The Market Value of Votes: An Experiment[1]

by

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Abstract

Suppose a legislature must vote on a bill. There are two lobbyists, one of which favours the proposed bill whereas the other wants the status quo to prevail. The two lobbyists have identical budgets, and distribute them simultaneously across the voters in the legislature. The voters do not care about how they vote and do the bidding of whoever pays them most. The expected share of the budget given to a voter can be used as a measure of the voter's market value or P-power. If voters have different voting weights, the question arises of how the market value relates to these weights. We investigate this setup for the case of apex games, which are the simplest games with asymmetric voters. In an apex game there are n players, of which one is large and n-1 small, and the large player has as many votes as n-2 small players. Despite the large voter and the n – 2 small voters being perfect substitutes, the equilibrium market value of the lobbying game gives the large voter more than n-2 times the value of a small voter. The equilibrium also predicts that lobbyists may distribute their budget over a coalition that is larger than minimal winning; this is due to the uncertainty about the strategy of the other lobbyist. We investigate this setup experimentally and find qualitative support for both theoretical predictions. The empirical market value of the large player is above the combined value of n-2 small players. The lobbyists try to bribe coalitions larger than minimal winning relatively often, though not as often as the theory predicts.

Keywords: lobbying, weighted voting, vote buying, power measures, experiment

JEL Codes: D72, C72, C91

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INTRODUCTION

Consider a situation with four voters. One of the voters has 2 votes, the other three voters have 1 vote each, and 3 votes are needed for a majority. There are two types of minimal winning coalitions in this situation: the large voter together with one of the small voters, and the three small voters together. Suppose that voters do not care about how they vote, but instead can sell their vote to an interested agent. Because the voter with 2 votes can replace the two voters with 1 vote, it seems natural that its "market value" would be twice the value of a voter with 1 vote (see e.g. Owen et al., (2006)).

Despite this intuition, it is not necessarily the case that market values are proportional to votes in equilibrium. Young (1978a) studies a model in which two lobbyists with identical budgets compete for the voters, and each voter does the bidding of whoever pays them most. He measures the worth of a voter by the expected amount they are offered in equilibrium, and finds that a voter with 2 votes is worth more than twice as much as a voter with 1 vote in the situation above[2]. Similarly, most power indices give a disproportionately large share to the large voter. In particular, the Shapley value (which is considered to be the most appropriate index when there is a resource to be distributed, see Felsenthal and Machover, 1998) predicts a more than proportional payoff to the large voter. Furthermore, if we consider the family of apex games to which the game in the above example belongs, the share predicted by the Shapley value converges to 1 as the number of voters increases, even though the proportion of votes controlled by the large voter is never above 0.5.[3]

In our experiment the lobbyists have the same budget and must move simultaneously. Given a budget of 120 indivisible units for each lobbyist, we observe that the large voter gets a more than proportional average payoff for 4-player apex games and 5-player apex games, though the departure from proportionality is small and insignificant for the 4-player case. We also run experiments using a coarse budget (5 indivisible units). The advantage of the small budget is that we are able to calculate the lobbyists' equilibrium strategies[4]. With a small budget, the expected payoff for a large voter is disproportionately high and close to Young's prediction for the large budget. Experimental results for the small budget confirm that the large voter's share is higher than proportional, and the departure from proportionality is significant for both the 4-voter and the 5-voter cases.

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[2] Young's results are derived for a budget consisting of a large but finite number of indivisible units (the budget's size is not reported in the paper). He also finds that, if a lobbyist has substantially more funds than the other, equilibrium shares are proportional to the votes (Young 1978b).

[3] The nucleolus on the other hand predicts proportional payoffs.

[4] Little is known about simultaneous lobbying games. They are related to 'Colonel Blotto' games, which are notoriously difficult to solve. In view of this difficulty, most papers in the literature have opted for considering sequential moves (Groseclose and Snyder (1996), Diermeier and Myerson (1999), Banks (2000), Dekel et al. (2006), Le Breton and Zaporozhets (2010)). Except for Young's (1978a) computations (which only report expected payoffs without equilibrium strategies), nothing is known about the equilibrium of the game with asymmetric voters. Thomas (2009) analyses asymmetric objects, but in the original Blotto game in which the bidders' payoff is the total value of objects won.

Another question of interest is how often minimal winning coalitions are observed. At first sight it seems that, since a minimal winning coalition is sufficient to pass a proposal, there is no point in bribing a coalition larger than minimal winning (Riker's size principle). However, because a lobbyist does not observe the strategy of the other lobbyist, it may be optimal to spread the money over a larger coalition. Groseclose and Snyder (1996) and Banks (2000) make this point in a model where vote buyers move sequentially and the losing vote buyer is always granted a last chance to attack the winner's coalition. [5] Supermajorities also arise in the equilibria we find: lobbyists randomize between bribing several coalitions, some of which are larger than minimal winning.

It turns out that supermajorities are observed in our experiment, but not as often as the theory predicts. More generally, observed strategies are far from the equilibrium predictions.

THEORY

Apex games

Apex games are voting games with one strong voter and n-1 weak voters. There are two types of minimal winning coalitions: the strong voter together with one of the weak voters, and all the weak voters together. Apex games can be described as weighted majority games in which the strong voter controls n-2 votes, the n-1 weak voters control 1 vote each, and n-1 votes are needed to achieve a majority.[6]

The lobbying game

The voters in the apex game above must vote on a bill. There are two lobbyists, one of which favours the proposed bill whereas the other wants the status quo to prevail. The two lobbyists have identical budgets, and distribute them simultaneously across the voters. The voters do not care about how they vote and do the bidding of whoever pays them most. The lobbyists are assumed to spend their entire budget; this would be the case if they care a lot about the outcome but are budget constrained. In words of Young (1978a) “winning or losing is assumed to be of incomparably greater value than the prices paid”. We also assume a smallest money unit. In two of our treatments the smallest money unit is relatively small compared with the total budget (there are 120 indivisible units); in the other two treatments the smallest money unit is rather large (there are 5 indivisible units). The first case is perhaps more realistic, but the second case allows us to compute equilibrium strategies.

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[5] An extreme example of bribing supermajorities arises when, instead of both lobbyists being symmetric as we assume, one of them has a considerably larger budget than the other; then the lobbyist with the larger budget bribes *all* voters (Young 1978b).

[6] There are many equivalent representations for weighted majority games. For example, if four voters have 3, 2, 1 and 1 votes respectively and 4 votes are needed for a majority, the game is also an apex game. In what follows we use the homogeneous representation (this representation assigns votes in such a way that all minimal winning coalitions have the same number of votes). For apex games, the homogeneous representation exists and it is unique (up to rescaling). Note that even if we accept representations that are not homogeneous, the strong voter in an apex game cannot have more than half of the votes.

Theoretical Predictions

Below is a table that summarizes the predicted expected equilibrium share for the apex player depending on the number of players and on the fineness of the budget. In the five-player case there is a small interval of equilibrium payoffs; the table reports the smallest value. The predictions for the fine budget (B = 120) are taken from Young (1978a); the predictions for the coarse budget (B = 5) are derived in the next subsection. The table also includes the proportional prediction (i.e., the share of the total votes controlled by the apex player) and the Shapley value for comparison. The equilibrium predictions are very similar regardless of whether a fine or coarse budget is used, and they are clearly above the proportional prediction.

Four players				Five players			
B=5	**B=120**	**Prop**	**Shapley**	**B=5**	**B=120**	**Prop**	**Shapley**
0.51	0.50	0.40	0.50	0.54	0.56	0.43	0.60

Theoretical predictions

Apex game with four players

We assume lobbyists only play strategies that treat all minor players equally. For example, strategy 4100 denotes a mixed strategy in which the lobbyist allocates 4 units to the apex player and 1 unit to one of the three minor players at random.

Taking this into account, there are 16 strategy types. Four of them (5000, 0500, 0410 and 0320) are eliminated because they allocate the budget to a losing subset of players.

The table below is the resulting normal form game between the two lobbyists (entries on the table correspond to the probability that the row lobbyist wins). Because there are only two possible outcomes (winning and losing), risk attitudes are irrelevant under expected utility theory and a player’s payoff can be identified with the probability of winning.

Normal form for AP_4

	4100	**3200**	**2300**	**1400**	**3110**	**1310**	**2210**	**1220**	**2111**	**1211**	**0311**	**0221**
4100	0.5	11/12	11/12	11/12	5/6	3/4	3/4	2/3	0.5	1/3	1/3	1/6
3200	1/12	0.5	11/12	11/12	0.5	5/6	11/12	5/6	1	5/6	2/3	2/3
2300	1/12	1/12	0.5	11/12	0	11/12	0.5	1	0.5	1	5/6	1
1400	1/12	1/12	1/12	0.5	0	0.5	0	0.5	0	0.5	1	1
3110	1/6	0.5	1	1	0.5	11/12	11/12	5/6	3/4	7/12	7/12	1/3
1310	¼	1/6	1/12	0.5	1/12	0.5	1/24	0.5	0	0.5	11/12	1
2210	¼	1/12	0.5	1	1/12	23/24	0.5	11/12	0.5	11/12	5/6	3/4
1220	1/3	1/6	0	0.5	1/6	0.5	1/12	0.5	0	0.5	1	11/12
2111	0.5	0	0.5	1	1/4	1	0.5	1	0.5	3/4	3/4	0.5
1211	2/3	1/6	0	0.5	5/12	0.5	1/12	0.5	1/4	0.5	11/12	5/6
0311	2/3	1/3	1/6	0	5/12	1/12	1/6	0	1/4	1/12	0.5	0.5
0221	5/6	1/3	0	0	2/3	0	1/4	1/12	0.5	1/6	0.5	0.5

Using the Gambit software (McKelvey et al., 2006) we found a unique equilibrium of the payoff matrix above, with probabilities 30/77 on 4100, 12/77 on 3200, 8/77 on 2111, 24/77 on 1211 and 3/77 on 0221. In this equilibrium, the share of the budget offered to the apex voter is $\frac{1}{5}\left(\frac{30}{77}\times 4+\frac{12}{77}\times 3+\frac{8}{77}\times 2+\frac{24}{77}\right)=\frac{28}{55}\approx 0.51$. The share of each minor voter is $\frac{1}{3}\left(1-\frac{28}{55}\right)=\frac{9}{55}\approx 0.16$.

Some of the strategies used in equilibrium (2111 and 1211) involve lobbyists trying to bribe a supermajority. Supermajority strategies can be optimal because of the uncertainty about the strategy of the other lobbyist. For example, suppose the other lobbyist randomizes between 4100 and 0221. Strategy 1211 does quite well against both of these strategies: it wins 2/3 of the time against 4100 and 5/6 of the time against 0221. If a lobbyist is sure that the other lobbyist is playing 4100 it would do better by playing 0221 rather than 1211 (giving up on the apex voter since it can never be won by allocating just one unit and increasing the probability of winning all three minor voters); similarly if the other lobbyist is playing 0221 is it best to play a strategy such as 1400 (this strategy wins for sure by ensuring that the apex voter and one minor voters are bribed). It turns out however that if 4100 and 0221 are played with equal probability the unique best response is 1211.

In the equilibrium we have computed, supermajority strategies are played with probability $\frac{32}{77} \approx 0.42$.

Apex game with five players

Again we assume that lobbyists only play strategies that treat all minor voters equally and discard strategies that look implausible (the obtained equilibrium can be later checked against invasion by those strategies). We discard strategy 14000 and any strategies that allocate the budget to a losing subset of minor voters. Taking this into account, there are 12 strategy types.

Normal form for AP5_5

	50000	**41000**	**32000**	**23000**	**31100**	**22100**	**13100**	**12200**	**21110**	**12110**	**11111**	**02111**
50000	0.5	7/8	7/8	7/8	3/4	3/4	3/4	3/4	0.5	0.5	0	0
41000	1/8	0.5	31/32	31/32	15/16	29/32	29/32	7/8	13/16	3/4	0.5	3/8
32000	1/8	1/32	0.5	31/32	0.5	31/32	15/16	15/16	1	15/16	1	7/8
23000	1/8	1/32	1/32	0.5	0	0.5	31/32	1	0.5	1	1	1
31100	¼	1/16	0.5	1	0.5	47/48	47/48	23/24	15/16	43/48	3/4	5/8
22100	¼	3/32	1/32	0.5	1/48	0.5	95/96	47/48	0.5	47/48	1	15/16
13100	¼	3/32	1/16	1/32	1/48	1/96	0.5	0.5	0	0.5	0.5	1
12200	¼	1/8	1/16	0	1/24	1/48	0.5	0.5	0	0.5	0.5	1
21110	0.5	3/16	0	0.5	1/16	0.5	1	1	0.5	31/32	7/8	25/32
12110	0.5	1/4	1/16	0	5/48	1/48	0.5	0.5	1/32	0.5	0.5	31/32
11111	1	0.5	0	0	1/4	0	0.5	0.5	1/8	0.5	0.5	7/8
02111	1	5/8	1/8	0	3/8	1/16	0	0	7/32	1/32	1/8	0.5

Using the Gambit software, we find a small continuum of equilibria with support 41000 (with weight from $4/7 \approx 0.57$ to $16/29 \approx 0.55$) and 11111 (with weight from $13/29 \approx 0.45$ to $3/7 \approx 0.43$). The expected share for the apex voter is between $19/35 \approx 0.54$ and $77/145 \approx 0.53$.

THE EXPERIMENT

Experimental Design

The experiment was conducted at the University of Nottingham using subjects recruited from a university-wide pool of undergraduate students using ORSEE (Greiner, 2004). It was programmed in z-tree (Fischbacher, 2007).

All sessions used an identical protocol. Upon arrival, subjects were given a written set of instructions that the experimenter read aloud (instructions for one of the treatments are appended). Subjects then reviewed the instructions on their computer screens and were allowed to ask questions by raising their hands and speaking to the experimenter in private. Subjects were not allowed to communicate with one another throughout the session.

At the beginning of the session subjects were paired to play the lobbying game for 45 rounds. Subjects were not told who of the other people in the room was paired with them, but they knew that they were playing the same subject throughout. Because the game is zero sum we were not worried about repeated game effects. Keeping subjects in the same pairs allows us to treat each pair as an independent observation since subjects in one pair cannot influence or be influenced by the decisions of subjects in any other pair.

The subjects were told to distribute their budget between ‘objects’, each of which was worth a given number of ‘points’. An object is won if a subject allocates more than the opponent to it, or, if both subjects allocate the same amount, if the subject wins the random computer draw. The subject that wins the most points in a given round is paid 50 p. At the end of each round, subjects were informed of how much they bid for the object, how much the opponent bid, who won each object and whether it was a random draw.

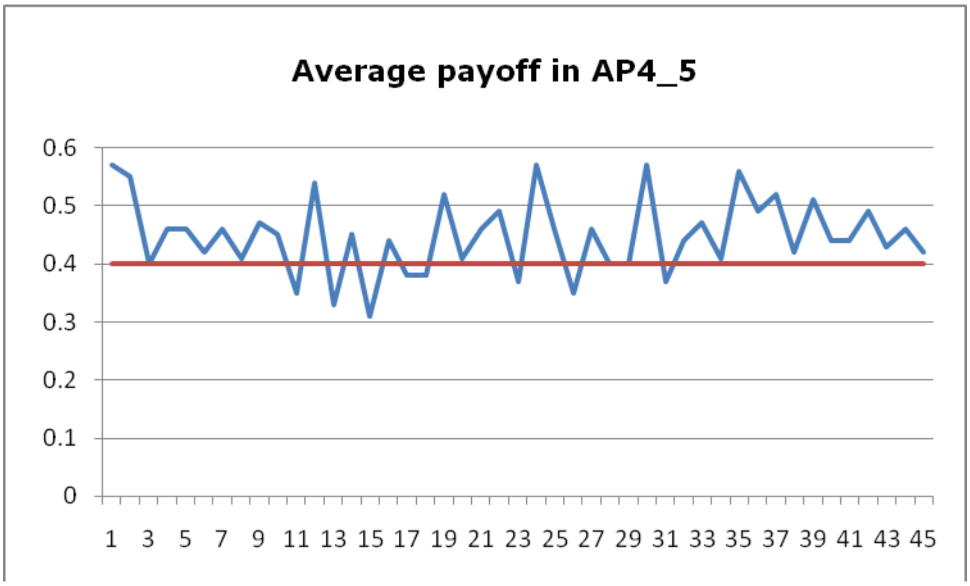
Treatments differ in the number of voters (4 or 5) and in the coarseness of the budget (5 or 120 indivisible units). A treatment is denoted by the voting situation followed by the budget: for example, AP4_5 is the apex voting situation with four voters and a budget of 5 indivisible units.

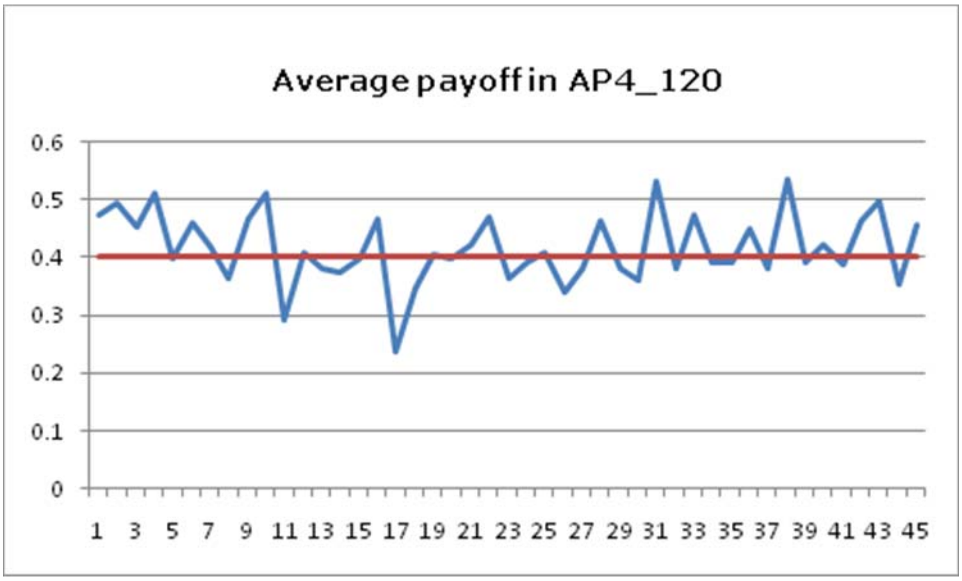
We run one session for treatment AP4_5 and two sessions each for treatments AP4_120, AP5_5 and AP5_120. Between 14 and 20 subjects participated in a given session. Each sessions took approximately 1.5 hours and subjects earned on average £11.25 (about $17 at the time of the experiment).

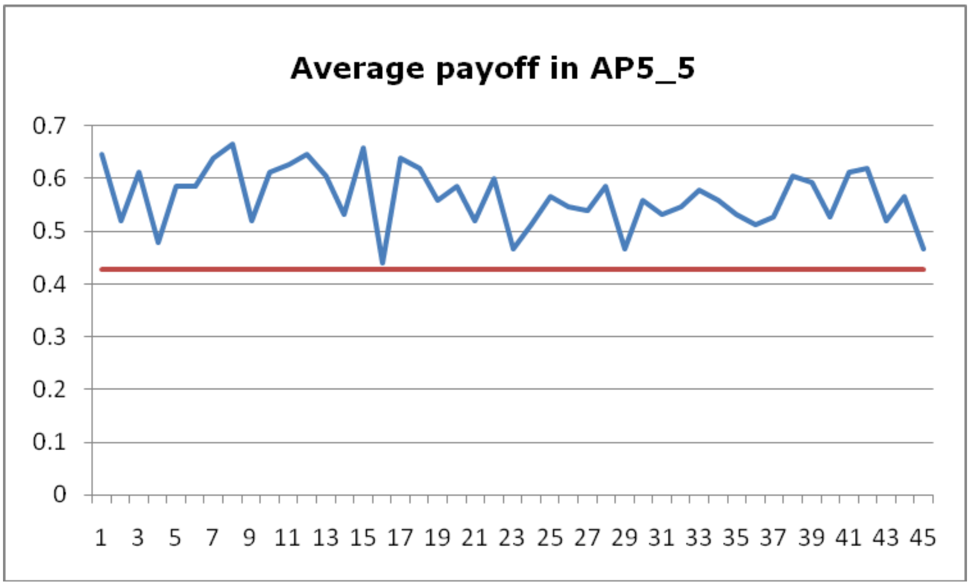
Results on proportionality

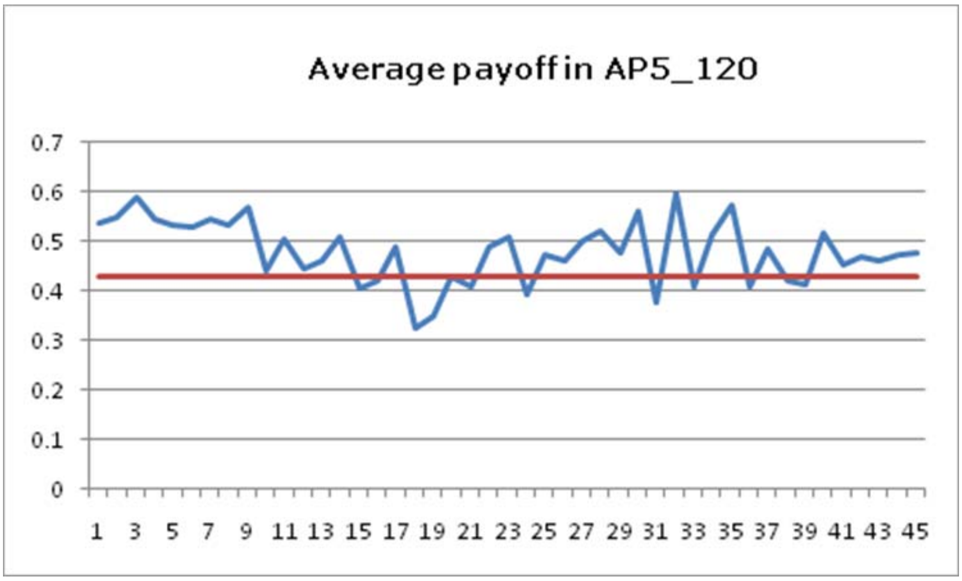
We are interested in testing whether average payoffs for the strong voter are significantly above proportional.

Below is the evolution of average payoff for the strong voter in each of the four treatments over the 45 rounds. The proportional payoff division is indicated by a dashed line. Payoffs are quite stable and seem to be superproportional except in AP4_120.









In order to test whether payoffs are significantly different from proportional, we calculate the average payoff for each pair over the 45 rounds and use a sign test.

For AP4_5 there was only one session with 10 pairs. The average share for the apex voter is significantly below the equilibrium prediction and above proportional (at a 10% significance level).

Pairs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
S1	0.46	0.42	$0.50_=$	0.43	0.39	0.45	0.49	0.36	$0.50_=$	0.50_-	0.45

For AP4_120 there were two sessions (S1 and S2) and 17 pairs in total. Average payoffs are significantly below the equilibrium prediction and are not significantly different from proportional.

Pairs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
S1	0.41	0.44	0.43	0.43	0.51_-	0.34	0.33				0.41
S2	0.52	0.40_-	0.46	0.41	0.61	0.35	0.35	0.30	0.40_+	0.45	0.42

For AP5_5, the share is above proportional in all cases and not significantly different from the equilibrium prediction.

Pairs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
S1	0.46	0.63	0.60_-	0.55	0.50	0.66	0.56	0.51	0.56
S2	0.58	0.68	0.58	0.59	0.54_-	0.51	0.56		0.58

For AP5_120, the share is significantly below the equilibrium prediction and above the proportional prediction.

Pairs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
S1	0.58	0.50	0.52	0.43_-	0.42	0.48	0.54_-			0.49
S2	0.46	0.53	0.52	0.44	0.45	0.54_-	0.42	0.49	0.43_+	0.48

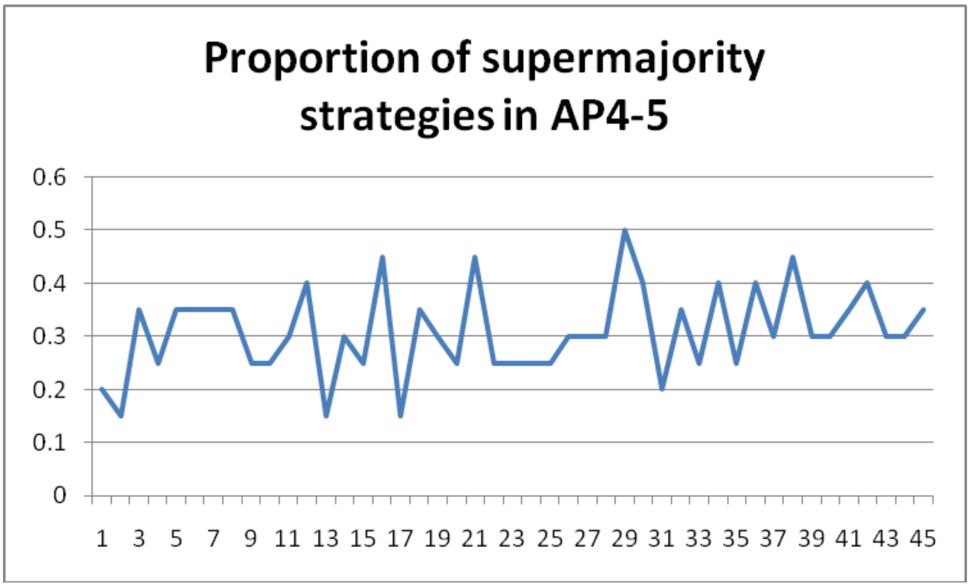
Comparison of strategies used with equilibrium strategies

We can only compare observed frequencies with equilibrium predictions for the case of a coarse budget. Observed frequencies are far from predicted frequencies in both AP4_5 and AP5_5 as the tables below show.

Strategy	Predicted frequency	Observed frequency
4100	0.39	0.20
3200	0.16	0.20
2111	0.10	0.04
1211	0.31	0.05
0221	0.04	0.22
3110	-	0.10
2210	-	0.05
1220	-	0.04
Other	-	0.09

Predicted and observed frequency of strategies in AP4_5

If we focus on supermajority strategies, these are predicted with probability 32/77 (about 42%). The proportion observed is lower (31% overall and 35% in the last 10 periods).



The only two supermajority strategies predicted in equilibrium are 2111 (with 10% probability) and 1211 (with 31% probability). They are observed only 4 and 5% of the time respectively in the experiment. The most popular supermajority strategy is 3110 (10%). 2210 and 1220 are observed as well (5 and 4% of the time respectively).

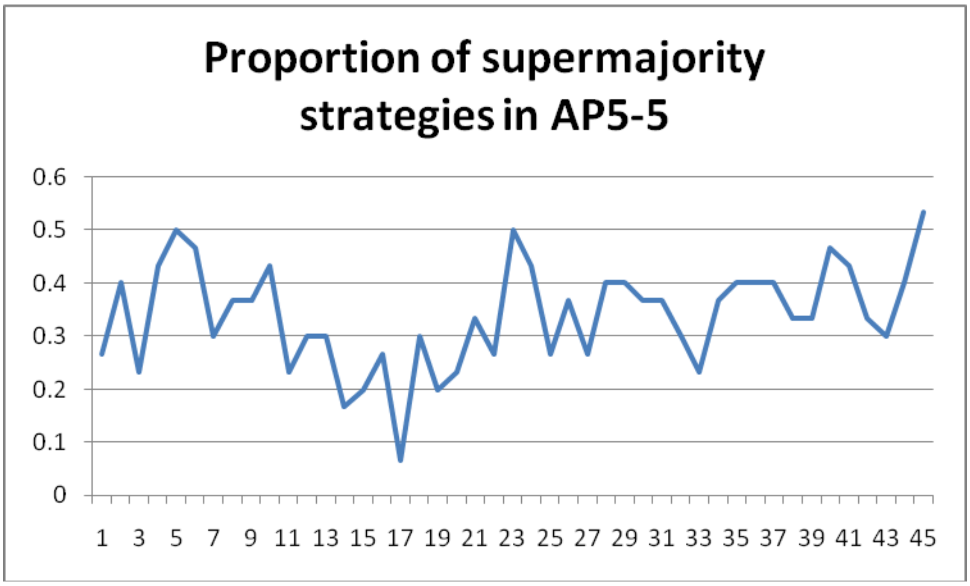
Observed frequencies also differ from the equilibrium predictions in AP5_5. The equilibrium prediction in this case is that only two strategy types are played: the minimal winning coalition strategy 41000 and the supermajority strategy 11111. Equilibrium strategies were played only 37% of the time in the experiment; the ‘minority’ strategy

50000 was rather popular as well as the minimal winning coalition strategy 02111 and the supermajority strategy 31100.

Strategy	Predicted frequency	Observed frequency
41000	0.56	0.27
11111	0.44	0.10
50000	-	0.17
02111	-	0.12
31100	-	0.12
32000	-	0.07
21110	-	0.07
Other	-	0.08

Predicted and observed frequency of strategies in AP5_5

If we focus on the frequency of supermajorities, the supermajority strategy 11111 is played between 43% and 45% of the time. As in the previous case, the proportion of supermajorities observed is lower than predicted (34% overall) but does not dissapear over time (the proportion in the last 10 periods is 39%). The actual strategy 11111 is only played about 10% of the time (14% in the last 10 periods). Other supermajority strategies that are played a significant proportion of the time are 31100 (12% overall; 11% in the last 10 periods) and 21110 (7% overall; 8% in the last 10 periods).



Concluding remarks

The lack of proportionality between votes and payoffs and the possibility of supermajorities may be related. Power indices like the Shapley value, which assigns a disproportionately high payoff to larger voters, take into account all coalitions in which a player is pivotal, irrespective of whether they are minimal winning. The large voter is pivotal in many coalitions that are not minimal winning (these are coalitions that contain the large voter and at least two but not all minor voters); on the other hand, the two cases in which a minor voter is pivotal both involve minimal winning coalitions.

Felsenthal and Machover (1998, p. 174) also refer to buying and selling votes in their discussion of P-power. They point out that, if an outsider stands to gain 1 unit if a board were to pass a certain bill and lose 1 unit if the board were to defeat that bill, the price it would be willing to pay to an individual voter (having no knowledge of any of the voters' intentions) would equal the Banzhaf measure. This argument is not conclusive in our framework since once there are two lobbyists trying to bribe multiple voters it may not be the case that voters vote independently yes or no with equal probability. Indeed Felsenthal and Machover go on to rebut this argument and dismiss the Banzhaf measure as a measure of P-power. Nevertheless, it is worth mentioning that the Banzhaf index also makes a superproportional prediction.

Equilibrium predictions receive some qualitative support in that expected payoffs for the apex voter tend to be above proportional. However, the strategies played by the lobbyists are rather far from equilibrium. We analyze the strategies played in more detail in the companion paper Montero et al. (2011).

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Instructions

General rules

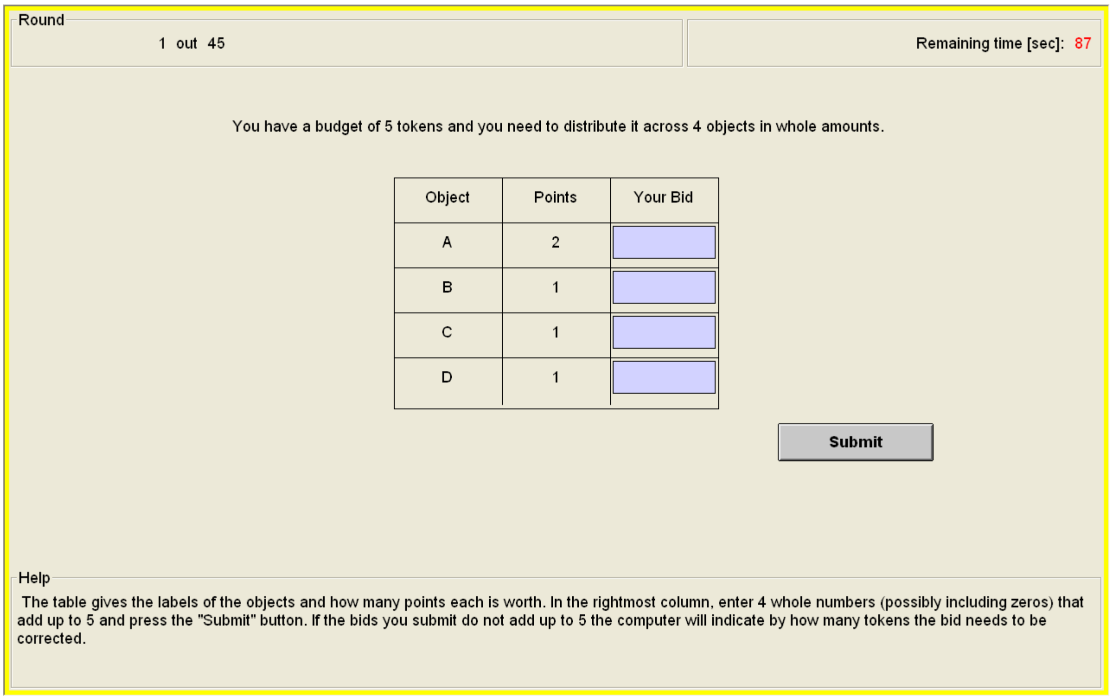
Welcome! This session is part of an experiment in the economics of decision making. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of money.

In this session you will be competing with one other person, randomly selected from the people in this room, over the course of forty-five rounds. Throughout the session your competitor will be the same but you will not learn whom of the people in this room you are competing with. The amount of money you earn will depend on your decisions and your competitor’s decisions.

It is important that you do not talk to any of the other people in the room until the session is over. If you have any questions raise your hand and a monitor will come to your desk to answer it.

Description of a round

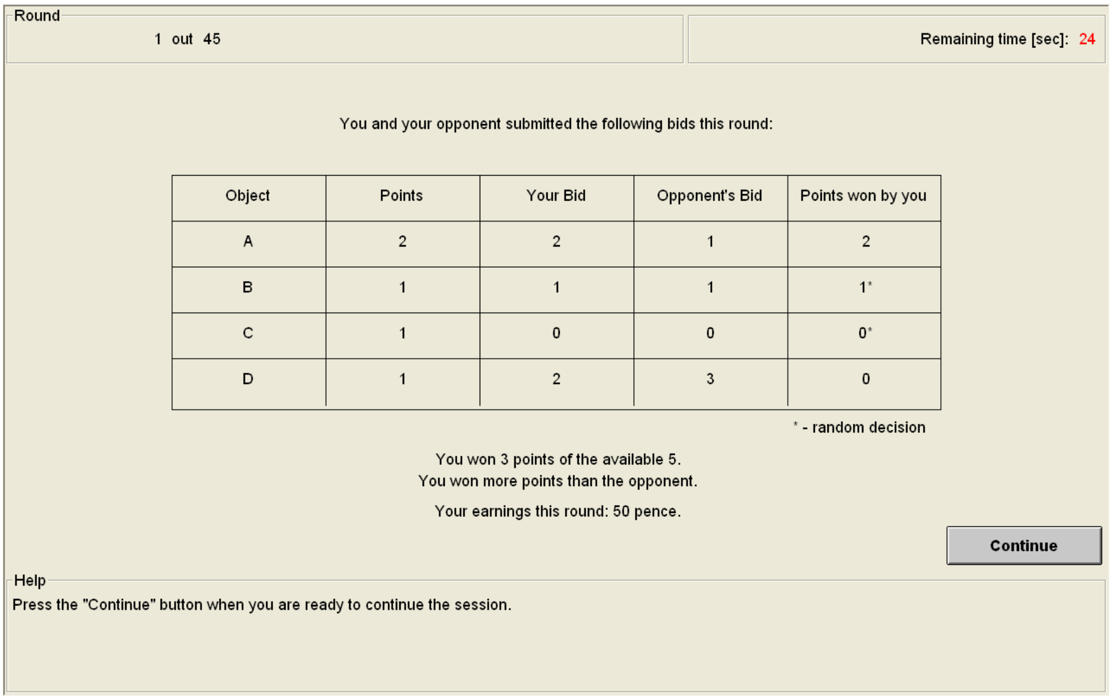
Each of the forty-five rounds is identical. At the beginning of each round your computer screen will look like the one below.



You have 5 tokens. You must use these to bid on 4 objects labelled A, B, C and D. You get points for winning objects – object A is worth 2 points and the other objects are worth 1 point each. For each object you can bid any whole number of tokens (including zero), but the total bid for all objects must add up to 5 tokens. You bid by entering numbers in the boxes, and then clicking on the “Submit” button. If the bids you submit do not add up to 5 the computer will indicate by how many tokens the bid needs to be corrected. If you do not submit a valid bid within 90 seconds the computer will bid for you and will place zero tokens on each object.

Please turn over

When everyone in the room has submitted their bids, the computer will compare your bids with those of your opponent. Your computer screen will look like the one below (the bids in the figure have been chosen for illustrative purposes only):



You win an object if you bid more for it than your opponent. (If you and your opponent bid the same amount the computer will randomly decide whether you or your opponent wins the object, with you and your opponent having an equal chance of winning the object. In this case the computer screen will indicate with an asterisk that the object was awarded randomly). **The winner of the round is the person who gets the most points.**

The winner of the round earns 50 pence, the other person earns zero.

Ending the Session

At the end of the session you will be paid the amount you have earned from all forty-five rounds. You will be paid in private and in cash.

Now, please complete the quiz. If you have any questions, please raise your hand. The session will continue when everybody in the room has completed the quiz correctly.

Quiz

1. Suppose your bids and your competitor's bids were as follows:

Object	Points	Your Bid	Opponent's Bid
A	2	2	3
B	1	1	2
C	1	1	0
D	1	1	0

How many points would you receive? _________ .

How many points would your opponent receive? _________.

What would your earnings from this round be (in pence)? _________.

What would your opponent's earnings from this round be (in pence)? _________.

2. Suppose your bids and your competitor's bids were as follows:

Object	Points	Your Bid	Opponent's Bid
A	2	2	0
B	1	1	1
C	1	1	2
D	1	1	2

Who wins object A? Me / My Opponent / Randomly Determined (Circle One)

Who wins object B? Me / My Opponent / Randomly Determined (Circle One)

For the remaining questions suppose the computer awards object B to your opponent:

How many points would you receive? _________.

How many points would your opponent receive? _________.

What would your earnings from this round be (in pence)? _________.

What would your opponent's earnings from this round be (in pence)? _________.