that each member of *R*'s *paid* coalition (legislators 3, 4, 5, and 6) are equally expensive for *L* to buy back. Thus, if *L* were to invade, she would be indifferent between buying any two from this set. There are therefore six $(= \binom{4}{2})$ different ways she could obtain a winning coalition, between all of which she is indifferent. However, only one of these ways, buying 3 and 4, achieves a cut point; the five others do not.

The result is analogous to the "no soft spots" theory of international relations (Dresher [1966]). Suppose a country must defend two points of entry along its border: a plain and a mountain pass. If it positions troops optimally, it will place fewer at the mountain pass, since this point already contains a natural barrier. In fact, since an invader will choose the least difficult point of entry, the defending country will allocate troops such that each point is equally difficult to invade. As a consequence, if a country does invade, it will not necessarily choose the point with the smallest initial barrier. This is similar to the vote buying example: if L invades R's coalition, she will not necessarily buy the members who had initial preferences closest to hers.

It should be noted, however, that L's invasion of R's coalition in this example is an out-of-equilibrium action. It is not literally a case of a cut point not occurring. In fact, as is stated below in Proposition 2, when actors have complete information—as in this example—a cut point is guaranteed. The intention here is only to provide intuition of why cut points sometimes will not occur once incomplete information is introduced and price discrimination is allowed. To show this formally, I offer the following example.

Example 2

Let $N = \{1,2,3\}$. Let α_1, legislator 1's intensity of preference for x_b, be $-M$, where M is so large that R realizes that buying 1's vote is too expensive, and consequently 1 votes for x_0 for sure. For the other two legislators assume L and R do not know the values of α_2 and α_3, only that α_2 is distributed uniformly along [–1,0] and α_3 is distributed uniformly along [0,1]. Note that with probability one $\alpha_1 \leq \alpha_2 \leq \alpha_3$. The preference parameters of the coalition leaders are $\alpha^L = -1$ and $\alpha^R = 3$. Assume that each coalition leader knows with certainty the value of the other coalition leader's preference parameter. Finally, for each legislator and coalition leader, assume that utility in favors is linear; viz., $v(z) = v^L(z) = v^R(z) = z$.

Since the vote is decided by a simple majority, for R to obtain victory, he must persuade *both* 2 and 3 to vote for x_b. However, since L already has 1's vote, she only needs to persuade *either* 2 or 3 to vote for x_0. It can be verified (see appendix) that the unique equilibrium to this game is

$$(z_2^{L*}, z_3^{L*}, z_2^{R*}, z_3^{R*}) = (1/4, 1/4, 3/4, 0).$$

At these prices a cut point sometimes fails to exist. For instance, suppose the realizations of α_2 and α_3 are respectively—1/4 and 1/8. Substitution into (2) shows that legislator 2 votes for x_b (since $1/4 < -1/4 + 3/4$), while 3 votes for x_0 (since $1/4 \geq 1/8 + 0$). Since 3's ideal point is greater than 2's, a cut point does not occur. In fact for all realizations such that $\alpha_2 \in (-1/2, 0)$ and $\alpha_3 \in [0, 1/4]$, a cut point does not occur.

Sufficient Conditions for Cut Points

The following two propositions give conditions when a cut point is guaranteed to occur. For the two results closed-form solutions to the equilibrium values of the game need not be derived. All that is required is that they exist, which is assured by the sequential nature of the game and by the fact that each player possesses perfect information.[13]

For the one-price model we can drop subscripts and denote z^{R*} and z^{L*} as equilibrium favors for a vote promised by R and L respectively. The following proposition states that for any values of z^{R*} and z^{L*}, a cut point must exist.

13. For some parameterizations, however, to ensure the existence of an equilibrium we may need to postulate how coalition leaders will act when they face indifference. For a discussion of the assurance of an equilibrium to these types of games and the occasional need for postulating how players act under indifference, see Kreps [1990b, 400–2, 424–5].

PROPOSITION 1. *Without price discrimination, a cut point always exists.*

It can also be shown that when actors are completely informed about other actors' preference parameters, a cut point is guaranteed to exist. The following proposition expresses this formally.

PROPOSITION 2. *With complete information a cut point always exists.*

The proof of the latter proposition relies on the fact that a coalition leader who knows he or she will lose will decline to trade any favors. As a result, only the winning coalition leader trades favors, and he or she buys votes such that only the least expensive legislators are in his or her coalition. This, in turn, causes a cut point to occur.

V. TESTING THEORIES OF FAVOR TRADING: THE BYRD AMENDMENT TO THE 1990 CLEAN AIR ACT

I now use these theoretical results along with evidence from a vote in the U.S. Senate to examine empirically some theories about legislative favor trading. The vote is the Byrd amendment to the 1990 Clean Air Act, an amendment that would have provided substantial benefits to coal miners losing their jobs due to the clean air bill. The amendment would have benefited constituents only from states that mined high-sulfur coal, which included primarily West Virginia, Kentucky, Illinois, and Pennsylvania. By conventional estimates at most ten to fifteen states would have benefited; thus to obtain passage, Byrd had a difficult task.

But as *Congressional Quarterly* reported,

> A man with 32 years' worth of IOUs in one vest pocket and countless future chits to hand out in the other, Byrd had gone door to door to meet with Republicans and Democrats alike over the past several weeks and had penned and typed them many notes. "I went to many offices and said 'I need your help,'" he said after the vote. (Kuntz and Hager [1990, 984])

The vote initially was to have taken place on March 27, but Majority Leader George Mitchell delayed it until the 29th. Meanwhile the strange-bedfellows coalition of Mitchell and President George Bush countered with their own active effort to recruit votes to prevent passage of the amendment. This included Bush, speaking through allies on the Senate floor, first promising to veto the Clean Air Act if the Byrd amendment passed, then later indicating that he would only "probably veto" the Act if it contained the Byrd amendment. On the day of the vote it appeared that Byrd had gathered enough votes to win. He even had the cancer-stricken Spark Matsunaga wheeled into the chamber to vote. However, the final tally did not match Byrd's expectations. As Congressional Quarterly reported, quoting Byrd, "'three of my votes took wings,' he added, flapping his arms, 'with the help of the boys downtown' in the White House." (Kuntz and Hager [1990, 984]) The final vote was 49–50, and it would have been 50–50 had not Bennett Johnston of Louisiana been delayed by bad weather when he was visiting his state earlier that day. But even if he had attended the vote, Vice-President Dan Quayle was expected to cast the tie-breaking vote against the amendment.

Of the three votes that "took wings" two might have been Joe Biden (D-DE) and Alfonse D'Amato (R-NY). The *New York Times* reported on March 30, 1990 that these two senators had made last-minute switches in their positions on the Byrd amendment. Biden in fact had been escorted to the Democratic cloakroom just prior to casting his vote, where a phone call was waiting from White House Chief of Staff John Sununu.

This case provides some interesting anecdotal evidence about favor trading. First, Byrd did not adopt a strategy of a minimal-winning coalition. According to his report in *Congressional Quarterly*, the total size of his coalition, before being invaded by Mitchell and Bush, was the forty-nine votes he actually received, plus the one vote (Johnston) who was absent the day of the vote, plus the three votes who "flew away." This gives a total of fifty-three votes, two more than the minimal winning coalition size of fifty-one (assuming Quayle was against the amendment).

Second, anecdotal evidence suggests that the coalition leaders did not collude. Namely a few facts are inconsistent with the hypothesis that Byrd and the Bush-Mitchell team minimized the total favors they paid to legislators, which they would have done had they colluded. Primarily, given that the Bush-Mitchell team won the vote, Byrd's promising any favors is not consistent with this hypothesis. And the evidence is fairly clear that Byrd promised favors to gather votes. Not only did he admit to visiting offices to ask for help, Bob Dole (R-KS) playfully alluded to Byrd's favor-trading in a floor speech. "Had I offered an amendment like this, I would not get five votes," said Dole. "But in any case, it indicates the strength of the Senator from West Virginia that comes with seniority and other things. But I know how you count votes and I know how you get votes, and the Senator from West Virginia has certainly worked that."[14]

Third, anecdotal evidence suggests that price discrimination was exercised. For this issue the most pro-Byrd senators were the ones from high-sulfur coal states, primarily West Virginia, Kentucky, Pennsylvania, and Illinois. Next on the Byrd side were very pro-labor senators such as Ted Kennedy and Howard Metzenbaum. If price discrimination were not exercised, the invading coalition leader (the team of Bush and Mitchell) should have bought back the most anti-Byrd members of Byrd's coalition. These members, most likely, were liberal Republicans and Southern Democrats. That Joe Biden was bought back is not consistent with this hypothesis. Not only is Biden very pro-labor (with a 1989 COPE score of 100], in a campaign speech for his 1988 presidential bid he made special mention of the coal miners among his ancestors.[15]

There also exists more rigorous statistical evidence that price discrimination occurred on this vote. The remainder of this section reports the results of a statistical test to discern if a cut point occurred on the Byrd vote. As Example 2 and Proposition 1 imply (subject to the maintained assumptions mentioned), if a cut point does not occur, then price discrimination must have been practiced.[16]

The test first requires a method for estimating ideal points. I use a latent-variables technique very similar to a probit method, in which ideal points are assumed to be a linear function of a number of independent variables plus a homoskedastic error term independently distributed $N(0, \sigma^2)$. That is, I assume ideal points are described by the equation

$$y_i = x_i'\beta + \varepsilon_i,$$

where x_i' is the vector of independent variables for legislator i, β is an unknown coefficient to be estimated, and ε_i is a normally distributed error term.

The independent variables are:

1. A constant,
2. 1989 vote scores from the AFL-CIO's Committee on Political Education,

14. *Congressional Record*, 29 March 1990, p. S3481.

15. However, as later reports indicate, these were really Neil Kinnock's ancestors. Even though it appears that Biden was guilty of plagiarizing Kinnock's speech, Biden can truly include a coal mining engineer among his ancestors. See *Newsweek*, 28 September 1987, pp. 26–7 for an account of the speech and the subsequent controversy.

16. Also, by Proposition 2, if a cut point does not occur, then the complete information hypothesis can be rejected.

3. 1989 vote scores from the National Taxpayer's Union,
4. Estimated coal mining jobs lost per capita due to the Clean Air Act,[17]
5. A dummy variable indicating membership on the Senate Appropriations Committee,
6. A dummy variable indicating membership in the Senate majority leadership,
7. *Nominate* scores for the 99th Senate,[18]
8. 1989 Americans for Democratic Action scores,
9. A dummy variable indicating membership in the Democratic Party, and
10. 1989 League of Conservation Voters scores.

Given this structure and data for estimating ideal points, one next needs a dependent variable that indicates which senators have higher ideal points than others. For instance, if the vote produced a cut point, then a standard probit equation would give consistent estimates of ideal points, with roll-call votes of the senators used as the dependent variable. The problem, of course, is that the existence of a cut point is the very thing that is being tested, so it should not be assumed to be true. Consequently, this disallows use of a probit. Instead, I adopt a different method with a different dependent variable that does not assume the existence of a cut point. The dependent variable involves not only votes of senators, but also speeches they made.

To construct the dependent variable, I first assume that there exists a constant $c \in R$, which separates the ideal points of pro-Byrd *speech-makers* and anti-Byrd *voters*.[19] Similarly, I assume that there exists another constant $a \in R$, which separates pro-Byrd voters and anti-Byrd speech-makers. Finally, I assume that the ideal points of the two senators believed to have switched votes are greater than a and less than c. This allows a grouping of senators into five categories which is represented graphically in Figure 2: (I) senators who made a speech against the Byrd amendment, (II) senators whom we think switched votes at the last moment (i.e., Biden and D'Amato), (III) senators who made a speech for the amendment, (IV) senators who voted against the amendment but did not make a speech, and (V) senators who voted for the amendment but did not make a speech.[20]

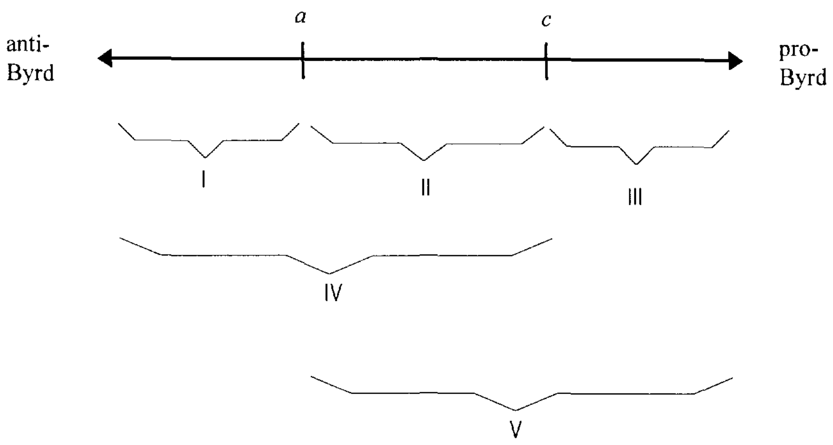
17. These estimates came from a report by ICF Resources Incorporated, Fairfax, Va. Aides from Byrd's office directed me to the report, which seems to be the source of estimates to which various senators referred in committee hearings and speeches on the floor. The variable I used was the sum of four estimates given in the report (high and low forecasts of jobs to be lost in years 1995 and 2000 for the Senate version of the clean air bill).

18. These were provided to me by Howard Rosenthal. See Poole and Rosenthal (1991) for an explanation of how they are computed.

19. This assumption, in fact, is sufficient by itself to produce a test for a cut point. To see this, consider the following procedure. First, from the sample of senators omit all those not in either of the above two groups—that is, omit senators who voted for the Byrd amendment but did not make a speech. Next, construct a dependent variable equal to one if the senator made a speech for Byrd, and equal to zero if he or she voted against Byrd. Then, using this dependent variable, estimate β with a standard probit technique. Next, construct estimated ideal points for all senators, even those originally omitted from the sample. Finally, compare estimated ideal points with roll-call votes to determine if they are consistent with a cut point existing among actual ideal points. (This final step is explained more fully later in the text.) Although this procedure may serve as an adequate test for a cut point, it is not as powerful as the one I actually adopt, in which similar, additional assumptions are incorporated. I describe this procedure primarily for heuristic reasons, and in particular, to help explain the perhaps paradoxical use of roll-call votes to estimate ideal points, while using these ideal points in turn to test a hypothesis about the roll-call votes.

20. A justification for these assumptions can be explained by the price discrimination case of Example 1. Suppose R has offered favors according to the equilibrium outcome of the game. (This is noted in Figure 2.) Recall that under this result legislators 3, 4, 5, and 6 are each equally expensive for L to buy back. However, 7 is strictly more expensive to buy back. Now suppose that the legislators themselves are unsure if L will make counter-offers. Also suppose that speeches take place after R makes offers but before L makes counter-offers. At the time for speech-making, 7 is certain that L will not try to buy his vote. Thus, unlike legislators 3, 4, 5, and 6, he is sure he will vote for x_b, and hence he might make a speech for R. Legislators 3, 4, 5, and 6, however,

FIGURE 2
Assumptions about Location of Ideal Points



Key: Group I represents senators who made a speech against the Byrd amendment; group II represents those who switched votes; group III represents those who made a speech for the Byrd amendment; group IV represents those who voted against the Byrd amendment but did not make a speech; group V represents those who voted for the Byrd amendment but did not make a speech.

Given these assumptions about how legislators are grouped, the following likelihood function allows estimation of ideal points. The function is similar to a probit, and even more similar to an ordered probit; however, it is still different from both.

$$L(X; \beta, a, c, \sigma) =$$

$$\prod_{i \in I} \Phi(\frac{a - x_i' \beta}{\sigma}) \times \prod_{i \in II} [\Phi(\frac{c - x_i'\beta}{\sigma})$$

$$- \Phi(\frac{x_i'\beta - a}{\sigma})] \times \prod_{i \in III} \Phi(\frac{x_i' \beta - c}{\sigma})$$

$$\times \prod_{i \in IV} \Phi(\frac{c - x_i'\beta}{\sigma}) \times \prod_{i \in V} \Phi(\frac{x_i' \beta - a}{\sigma})$$

where $\Phi()$ is the standard normal distribution.

This equation, however, is under-specified. Namely, like a probit, if a, c, σ and each β_j is multiplied by a constant, the

hope that L will make them a better offer, and as a result will not want to make a speech, since they would look foolish to constituents if they end up voting differently from their speech. On the other side, legislators 1 and 2 are certain they will vote for L's bill, and thus they might make a speech for L. This justifies the assumptions about the ordering of ideal points. For instance, a senator who makes a speech for R must be a certain-for-x_b type (like 7), and he or she necessarily has a greater ideal point than a senator who votes against x_b, who must be either a certain-for-x_0 type (like 1 or 2) or an uncertain type (like 3, 4, 5, or 6).

value of the likelihood function does not change. This disallows estimation of β. It only allows estimation of the ratios of each β_j to σ. Similarly, like a probit, a, c, and ideal points can be estimated only up to an additive constant. To avoid these indeterminacies I set $\sigma = 1$ and $a = 0$. The indeterminacies allow estimation only of relative ideal points, not absolute ideal points. However, they do not affect the results of any statistical tests performed in this paper. That is, a and σ could be set to other values without changing the value of any t– or p-statistic reported here.

The results of maximizing the likelihood function with various specifications of independent variables are reported in Table I.[21] The values of these coefficients raise several points. First, perhaps as expected, the AFL-CIO Committee on Political Education and National Taxpayer's Union scores and lost mining jobs variables consistently help to explain preferences for the Byrd amendment across many different specifications of the econometric model, with the Committee score variable being consistently statistically significant and the lost jobs variable overwhelmingly so. Preferences for the Byrd amendment thus can roughly be described by a constituent component, the degree the amendment would provide benefits to their state, and by ideological components, how pro-labor or anti-government spending the senators are as represented by AFL-CIO Committee on Political Education and National Taxpayer Union scores.

Next, two variables, membership on the Appropriations Committee and membership within the majority leadership, help explain preferences. The Appropriations variable is consistently significant across many specifications in Table I, and the Leadership variable approaches significance in the one specification in which it is tested.

Three other variables, Nominate scores, membership in the Democratic Party and Americans for Democratic Action scores, were included as more general indicators of left-right ideology. Democratic party membership and ADA scores were far from significant. That party membership is insignificant is consistent with the recent finds of Krehbiel [1991]: once constituent and ideological preferences are controlled, a member's party does not help explain voting behavior. Although the Nominate score variable approaches significance, it has the opposite sign from what was expected. This variable is constructed such that conservative members have high values and liberal members low values. Thus, ceteris paribus, if a conservative ideology indicates preferences *against* the Byrd amendment, then the coefficient should be negative. However, it is positive in Table I.[22]

Finally, note that the coefficient of the League of Conservation Voters score variable is positive (but not significant). This is the opposite sign that should have occurred had senators believed Bush's veto threat. In contrast, if the veto threat had been credible, pro-environment senators would have had a tendency to oppose the Byrd amendment, thus giving the League

21. The likelihood ratio test values are computed by the formula $2[\ln L(\theta) - \ln L(\theta_0)]$, where $L(\theta)$ is the unconstrained likelihood function and $L(\theta_0)$ is the likelihood function when all coefficients except β_0 and c are constrained to be zero. To perform joint tests of significance, the values should be compared to the chi-squared distribution with respectively three, four, five, five, five, five, five, and four degrees of freedom. All are significant at the .01 level.

22. An explanation for this involves the possibility that variables in the econometric procedure represent factors of ideology other than what they are nominally intended to represent. For instance, a Committee on Political Education score might represent not only a member's labor preferences, but preferences for other liberal causes as well. This introduces greater colinearity between it and a general ideology variable such as the Nominate scores, which in turn can cause a counfounding effect upon the coefficient of the ideology variable. (See Groseclose [1992] for a more detailed discussion.)

TABLE I
Maximum Likelihood Results

	1	2	3	4	5	6	7	8
Constant	.5372 (1.3436)	.7178 (1.4270)	.0345 (1.4014)	1.0473 (1.4813)	.7208 (1.4405)	.9748 (1.4945)	.0911 (1.5683)	.1275 (1.4628)
Cope	.0252 (.0062)	.0318 (.0072)	.0345 (.0074)	.0496 (.0150)	.0343 (.0119)	.0231 (.0160)	.0275 (.0082)	.0222 (.0072)
Ntu	−.0225 (.0276)	−.0459 (.0312)	−.0443 (.0305)	−.0689 (.0362)	−.0458 (.0314)	−.0498 (.0321)	−.0352 (.0331)	−.0156 (.0292)
Coal	1.1247 (.2692)	1.5191 (.3453)	1.5540 (.3437)	1.6402 (.3791)	1.5229 (.3501)	1.5343 (.3456)	1.4460 (.3471)	1.0761 (.2686)
App	—	1.3785 (.4844)	1.4889 (.4974)	1.3771 (.4814)	1.3861 (.4862)	1.4354 (.4891)	1.4028 (.4844)	—
Lead	—	—	−.9167 (.6930)	—	—	—	—	—
Nom99	—	—	—	1.5226 (1.0486)	—	—	—	—
Ada	—	—	—	—	−.0032 (.0118)	—	—	—
Party	—	—	—	—	—	.7618 (1.2710)	—	—
Lcv	—	—	—	—	—	—	.0096 (.0097)	.0070 (.0095)
c	3.2127 (.5018)	3.5707 (.6153)	3.5488 (.6047)	3.8196 (.6852)	3.5847 (.6221)	3.5923 (.6234)	3.6562 (.6487)	3.2838 (.5316)
p_1	.0131	.0008	.0444	.0001	.0001	.0004	.0003	.0357
p_2	.0702	.0209	.0555	.0086	.0117	.0118	.0173	.0524
Likelihood Ratio Test	60.6816	66.4153	67.5663	67.6975	66.4614	66.6702	67.0372	61.0843

Notes: Standard errors in parentheses.

Cope is scores from the AFL-CIO Committee on Political Education; *Ntu*, scores from the National Taxpayers Union; *Coal*, mining jobs lost to the Clean Air Act; *App*, membership on the Senate Appropriations Committee; *Lead*, membership among the Senate Leadership; *Nom99*, Nominate scores for the 99th Senate; *Ada*, scores from Americans for Democratic Action; *Party*, Democratic Party membership; *Lcv*, League of Conservation Voters scores.

of Conservation Voters variable a negative coefficient.

Next, I use Table I's estimates of β to compute estimated ideal points and, in turn, to test for a cut point. Table II lists estimates of ideal points from the specification of column 1 from Table I. The estimates are computed simply by multiplying the estimate of β by the relevant vector of data for each senator.

A cut point does not exist among the *estimates* of ideal points. For instance, McClure, Cochran, and Grassley voted for the Byrd amendment yet all have estimated

TABLE II
Senators' Estimated Ideal Points

Senator	$\hat{y}_i$	Vote	Senator	$\hat{y}_i$	Vote
1. Roth (R-DE)	–0.9669	N	51. Heflin (D-AL)	1.8210	Y
2. Symms (R-ID)	–0.8547	N	52. Shelby (D-AL)	1.8435	Y
3. Wallop (R–WY)	–0.8322	N	53. Baucus (D-MT)	1.8489	N
4. Armstrong (R-CO)	–0.7649	N	54. Bumpers (D-AR)	1.9108	Y
5. McClure (R-ID)	–0.7424	Y	55. Pryor (D-AR)	1.9305	N
6. Boschwitz (R-MN)	–0.7424	N	56. Wirth (D-CO)	1.9557	Y
7. Gramm (R-TX)	–0.7200	N	57. Fowler (D-GA)	1.9754	N
8. McCain (R-AZ)	–0.6975	N	58. Lieberman (D-CT)	1.9782	Y
9. Thurmond (R-SC)	–0.6302	N	59. Reid (D-NV)	1.9936	Y
10. Burns (R-MT)	–0.5853	N	60. Daschle (D-SD)	2.0006	N
11. Garn (R-UT)	–0.5792	N	61. Llautenberg (D-NJ)	2.0231	Y
12. Humphrey (R-NH)	–0.5295	N	62. Bentsen (D-TX)	2.0231	Y
13. Kassebaum (R-KS)	–0.5179	N	63. Kennedy (D-MA)	2.045.5	Y
14. Helms (R-NC)	–0.5070	N	64. Bingamen (D-NM)	2.0455	Y
1.5. Nickles (R-OK)	–0.4967	N	65. Matsunaga (D-HA)	2.0652	Y
16. Dole (R-KS)	–0.4730	N	66. Cranston (D-CA)	2.0904	Y
17. Mack (R-FL)	–0.4451	N	67. Bryan (D-NV)	2.1408	Y
18. Simpson (R-WY)	–0.3608	N	68. Leahy (D-VT)	2.1408	N
19. Warner (R-VA)	–0.3104	N	69. Exon (D-NE)	2.1408	Y
20. Kasten (R-WI)	–0.2152	N	70. Kerrey (D-NE)	2.1408	Y
21. Cochran (R-MS)	–0.1982	Y	71. Biden (D-DE)	2.1632	N
22. Domenici (R-NM)	–0.1954	N	72. Mitchell (D-ME)	2.1857	N
23. Murkowski (R-AK)	–0.1757	N	73. Breaux (D-LA)	2.2081	N
24. Rudman (R-NH)	–0.1757	N	74. Graham (D-FL)	2.2306	N
25. Lott (R-MS)	–0.1029	N	75. Levin (D-MI)	2.2306	N
26. Grassley (R-IO)	–0.0400	Y	76. Kerry (D-MA)	2.2306	Y
27. Gorton (R-WA)	–0.0356	N	77. Riegle (D-MI)	2.2306	N
28. Hatch (R-UT)	–0.0125	N	78. Adams (D-WA)	2.2306	Y
29. Wilson (R-CA)	0.1665	N	79. Inouye (D-HA)	2.2476	Y
30. Pressler (R-SD)	0.2447	N	80. Dodd (D-CT)	2.2979	N
31. Durenberger (R-MN)	0.3740	N	81. Burdick (D-ND)	2.3204	Y
32. Chafee (R-RI)	0.5536	N	82. Gore (D-TN)	2.3221	Y
33. Bond (R-MO)	0.6137	Y	83. Sasser (D-TN)	2.3331	Y
34. Jeffords (R-VT)	0.6264	N	84. Moynihan (D-NY)	2.3428	Y
35. Hatfield (R-OR)	0.6542	Y	85. Harkin (D-IO)	2.3439	Y
36. Stevens (R-AK)	0.7162	Y	86. Sanford (D-NC)	2.4102	Y
37. Danforth (R-MO)	0.7538	Y	87. Mikulski (D-MD)	2.4797	Y
38. Boren (D-OK)	1.0572	N	88. Sarbanes (D-MD)	2.7042	N
39. Packwood (R-OR)	1.1312	N	89. Lugar (R-IN)	3.3298	N
40. Johnston (D-LA)	1.9060	Y	90. Coats (R-IN)	3.6325	Y
41. Cohen (R-ME)	1.4060	N	91. Specter (R-PA)	5.3906	Y
42. D'Amato (R-NY)	1.5907	N	92. Heinz (R-PA)	6.1478	Y
43. Pell (D-RI)	1.6360	Y	93. Metzenbaum (D-OH)	6.1484	Y
44. Bradley (D-NJ)	1.6809	Y	94. Glenn (D-OH)	6.3953	Y
45. Hollings (D-SC)	1.7033	Y	95. Dixon (D-IL)	13.5620	Y
46. Robb (D-VA)	1.7258	N	96. Simon (D-IL)	13.7191	Y
47. Nunn (D-GA)	1.7482	N	97. McConnell (R-KY)	32.6456	Y
48. Conrad (D-ND)	1.7986	Y	98. Rockefeller (D-WV)	34.7319	Y
49. Kohl (D-WI)	1.7986	Y	99. Ford (D-KY)	34.7995	Y
50. DeConcini (D-AZ)	1.8156	Y	100. Byrd (D-WV)	35.2313	Y

ideal points among the smallest fifty. Similarly Sarbanes, Lugar and Dodd have estimated ideal points among the largest fifty but voted against the Byrd amendment. Define these occurrences as *apparent violations of a cut point*. Formally, they are yea voters ranked within the smallest fifty estimated ideal points and nay voters ranked within the largest fifty estimated ideal points.[23] Table II lists twenty-eight apparent violations of a cut point. Because these estimates are imperfect measures of actual ideal points, the existence of an apparent violation does not necessarily mean that a cut point does not exist. For instance, Senator McClure, who has a very small estimated ideal point, may have an actual ideal point within the largest fifty if the ε_i term for him is very large. If this is the case, then his yea vote would be consistent with the existence of a cut point. In fact even when a cut point exists, because of the error terms one should expect some apparent violations of a cut point. But is twenty-eight significantly greater than what one should expect?

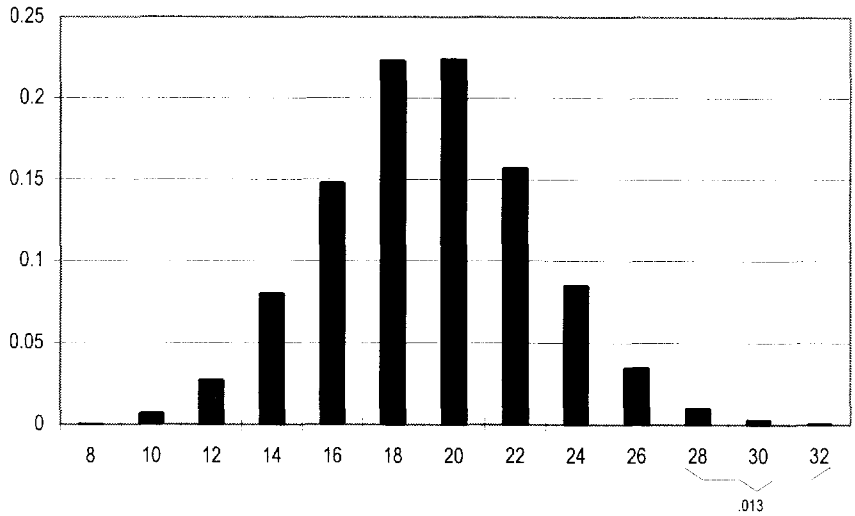
To answer this I form a null hypothesis that a cut point exists among actual ideal points and an alternative hypothesis that a cut point does not exist. The alternative hypothesis implies a tendency for the apparent violations to be greater than the number that would be expected by chance. Next, I adopt a Monte Carlo procedure to test if the observed number, twenty-eight, is significantly greater than the expected number. First, with the set of estimated ideal points in Table II, a computer program simulates a set of actual ideal points by adding a N(0,1) random variable to each estimated ideal point.[24] Next, simulated actual ideal points are converted into simulated votes by noting which were ranked in the least fifty and which were ranked in the greatest fifty. With this set of simulated votes, the number of simulated apparent violations is recorded. This is the total number of simulated yea (nay) votes with corresponding estimated ideal points ranked in the least (greatest) fifty. These steps are repeated 10,000 times to obtain an approximate density of the apparent violations that should be observed under the null. This density is presented graphically in Figure 3. Of the 10,000 trials, the proportion which produced at least twenty-eight apparent violations was .013. Since this number is less than .05, one can reject the null hypothesis of a cut point in favor of the alternative. This procedure is repeated for the different econometric specifications represented in Table 1, and the results are presented in the p_1 row of Table I. For these other specifications the same qualitative results occur: the null can always be rejected at a 5 percent significance level.

The above procedure, however, ignores the fact that the estimates of β in Table I are not the true values of β. To account for this I adopt a second procedure, which is identical to the first except that at each simulation I draw a $\hat{\beta}$ from a multivariate normal distribution with mean β and variance-covariance matrix produced from the estimation procedure for β. The draw of $\hat{\beta}$ is used to compute a set of estimated and simulated actual ideal points, as described in the above procedure, where actual ideal points are simulated by adding a N(0,1) random variable to estimated ideal points. Then, at each round the computer program records the number of apparent and simulated actual violations, and notes whether the latter number is at least as great as the former. After 10,000 rounds the proportion of times this occurs is recorded. These proportions are listed in the p_2 row of Table I. As before, this procedure usually allows the null hypothesis to be rejected at the 5 percent level; however,

23. The number fifty is chosen because the observed tally contained fifty nay votes, counting Bennett Johnston.

24. Recall that I assume $\sigma = 1$ when estimating β. Assuming a different value for σ does not change the p value for this test.

FIGURE 3
Density of Apparent Violations



Key: Since the observed number of apparent violations, 28, is greater than all but 1.3 percent of the simulated violations, the null (cut point) hypothesis can be rejected.

the p-values for this procedure tend to be greater than those of the first procedure. Although the two procedures give different p-values, as the sample size grows to infinity, the two procedures will give identical values. This is because the variance of the estimates of β will approach zero as the sample size grows, while the variance of the $\hat{\varepsilon}_i$'s will remain constant. Thus, as both $\hat{\beta}$ and $\hat{\hat{\beta}}$ approach β, the two procedures become identical.[25]

VI. DISCUSSION

For two different testing procedures and for many different specifications of independent variables, the null (cut point) hypothesis was consistently rejected. This, along with the theoretical results of section IV, suggests that coalition leaders practiced price discrimination on the Byrd amendment. The result also suggests that favor trading itself occurred. Note that the

25. A natural curiousity is what this method produces for a vote that is expected to produce a cut point. A natural case to test, and one of the most famous instances in which senators' ideal points have been estimated, is Krehbiel and Rivers [1988] study of two minimum-wage votes in the Senate. For these votes the authors indicate no evidence that favor trading occurred. Thus, each vote should produce a cut point. With the method described above and data graciously provided to me by Krehbiel and Rivers, I tested the votes for a cut point. For the Tower amendment, when all independent variables considered by Krehbiel and Rivers were included, p_1 and p_2 were respectively .542 and .275. For the Bartlett amendment, p_1 was .479. The coefficients for Party and South on this vote, however, exploded. This disallowed estimates of the variances of these coefficients and consequently disallowed computation of p_2. Since none of the three p values are less than .05, for each test the cut point hypothesis cannot be rejected.

lack of favor trading is simply a special case of favor trading in which each coalition leader offers a price of zero to each legislator. By Proposition 1, the failure to find a cut point implies that favor trading occurred.

The statistical and anecdotal evidence from the Byrd vote thus allow the following conclusions: (i) favor trading occurred, (ii) the coalition leaders practiced price discrimination, (iii) they did not collude with one another, and (iv) at least one coalition leader (Byrd) did not adopt a minimal-winning coalition strategy. Each of these conclusions is an empirical question and accordingly should be answered with data and statistical tests or at least anecdotal evidence. One of the main points of the paper is to show that, despite the near impossibility of observing favors, testing theories of favor trading is still possible.

A natural question is the extent to which the Byrd amendment is typical of a vote in Congress. Specifically, how often should one expect roll-call votes to violate a cut point? Although the data and statistical tests of the paper are silent on this question (except to say that at least one vote, the Byrd vote, has violated a cut point), the theory of the paper suggests that cut points should be violated only rarely. That is, the Byrd vote was probably atypical of votes in Congress. The reason relies on Proposition 2. When competing coalition leaders are completely informed of the preferences of all other actors, at least one leader will decline to buy votes. This causes the final vote to produce a cut point. Consequently, to the extent the information of coalition leaders is approximately complete, violations of a cut point should be rare.

This fact is encouraging for research on Congress that assumes cut points exist. For instance, it implies that favor trading will only occasionally cause probit and logit techniques to produce inconsistent estimates. Similarly, it implies that favor trading will not significantly add to the errors-in-variables problem in the research on legislator ideology.

However, the fact is discouraging for future tests of favor trading. Namely, to the extent information is complete, it will be rare for both coalition leaders on an issue to engage in favor trading. As a consequence, at least in terms of cut points, most votes on which favor trading takes place will be observationally equivalent to those on which favor trading does not take place. Thus, it is doubtful that tests for a cut point hold much promise as a general method for discerning and measuring the presence of favor trading on typical votes in Congress.

For the same reason the fact underscores the importance of the data from the Byrd vote. Since on this vote coalition leaders from each side of the issue engaged in favor trading, it is an exceptional opportunity to test hypotheses of favor trading. Like an eclipse for an astronomer or an earthquake for geologist, the Byrd vote should be regarded as a rare and valuable natural experiment, providing an extraordinary glimpse into the institutional structure of legislative vote markets.

APPENDIX

LEMMA. $y_i < y_j \Leftrightarrow \alpha_i < \alpha_j$.

Proof. ($\Rightarrow$): Suppose $y_i < y_j$. Define

$$\lambda = \frac{x_b - x_0}{(x_b - x_0) + (y_j - y_i)} .$$

By the hypothesis and the assumption that $x_b > x_0$, it follows that $\lambda \in (0, 1)$. Next note that

$$x_b - y_j = \lambda(x_b - y_i) + (1 - \lambda)(x_0 - y_j).$$

By the strict concavity of $u()$,

(A1) $\quad u(x_b - y_j) > \lambda u(x_b - y_i) + (1 - \lambda)u(x_0 - y_j).$

Note also that

(A2) $$x_0 - y_i = (1-\lambda)(x_b - y_i) + \lambda(x_0 - y_j).$$

Hence, we similarly have

(A2) $$u(x_0 - y_i) > (1-\lambda)u(x_b - y_i) + \lambda u(x_0 - y_j).$$

Inequalities (A1) and (A2) imply

$$u(x_b - y_j) + u(x_0 - y_i) > u(x_b - y_i) + u(x_0 - y_j).$$

Rearranging and substituting for α_i and α_j, the above gives

$$\alpha_i < \alpha_j.$$

($\Leftarrow$): Since y_i and y_j are arbitrary in the above part of the proof, we can rearrange subscripts and have

$$y_j < y_i \Rightarrow \alpha_j < \alpha_i.$$

Taking the contra-positive of this statement gives

(A3) $$\alpha_i \leq \alpha_j \Rightarrow y_i \leq y_j.$$

Now, by the definition of α_i,

$$y_i = y_j \Rightarrow \alpha_i = \alpha_j.$$

The contra-positive of this statement is

(A4) $$\alpha_i \neq \alpha_j \Rightarrow y_i \neq y_j.$$

Finally, (A3) and (A4) imply

$$\alpha_i < \alpha_j \Rightarrow y_i < y_j. \qquad \blacksquare$$

Solution to Example 2

Here I show that $(z_2^{L*}, z_3^{L*}, z_2^{R*}, z_3^{R*}) = $ ¼,¼, ¾,0) are optimal responses for L and R.

First note that the probability that 2 votes for x_0 is $\Pr\{\alpha_2 \leq z_2^L - z_2^R\}$, and this equals $z_2^L - z_2^R + 1$, as long as $z_2^L - z_2^R \in [-1, 0]$. Next note that the probability that 3 votes for x_0 is $\Pr\{\alpha_3 \leq z_3^L - z_3^R\}$, and this equals $z_3^L - z_3^R$ as long as $z_3^L - z_3^R \in [0, 1]$. Finally, note that the probability that x_0 wins is

$$1 - (z_2^R - z_2^L)(1 - z_3^L + z_3^R).$$

with similar bounds placed upon $z_2^L - z_2^R$ and $z_3^L - z_3^R$.

This allows L's expected utility to be written as a constant plus

$$-\alpha^L \,\mathrm{PR}\{x_0 \text{ wins}\} - z_2^L \Pr\{2 \text{ votes for } x_0\}$$
$$- z_3^L \Pr\{3 \text{ votes for } x_0\}.$$

After substituting into this equation, it follows that L maximizes

$$1 - z_2^R + z_2^L + z_2^R z_3^L - z_2^R z_3^R$$
$$- z_2^L z_3^L + z_2^L z_3^R - z_2^L(z_2^L - z_2^R + 1)$$
$$- z_3^L(z_3^L - z_3^R)$$

subject to $z_2^L, z_3^L \geq 0$. Taking the derivative of this with respect to both z_2^L and z_3^L, setting each equal to zero, then solving gives

$$z_2^L = z_3^L = (z_2^R + z_3^R)/3.$$

This is the solution as long as $(z_3^R/3) - (2z_2^R/3) \in [-1, 0]$ and $(z_2^R/3) - (2z_3^R/3) \in [0, 1]$.

This allows L's responses, z_2^L and z_3^L, to be written as functions of z_2^R and z_3^R. In turn, it allows us to write

$$\Pr\{2 \text{ votes for } x_0\} = (z_3^R/3) - (2z_2^R/3) + 1$$

$$\Pr\{3 \text{ votes for } x_0\} = (z_2^R/3) - (2z_3^R/3)$$

$$\Pr\{x_0 \text{ wins}\} = 1 - (2z_2^R/3) + (z_3^R/3)$$
$$+ 2/9(z_2^R)^2 - 5/9(z_2^R z_3^R) + 2/9(z_3^R)^2$$

This allows us to write R's maximization function as

$$3[(2z_2^R/3) - (z_3^R/3) - 2/9(z_2^R)^2$$
$$+ 5/9(z_2^R z_3^R) - 2/9(z_3^R)^2]$$
$$- z_2^R[(2z_2^R/3) - (z_3^R/3)]$$
$$- z_3^R[1 - (z_2^R/3) + (2z_3^R/3)]$$

subject to the constraints $z_2^R, z_3^R \geq 0$.

Taking first-order conditions shows that the constraint $z_3^R \geq 0$ is binding, while the other constraint is not. Substituting $z_3^{R*} = 0$ and differentiating with respect to z_2^R, then setting this expression equal to zero gives $z_2^{R*} = 3/4$. Substituting these values into the expressions for z_2^{L*} and z_3^{L*} gives the postulated equilibrium.

PROPOSITION 1. *Without price discrimination, a cut point always exists.*

Proof. Let z^{R*} and z^{L*} be the equilibrium payments offered in the one-price model. To show that there exists a cut point, let i and j be any two legislators such that $y_i < y_j$ and assume that i votes for x_b. We must show that this implies that j votes for x_b. First note that since i votes for x_b, by (1),

$$v(z^{L*}) < \alpha_i + v(z^{R*}).$$

Next, since $y_i < y_j$, by the lemma, $\alpha_i < \alpha_j$. This along with the above inequality implies

$$v(z^{L*}) < \alpha_j + v(z^{R*}).$$

Finally this statement, by (1), implies that j votes for x_b. ∎

PROPOSTION 2. *With complete information a cut point always exists.*

Proof. First assume all actors have complete information. Because of Proposition 1, we need only prove that a cut point exists in the many-price model. To do this, we first note that under complete information, at most one coalition leader pays any favors. To see this, suppose not. Then there is one coalition leader who pays favors and loses the vote. This coalition leader would have been strictly better off by conceding the vote and not offering any favors. Furthermore, under complete information the coalition leader could have foreseen this outcome, and it contradicts the coalition leader's maximizing his or her utility. Next let us separate legislators into two categories. Define

$$N_L = \{i : \alpha_i \leq 0\}$$

and

$$N_R = N \setminus N_L.$$

These represent the legislators who will respectively vote for x_0 and x_b if no payments are made. We must check two cases: (1) when R concedes and L buys votes, L buys the "leftmost" members of N_R, and (2) when L concedes and R buys votes, R buys only the "rightmost" members of N_L. To prove case (2), suppose not; that is, that R does not buy the rightmost members of N_L. This implies $\exists\, i, j \in N_L$, s.t. $\alpha_i < \alpha_j$, $z_i^{R*} > 0$, and $z_j^{R*} = 0$. Under complete information, R's objective is to make offers in a manner that maximizes the total amount of favors L would have to pay to gain victory of x_0. Given this, note that to buy i's vote L would have to pay the z_i^L that satisfies

$$v(z_i^L) = \alpha_i + v(z_i^{R*}).$$

By the properties of $v()$, there exists a z_i^L that satisfies the above and is unique. Furthermore it can be written as

$$z_i^L = v^{-1}[\alpha_i + v(z_i^{R*})].$$

We want to show that R instead of paying z_i^{R*} to legislator i, could have made a strictly smaller payment to j, $z_j^{R'}$, paid zero favors to i, and kept constant the amount L must pay to gain victory for x_0. The condition that we keep constant L's payment to ensure victory of x_0 requires

$$z_j^{L'} = z_i^L = v^{-1}[\alpha_i + v(z_i^{R*})]. \quad \text{(A5)}$$

To make L pay this much, R must choose $z_j^{R'}$ to satisfy

$$v(z_j^{L'}) = \alpha_j + v(z_j^{R'}),$$

which implies

$$z_j^{L'} = v^{-1}[\alpha_j + v(z_j^{R'})]. \quad \text{(A6)}$$

Equations (A5) and (A6) imply

$$v^{-1}[\alpha_i + v(z_i^{R*})] = v^{-1}[\alpha_j + v(z_j^{R'})].$$

Since $v^{-1}()$ is strictly increasing, the above implies

$$\alpha_i + v(z_i^{R*}) = \alpha_j + v(z_j^{R'}).$$

Since $\alpha_i < \alpha_j$, this is turn implies

$$v(z_i^{R*}) > v(z_j^{R'}).$$

Finally, since $v()$ is strictly increasing, this implies

$$z_i^{R*} > z_j^{R'}.$$

That is, R could have made a strictly smaller offer to legislator j while keeping constant the total number of favors L would have to pay to gain victory for x_0, which is a contradiction. The proof for case (1) takes the same approach, although it is slightly easier since we can ignore R's being able to make counter offers. Because in this case R concedes the vote before it is L's turn to offer favors, the proof is only an exercise in showing that the price L has to pay for a vote increases as legislators' ideal points move rightward. This follows from the Lemma and the assumption that $v()$ is strictly increasing.

■

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