Honors Thesis Proposal: Experiment in Regime Comparison in Handling Common Pool Resource Problems

By David Bates

Working Title: Experiment in Regime Comparison in Handling Common Pool Resource Problems

Project Purpose: This experiment is based on a game-theoretic problem that has troubled the field of political economy since people first started grazing cows in pastures: how can economies best solve collective action problems? This experiment looks at one aspect of this question—types of governance. Are different styles of government more or less likely to prevent a common-pool resource (as these goods are called by Elinor Ostrom[1]) from being depleted? Or is the style of governance irrelevant to the question of whether a CPR (common-pool resource) is sustained? I wish to show how it is that styles of governance affect this problem so we know what types of governance we should promote to care for common-pool resources (like lumber and fish) in future conservation efforts.

Project Importance: The current literature on this topic has said a great deal about certain institutions that have preserved common-pool resources, and others that have not. The problem is that often these solutions are tailored to a specific region or political environment. This makes it very difficult to transfer the discovered solutions to resources in other places. This project instead looks at very general political institutions, with the goal of understanding which of these institutions, when applied generally, is most likely to lead to conservation of a common-pool resource.

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[1] Ostrom, Elinor. *Governing the Commons*. Cambridge University Press, 2015.

Project Overview:

The problem of how to ensure that people cooperate to conserve a publicly accessible resource is as old as civilization. The problem is summed up nicely in a classic game-theoretic model named "The Prisoner's Dilemma". In this game, two criminals are put in separate rooms and given the option of selling out the other or staying quiet. If both sell each other out, they both go to prison for 10 years. If only one sells the other out while the other stays quiet, the one who spoke gets off without a sentence, while his comrade must serve 15 years. If they both stay quiet, then they both serve 2 years. The payoff structure is shown below:

2 2	0 15
15 0	10 10

The problem of CPRs (common pool resources) is much the same as this game. If everyone cooperates with the plan (that is, takes only their fair share), then the collective payout would be far greater than if any one person had defected. For example, everyone can graze on the pasture for a long time. However, if one person defects from the plan (sells out), then that person can walk away with all of the CPR, leaving nothing for the other players, unless the other players also defect.

The problem with this game is that everyone has an incentive to defect. Remember that in the Prisoner's Dilemma, the criminals are kept in separate rooms. One does not know what the other is doing, and must simply infer it. In the Prisoner's Dilemma, the rational position is to

expect your partner to defect. If you believe this about your partner, then, in order to avoid the 15 year sentence, you will also defect, and you will both serve 10 years. The only mathematical solution to the game is for both players to defect, even though this results in a payoff that neither wants. Each would have preferred to get the 2 year sentence, but because of rational expectations and incentives, both wind up with the 10 year sentence, which neither of them prefers.

In a CPR scenario, no one person knows what the others intend to do with the CPR. If everyone cooperates, then everyone can enjoy the resource for a long time. However, there is an incentive to cheat—graze more than your share, fish more than your share, or timber more than your share—because if you are the only one that cheats, you can abscond with nearly all the resource to yourself. The problem is, if everyone understands this, then everyone will choose to cheat, so that they can at least get a little piece of the resource before it is completely depleted.

This is the problem that economists and political scientists have been trying to solve. How can you change the incentives so that it is in the best interest of the people to cooperate? Many institutions have been tried, with varying levels of success. I will now examine how differences in the types of government administrating a resource can lead to differences in how well a CPR is preserved.

Now, what does theory say about the ways that different types of governance may affect the preservation of a common pool resource? First, we look at democracy.

Democratically elected representatives are supposed to be kept in check by the fact that they must face reelection by popular vote. This drives a leader to provide public goods and

engage in other activities that, theoretically, would be beneficial for the population. Within Bueno de Mesquita et al.'s framework, the potential challenge of a candidate who can provide more public goods for the "selectorate" or winning coalition needed to stay in power drives the incumbent to provide enough public goods to maintain that winning coalition for him or herself[2].

Then, according to selectorate theory, we would see that the CPR would be preserved to keep providing public goods to the selectorate. The leader would do what was necessary to ensure that the CPR survived for as long as he or she was running for reelection. We can thus assume that, theoretically, the CPR would survive under a simple democracy. One scenario that disrupts this theory is when a candidate is running up against term limits, and thus cannot be reelected. This may cause both decreased incentive for the current leader to preserve the CPR, and, as the people suspect the leader of skimming, a devaluation of their future payoffs. This would raise their incentive to take more than their individual shares, and deplete the CPR. This is explained more fully and mathematically in the Hypothesis portion of the proposal.

With an autocracy, the theory is a little clearer. The leader who keeps the people happy by sharing from the CPR stays in power – and gets to continue his or her own theft of the CPR. If the leader can, in addition, maintain a coalition that will help prevent access to the CPR except that authorized by the ruler, then the ruler's exploitation can continue without interference from others.

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[2] Smith, Alastair, Randolph M. Siverson, James D. Morrow, and Bruce Bueno de Mesquita. "The Logic of Political Survival." MIT Press. (2003).

In this case, we would have a private ownership scenario, with the dictator being the de facto private owner of the CPR. This is one way that game theory allows for the solution of a CPR problem (although Ostrom showed that there can exist more optimal solutions to the problem than private ownership). Since the dictator is the private owner, he or she has a vested interest in preserving the CPR for the future. As long as this private ownership is maintained by the decree of the ruler, then the CPR will be maintained. It is in this way that an autocracy can lead to cooperation in CPR.

The theory of how an anarchic society handles a CPR shows that anarchy does not necessarily mean chaos. In fact, the anarchic society is quite controlled in the way that each citizen takes from the CPR. This, however, will only occur under the condition of repeated interactions.

The biggest problem of the Prisoner's Dilemma game is that the two players do not intend on ever having to play the game with each other again. However, if the players of the game are not criminals, but members of the same village or community, then these players must choose their actions by taking into account their next round of play with the same players. In this scenario, a decision to defect from the *status quo* leads to a punishment in the next round, while cooperating leads to continued availability of the CPR. As long as the future benefits of cooperation are given more weight than the one-time immediate payout for defecting, then everyone would have an incentive to cooperate. This is all possible because of the repeated interactions that the players have with each other.

Hypothesis:

I hypothesize that the anarchy treatment will be the most effective at making the CPR sustainable. This hypothesis relies on one condition: the discount factor 'delta' must be high enough for every person that the payout from defecting now is worth less now than the payout in the future for cooperating. The equation looks as follows:

$$\pi^d - \pi^* < (\pi^* - \pi^N)(\frac{\delta}{1+\delta})$$

where π^d refers to the payoff to the person from defection, π^* refers to the payoff to the person from cooperating to preserve the resource, π^N refers to the payoff to the player in the strict Nash equilibrium that serves as the punishment path after the player's defection, and δ refers to the discount factor, or how much value a player gives to payoffs in the future compared to current payoffs. δ must be a number between 0 and 1. In order for a player to be incentivized to choose the future payoffs of cooperation over the current payoff of defection, the δ must be high, which is interpreted as the player valuing future payoffs as almost equal to current payoffs. The other ways to make the above equation true are for the defecting payoff to be low, or for the difference between cooperation and the punishment path to be high.

We can assume that the defecting and cooperating payoffs remain constant across political systems. However, both the punishment path and the value for δ vary across these different systems.

Of the three systems I hypothesize that an autocratic structure will be the one where the punishment path is the strictest, because the autocrat behaves and excludes like a private owner. The democratically elected leader would also be able to credibly punish at a greater rate than the people in a horizontal structure. However, I believe that δ will be highest in the horizontal structure, under certain conditions. First, I assume that an autocratic leader causes

the people to devalue their future payoffs as the leader takes more than his or her share from the resource. While this leads to a stable outcome, the difference between the optimal structure and the structure where the leader is deviating without punishments leads to a drop in the value of the payoffs generally. Second, I assume that the instability of a horizontal structure is relatively small, when compared to the instability of a democracy. In a democracy, a new leader could potentially be elected every cycle, with a new winning coalition. I assume that the instability of this system causes people to devalue future payoffs due to uncertainty, while the lesser instability of the horizontal structure does not cause as great a devaluation. This assumption, I understand, depends almost entirely on the people of a horizontal structure all trusting each other, which is not an element that is accounted for in rational choice theory. In my experiment, then, I am testing how much people trust each other in different political systems, and whether they can trust each other at all without a central system of governance. I hypothesize that this experiment will yield positive results, and that the horizontal structure will be the most successful at conserving the common pool resource due to a high δ. I hypothesize that the lesser stability contrasted with the more credible punishment path (a lower π^N) will make the autocratic systems the second best at conserving common pool resources. Finally, as a democratic system has both instability and less credible punishment options (the government is not the sole private owner of the resource, and so cannot punish unilaterally without electoral repercussions), it will be the least capable of conserving the common pool resources.

Method:

This experimental design is in large part borrowed from Ostrom, Gardner and Walker in their book *Rules, Games and Common-Pool Resources*[3]. The difference will be in the treatments used in this experiment being different from theirs, but the method of obtaining results is the same.

I will randomly select groups of five participants from a pool of volunteers. I will then put each player in front of a computer, all in separate rooms so that no player can see or hear any other. The players will be able to communicate with each other, both privately and as a group, via digital messaging embedded in the game.

The players will be told how long each period will be, as well as at what point the resource stops replenishing (the "red line"). They will also be told of their payout if everyone cooperates, which will be some nominal amount around $3-5.

In 5 minute periods, the resource will replenish (or not) and the players will choose how much money to take out of the central pool, up to a maximum cap. Their compensation for the study will depend entirely on their winnings from the game, and they will know this, so they will be highly motivated to maximize their winnings.

After a randomly selected time between 1 hour and 50 minutes and 2 hours and 10, which the experimenter will know, but not the participants, the game will end, and each player will be given their individual winnings. Random participants will be selected to participate in a qualitative interview about their experience.

Control Group:

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[3] Ostrom, Elinor, Roy Gardner, and James Walker. *Rules, Games, and Common-Pool Resources.* University of Michigan Press, 1994.

In the control group, there is no interaction between the players during the game, even via digital communication. There is also no possibility of sanctions, meaning that it is not possible to kick a player out of the game. There is no leader selected, and there are no elections. Each player simply takes what they want each period (below the cap), and walk away with their winnings.

Treatment 1 (Democracy):

Before groups in this treatment begin their rounds, they will meet together, be explained the rules of the game, and each player will be given the chance to put forth a platform to win votes from the group. The group will then elect a leader, by simple majority. This player is able to impose taxes on the other players, but is primarily responsible with maintaining the common pool resource through credible sanctions. The president has no cap on the amount he or she can take from the central resource in a given period. The president may propose removing a player from the game for defecting, and with simple majority that proposal can be approved. A president can also propose the seizing of resources from a player suspected of stealing from the CPR.

Every six periods, or 30 minutes, an election will be held and players can vote for who they think should be the next president (players must announce their candidacy and their platform at any point in the periods preceding). The next president immediately takes office and has all the same powers as the previous president.

Treatment 2 (Autocracy):

In this group, one player will be selected as autocrat. The selection process is as follows: Each player will be randomly given a starting pool of money of a certain amount, and then each

will be asked, in their group meeting before the game, to bid on the role of leader. The highest bidder has that amount subtracted from his or her pool, and the game begins. The leader can impose taxes on the other players, as well as having no cap on how much he can take from the central resource. The player can also sanction any player he or she likes, without needing extra support. The autocrat can only do this, however, to up to three players. The autocrat cannot be removed from power.

Treatment 3 (Horizontal Structure):

In this group, the players begin in their group meeting, after having been explained the game, deciding communally on the rules that they agree to abide by, and possibly the punishments for them. The different players will be able to, by majority vote, impose "sanctions" on another player that they believe is cheating. This "sanction" can be whatever the group decides on, from taking away a couple of units away from the player and returning it to the pool, to removing the player for a couple of rounds, is to removing the player from the game and returning his or her collected "resources" to the pool. These measures require a majority vote of all players, including the player being sanctioned. The group may also change the sanctions and rules voted on in the beginning by a majority vote during the game. (This also happens *de facto* since no rule can be enforced without a majority vote during the game)

Outcome Measure:

The outcome measure in this case is twofold. One, we look at a simple binary variable of whether or not the resource has crossed the "red line", meaning that it is no longer replenishing. Second, what percentage of the common pool resource is left as a percentage of

the amount that should be left if everyone had played the game optimally, taking the most possible while still preserving the resource.

Rejection Region:

The significance level at which I will reject the null hypothesis that a governance treatment does not affect the preservation of common pool resources is P=.05, or 5%.

Limitations:

First, it must be kept in mind that this is a lab experiment, not a field experiment. There are therefore some inherent problems with external validity. For one, even though there are several iterations, playing this game over only two hours or so is not reflective of real-world situations.

I also understand that my governance models are, of necessity, very simplistic. These simpler models were adopted so that effects could be seen more clearly, and also so that the test could have the power that comes with a greater n of games. This power would have been lesser had the models required more complicated rules requiring a greater number of people to complete.

In conclusion, this experimental design will help to determine how different types of governance affect the preservation of common pool resources. Looking at three basic models of governance, democracy, autocracy, and anarchy structures, I use a simple game with simple rules to mimic the CPR problem under all of these structures and a control. By tracking how many of the groups manage to preserve their resource, or how far they let it drop if they don't succeed in preserving it, I can draw conclusions as to what type of government is most suited to

the task of preserving a CPR. Then, with the help of theory and qualitative interviews of participants, I can determine why that might be the case.

Qualifications of Thesis Committee: My faculty advisor for this thesis project will by Professor Dan Nielson. I have worked with Dr. Nielson in his research lab since last September, and I have also been in one of his classes. He is well-versed in Ostrom's work, in collective action problems in general, and experimentation in political science. It is his focus on experimentation that I believe makes him the right person to advise me on this project, since I am using a lab experiment as my method for study. He has also been supportive and encouraging as I've planned out this project and has taken a great interest in its success.

My faculty reader is Dr. Jaren Pope, from the economics department. I am currently enrolled in Dr. Pope's Price Theory course. I asked Dr. Pope to be the faculty reader on my committee because the question I am asking is just as much economic as it is political, and I wanted to have an economist to check my work alongside a political scientist. Dr. Pope specifically focuses his research on environmental and urban economics, so he is very familiar with the common pool resource problems and the environmental consequences of how that resource is allocated. His background in the economic side of conservation problems makes him a well-qualified member of my thesis committee.

My Honors Coordinator for this project is Dr. Michael Barber of the Political Science Department.

Project Timeline: I propose to begin recruiting volunteers for the experiment on August 9th. While not many students will be on campus, the idea is to get the experiments going as soon as possible so that I can work out any problems with the setup. Recruiting will begin heavily on

September 5th, the beginning of the fall semester, with the goal of finishing all the experiments we need by December 21st, the last day of fall classes. During the fall semester and the beginning of winter semester, data analysis will be run on the results of the experiments. A draft of the thesis will be available for the panel to review on January 30th. After comments and corrections, a draft will be presented to the panel on February 20th. After final corrections, the thesis will be bound and ready to present at the thesis defense in early March.

IRB Approval: IRB approval is pending.

Funding: For this project, I will require funding from the Honor's Department. The $1,000 will be needed to pay the volunteers after the game has been played. Although the games are played for relatively small amounts of cash, the scale on which the experiment is being done means that these amounts accumulate to a larger sum. This money will not go to paying for research assistants or equipment, as the experiments will be fairly simple to administer.

Culminating Experience: I hope to be able to publish my findings in a peer-reviewed journal. I would like this work to be the project that launches me from undergraduate to graduate-level studies.