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Regulation through Collaboration: Final Authority and Information Symmetry in Environmental Coasean Bargaining*

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Abstract
Many people see collaborative decision-making as the next wave in environmental regulation. This paper examines how two elements within collaborative processes—final authority over stakeholder negotiations and information symmetry through mandated information sharing of relative payoffs—affect the efficiency and the distribution of wealth. Using a Coasean bargaining experiment, we find final authority for stakeholders is critical for efficient negotiations. Efficiency drops by two-thirds given a 10% risk to the final authority given symmetric information. Efficiency declines further once asymmetric information is considered. Final authority appears to be a necessary but not sufficient condition for efficient agreements.

1. Introduction

Many observers see place-based collaboration as the next wave in environmental regulation (e.g., Sabel et al. 2000; Yaffee and Wondolleck 2000). Following the current policy push toward more decentralized environmental regulations (see Wilson 1996; Oates 2001), collaborative processes encourage local stakeholders to resolve local environmental disputes through bargaining and negotiation, rather than through litigation or by federal mandate (e.g., Crowfoot and Wondolleck 1990; Fiorino 1995; Snow 1997).

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Devolution of environmental regulation allows communities to develop and enforce consensus management plans that adopt specific place-based strategies that complement federal legislation (Renn et al. 1995). In principle, collaboration offers the potential for an efficient Coasean (1960) construction of local environmental protection.[1]

Place-based collaboration is being promoted at both the federal and state levels.[2] At the federal level, for example, Congress enacted the Alternative Dispute Resolution Act of 1990, which moved environmental protection activities away from relying strictly on the federal agencies to a balanced approach that engages local citizen groups.[3] At the state level, an illustrative example of this collaborative principle is the Western Governors Association's environmental doctrine called Enlibra (see WGA 2002). The first and second Enlibra principles are ''national standards, neighborhood solutions—assign responsibilities at the right level;'' and ''collaboration, not polarization—use collaborative processes to break down barriers and find solutions.'' The idea behind these principles is that locals understand local conditions. And rather than offering up absentee bureaucratic responses, the federal government is asked to help locals develop their own plans to meet accountable targets.

Such support has allowed collaboration to thrive. Today hundreds of collaborative groups exist ranging from informal grassroots associations to government-mandated advisory councils. Several reasons help explain why collaboration has worked to promote more effective solutions at the local level rather than traditional one-size-fits-all regulatory strategies (see, for example, Dinan et al. 1999). Collaboration reduces the risk that local net benefits will be downplayed relative to national concerns, which encourages local support for the final decision.[4] Locals included in a decision to make a local change are more likely to support or at least understand the suggested policy (see Yaffee and Wondolleck 2000). Collaboration also takes an ecosystem perspective by promoting

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1 Oates (2001, p. 24) makes a strong case for regulation at the local level: ''My own sense is that where environmental quality is basically a local public good, the case for the setting of environmental standards at an appropriately decentralized level of government is quite compelling. At the same time, one can envision an essential informational and guidance role for the central authority. With the substantial scientific and policy expertise at its disposal, a central agency can effectively provide a menu of options for standards and a choice of policy instruments. Such guidance would become an important resource for state and local officials and their constituencies in the actual design of decentralized environmental programs.''

2 A broad range of people now promote collaboration: Secretary of the Interior Gale Norton, pundits in the popular press (e.g., Blakeslee 2000; D'Alessio 1998; Mann and Plummer 1998; Page 1997; Sawhill 1998), and academics interested in the underlying structure of these groups (e.g., Bacow and Wheeler 1984; Bingham 1986; Crowfoot and Wondolleck 1990; Johnston and Krupin 1991; Melling 1995; Porter and Salvesen 1995; Bernard and Young 1997).

3 The private sector was already using negotiation, mediation, facilitation and other alternative methods to resolve disputes in the environmental arena. Congress saw this collaboration as having ''yielded decisions that are faster, less expensive, and less contentious'' than existing dispute resolution procedures such as litigation (Public Law 101–552, section 2).

4 While winners could hypothetically compensate losers in this scenario (see Kaldor 1940), this prospect often is not attractive at the local level. In fact, local groups have an incentive to organize and compete for a transfer of wealth from other groups to themselves (i.e., engage in rent-seeking activities), which can explain why local groups became discouraged with traditional decision-making procedures.

cooperation across fence lines of private landowners. Collaboration signals respect for indigenous and anecdotal knowledge that exists in the people most familiar with specific environmental problems, and promotes information sharing between people who might not necessarily trust each other's motives (see, for example, Fischer 1995).

But while one can hope for efficiency gains, collaborative decision-making is still only as effective as the protocol that defines the negotiation process and implementation of any consensus decision. If bargaining is costly due to missed opportunities or transaction outlays, then identifying the protocol that can produce more environmental protection at less expense makes sense. In the debate over collaboration, people struggle over the cost consequences of two elements of protocol—final authority and information symmetry. Experts believe local collaboration can be more effective when a bargaining protocol grants final authority to the local stakeholders and corrects for information asymmetries within the group (see, for example, Crowfoot and Wondolleck 1990). A collaborative process is efficient and fair, so the argument goes, if local stakeholders believe their agreement sets public policy, provided they negotiate from a position of symmetric information within the group. The open question is how crucial final authority and information symmetries are to effective regulation through collaboration.

Whether final authority matters depends on whom you ask. Many experts believe it is a necessary condition for collaboration. Otherwise, they contend that stakeholders will take their negotiations lightly if they think their recommendations are simply advisory rather than binding. One prominent supporter of final authority is former EPA Administrator William Ruckelshaus (1997), who stressed, ''it is best if the relevant governmental authority signals in unambiguous terms ... that what comes out of the [collaborative] process will likely prevail as public policy.''[5] An amendment added by U.S. Senate Majority Leader Tom Daschle to recent legislation suggests that some prominent political figures recognize the importance of final authority in a local agreement. The amendment gives final authority through force of law to a consensus agreement struck between the U.S. Forest Service, the logging industry, and two major environmental groups to allow thinning in the Black Hills National Forest. Daschle's amendment maintains final authority for the agreement by shielding it from any future appeal or legal challenge (see Margolis 2002).

Others disagree. While noting that collaboration makes sense in theory, they believe that final authority does not. Michael McCloskey, former executive director and chairman of the Sierra Club, makes the point vividly: delegating final authority ''would effect a massive transfer of power, a repudiation of the progress of the past century, a collapse in environmental gains, and a grievous wound to the practice of democracy'' (Marston 2000).[6] They fear deep-pocket industries will dominate locals in negotiations, leading to

5 The Western Governors Association's Enlibra principles also stress the role of final authority for local decision makers: people want strong local leadership and collaborative efforts that give locals control over how to enhance the environment and promote commercial productivity.

6 An illustrative example on final authority is the Quincy Library Group's forest management plan. The Quincy Library Group was a local collaborative group in northern California who asked for final authority for their five-year forest-management experiment developed by their coalition. They sought support for their plan on the national political arena after the Forest Service failed to adopt key aspects of

watered-down agreements that are binding.[7] While an inverse relationship should exist between the riskiness of final authority and the efficiency of collaboration, the open question is just how much risk must exist to reduce efficiency significantly.

The debate over the role of information symmetries between stakeholders is somewhat less contentious, but still important for cost-effective collaboration. Information asymmetries arise from many sources, usually caused by a breakdown in evenness between parties in bargaining relationships (Carpenter and Kennedy 1988; Raiffa 1982). Sources of information asymmetry include lack of knowledge about relative payoffs (or opportunity costs), the workings of the natural system, external funding, negotiating experience, and outside options (see Fisher et al. 1991). While some optimists believe all stakeholders will share their private information in a consensus setting, such sharing is by no means the rule, especially if some stakeholders enter the process with a basic mistrust of the other side. A collaborator who mistrusts his partners initially may not be as open and receptive to new ideas, and may not share resources and burdens.[8] Information withheld can inhibit bargaining, which reduces the overall effectiveness of collaboration. Stakeholders need to change their behavior of holding private information close to them. A goal of a collaborative process is therefore to create a bargaining protocol that promotes information sharing—the exchange of data between stakeholders on a common management issue. Information sharing can enhance symmetry in bargaining relationships by creating a common information set about the payoff structure for the collaborative group, thereby balancing the power among stakeholders (see Wondolleck and Yaffee 2000). The open question we address is the size of the efficiency gains created by an information-sharing protocol that creates symmetric knowledge about the payoffs to each party in the collaborative group.

This paper uses the lab to address how final authority protocol and information symmetry protocol affect the economic efficiency of Coasean-style collaboration. We also consider how the protocol affects the distribution of wealth between stakeholders. We

their plan (Davis and King 2000). The forests in their plan were the Plumas, Lassen and Tahoe National Forests in northeastern California. Despite the efforts of national environmental groups like the Wilderness Society, the Quincy group eventually was successful. Congress passed (by a 429–1 vote) and President Clinton signed their plan into law in 1998; and since then they have received nearly $25 million in federal funds to help implement their plan. The Herger-Feinstein Quincy Library Group Forest Recovery Act was signed into law in 1998 and authorizes a five-year pilot project mandating the U.S. Forest Service to manage the Plumas, Lassen and Tahoe National Forests under the plan developed by the Quincy Library Group.

7 Decisions produced through collaborative channels must still offer and meet the requisite government-dictated procedural opportunities. For the current paper the question of local versus global efficiency, in which people set policy that is locally efficient but imposes costs on non-locals who would otherwise benefit from environmental protection, is beyond the scope of our analysis. We presume the local outcome is also globally efficient.

8 Beierle (2000, p. 23) offers that mistrust may actually play an important and positive role in forming appropriate consensus decisions: ''Mistrust among stakeholders and between stakeholders and government may uncover questionable science and bad ideas. Building trust may require tapping into independent sources of expertise or generating new knowledge. All of these suggest that the 'political' features of these more intensive stakeholder processes may create a positive synergy with the quality of its outcomes.'' Efficiency aspects of mistrust should be considered in any collaborative process.

design a Coasean bargaining experiment to ''testbed'' how alternative collaborative protocol affects behavior (see, for example, Hoffman and Spitzer 1982; Shogren 1992; 1998; Ishikda et al. 2000).[9] Continuing the trend in the regulation literature to use the lab to test certain facets of regulatory design before actual implementation (see, for example, Plott 1981; Smith 1981; Rassenti et al. 1994), Coasean experiments are well suited to examine how alternative protocol affects bargaining behavior, which can complement the more traditional case study approach (e.g., Yaffee and Wondolleck 2000). While providing insight into why some processes work and others do not, the case study approach lacks a uniform evaluation procedure to compare alternative protocol (see Crowfoot and Wondolleck 1990). This poses a challenge for the decision-maker who must select an effective collaborative process for a particular environmental management dispute (Manring et al. 1990). In contrast, our controlled evaluation through laboratory experiments provides the control to estimate the efficiency of existing and new collaborative processes (see Rhoads and Shogren 2001).

Providing final authority and information symmetry among stakeholders requires a commitment of resources. Clear information about the efficiency impacts of these protocol choices can aid in generating more efficient collaborative processes.[10] While we expect that more risk will reduce bargaining efficiency, our results suggest that bargaining efficiency is sensitive to the presence of final decision-making authority and to the information symmetries among stakeholders. Adding a small risk of losing final authority from a collaborative group significantly reduces their bargaining efficiency in the lab—a 10% risk of losing final authority caused efficiency to decrease by nearly seventy percent. Information asymmetries among stakeholders further reduced bargaining efficiency, even when stakeholders had complete final authority. We conclude that while final authority is a

9 Economists use laboratory experiments as a ''testbed'' for economic design—the construction of new institutions and mechanisms designed for efficient resource allocation and cost-effective rules for regulation of markets and firms. The most prominent example is the use of the lab to test pilot the efficiency of the proposed FCC spectrum auctions (see, for example, Plott 1994, 1997), to compare alternative policy options, to explore how friction affects efficiency and the distribution of wealth, and to consider how institutional power can transform patterns of behavior. A testbed carbon emission trading system designed in laboratory markets can evaluate the institutional factors that will influence the effectiveness of carbon trading. Experiments can be designed to consider how flexibility in trading, imperfect information, multi-gas trading, links between domestic and international trading, and other factors affect the potential efficiency of trading (e.g., Bohm and Carlén 1999). Experimental work could prove useful in understanding what elements of emissions trading would reduce the efficiency of climate change policies. The ultimate success of testbedding different protocol rests in the open question of external validity—is the behavior in the lab a reliable guide to behavior in the real world? Experimental economists believe so, albeit within reasonable limits. Lab results represent real evidence about how certain people will behave in a given economic environment. Additional real-world complexity can then be added into the lab environment in a controlled fashion to identify likely conditions that might cause a protocol to fail in the wilds.

10 Guidelines for practitioners to follow when implementing a collaborative process are readily available. These studies are often case-specific, and differ in content and emphasis (see Crowfoot and Wondolleck 1990; Porter and Salvesen 1995; Keystone Center 1996; Bernard and Young 1997; Wondolleck and Yaffee 2000).

necessary condition for efficient agreements, it is not a sufficient condition. We now turn to the details of our experimental design.

2. Experimental Design

We explain the design of our testbed experiment, and how it captures the applied collaborative bargaining setting. Linking the design to the applied setting is critical at each step. Our foundation for modeling the collaborative process both recognizes participants' efforts to form consensus decisions and incorporates costs of bargaining. Practitioners consistently document these two unique features when describing successful collaborative bargaining frameworks in the field. Under our lab conditions, we can control final authority and information symmetry and measure their impact on efficiency and distribution. We first discuss the general design of the experiment, and then describe the precise controls on final authority and information symmetry.

2.1. General Design

Three players—A, B and C—negotiate over the chances, or lottery tickets—p_A, p_B and p_C — to win a \$10.00 prize.[11] Subjects negotiate over lottery tickets and not the prize so we can more easily control for their heterogeneous utilities and risk preferences. A collaborative bargaining setting includes stakeholders—such as regulators, developers, environmentalists, and property owners—that come from diverse backgrounds (Porter and Salvesen 1995). Financial and political backing can vary among stakeholders, which makes it necessary to control for risk preferences influenced by perceived relative fiscal and political standing. The binary lottery game we use in this experiment provides the mechanism that allows utility to be exactly equal to the probability of winning the \$10.00 prize for each agent (see Roth and Malouf 1979). For each bargaining round, the maximum number of lottery tickets that could be distributed was 100; the minimum number was 70.

Each bargain involved a number contract and transfer contract. In each round, the number contract specifies the initial chances of winning the large, non-shrinking reward, $Z = \$10.00$, requiring the bargaining trio to select one of six numbers from the lottery schedule (see table 1). After a number contract is determined, players can use a transfer contract to redistribute lottery tickets. For example, if a bargaining trio agree to select number contract #5 from Lottery Schedule 1 in table 1, player A has 5 lottery tickets, $p_A = 0.05$; player B has 25 lottery tickets, $p_B = 0.25$; and player C has 40 lottery tickets, $p_C = 0.40$. The house has 30 lottery tickets, $p_H = 1 - p_A - p_B - p_C = 0.30$. If the players then agree to a transfer contract that stipulates player C giving 20 lottery tickets to player A, player A and player B now both have a 25% chance to win the \$10.00 prize and player C now has a 20% chance to win the \$10.00 prize. This design mimics the setting typically

11 Most Coasean bargaining experiments involve agreements between two players or two groups (see, for example, Hoffman and Spitzer 1982; Shogren 1998). Our three-player Coasean bargaining experiment moves closer to actual field collaboration that involves many stakeholders. Future work could explore the robustness of the results with even more bargainers.

Table 1. Lottery Ticket Distribution Schedules

Lottery Ticket Distribution Schedule #1

Number	A's Lottery Tickets (%)	B's Lottery Tickets (%)	C's Lottery Tickets (%)
1	0	0	70
2	25	15	30
3	40	55	5
4	0	70	0
5	5	25	40
6	70	0	0

Lottery Ticket Distribution Schedule #2

Number	A's Lottery Tickets (%)	B's Lottery Tickets (%)	C's Lottery Tickets (%)
1	0	70	0
2	30	30	10
3	70	0	0
4	0	0	70
5	50	5	45
6	35	10	25

Lottery Ticket Distribution Schedule #3

Number	A's Lottery Tickets (%)	B's Lottery Tickets (%)	C's Lottery Tickets (%)
1	5	35	60
2	40	20	10
3	0	0	70
4	0	70	0
5	20	25	25
6	70	0	0

Lottery Ticket Distribution Schedule #4

Number	A's Lottery Tickets (%)	B's Lottery Tickets (%)	C's Lottery Tickets (%)
1	70	0	0
2	0	70	0
3	20	35	15
4	25	15	30
5	55	5	40
6	0	0	70

found in a collaborative bargaining framework—stakeholders negotiate to redistribute assets and specify the expected gains for each of the members in the group. While the possibility exists that stakeholders could restructure the relative distribution of assets among parties external to the negotiation, we abstract away from this possibility.

We use the final negotiated distribution of lottery tickets as a check on the rationality of our bargainers. This rationality check helps us assess whether our testbed experiment creates a stylized lab environment that does not hinder subjects' incentives to make rational decisions. We use the Nash bargaining model of the final distribution of lottery tickets as our rationality benchmark (see the Appendix for the formal model).

Many environmental disputes occur over the use of private property (e.g., habitat for endangered species protection). Practitioners make it a point to include these property owners as stakeholders in collaborative processes (Porter and Salvesen 1995). We therefore assume at least one of our three stakeholders holds property rights over the assets in question. We capture this idea by assigning unilateral property rights over the lottery schedule to one player in the bargaining group, called the controller, before the negotiation session begins. Prior to each bargaining round, players took a ''Trivia Quiz'' to determine who earned the right to be the controller of their bargaining group for only that round. The quiz had ten multiple choice questions that ask questions about a variety of trivia topics such as history, geography, sports and wildlife. Moral authority can be attached to the notion of the controller's property right over the lottery schedule if capturing that right involves some degree of skill in a game.[12] In practice, the stakeholder with the highest education or skill level does not always hold property rights over the assets in question. Property rights, however, do carry a moral authority derived from the legal privileges granted by them. It is this authority that we want to reproduce in the laboratory.

Many practitioners emphasize that stakeholder participation in a collaborative bargaining process should be voluntary. This is a key difference with the traditional regulatory procedure that compels advocacy groups to meet with legislators, agency administrators, or judges to generate solutions to environmental disputes.[13] While we do not provide a voluntary participation mechanism for the two non-controller subjects, we do proxy voluntary participation for the controller in each bargaining session. At any time during the 10-minute bargaining round, the controller can unilaterally terminate the round by selecting a number contract that would be perfectly enforced; no transfer was permitted. We call this the controller's right. By providing the controller the opportunity to exit the bargaining session at any time without losing rights to what she owns, the controller is at all times a voluntary participant in the bargaining session.

The outside option for the controller, p^0, is defined as the maximum number of lottery tickets the controller can capture for herself if she exercises the controller's right; in all bargains, the outside option is 70 tickets. Both the final prize to be won based on the

12 Establishing moral authority in lab bargaining remains an open challenge. We debriefed the subjects participating in our experiments. While some subjects thought the trivia quiz was ''unfair,'' most controllers ''believed'' they earned the right to have unilateral property rights over the Lottery Schedule because they did better than the other two subjects in their bargaining group. See Hoffman and Spitzer (1986) and Shogren (1998) on issues of induced property rights.

13 Dixit and Olson (2000) explore voluntary participation in the Coase Theorem. Based on a public goods model, they suggest the claims of universal efficiency in the Coase Theorem may be overstated if people have an option about participation or not. Herein we presume the interested parties have agreed to participate, and that the controller can choose to participate in the bargain voluntarily or he can opt out by exercising his outside option. The impact of voluntary participation of all key stakeholders could redefine the non-cooperative threat points, and remains an open research question.

distribution of lottery tickets and the controller's outside option remained constant throughout each bargaining session. If time expired before an agreement was reached, the controller was required to exercise her controller's right.

The experimental design combines the consensus structure of the 3-person Coasean bargaining experiment of Rhoads and Shogren (2001) with the delay cost treatments in Shogren (1998) to reflect the fundamental aspects of the collaborative process. In the next sections, we define the precise specifications of the consensus and delay cost features.

2.2. Consensus

Many experts argue that consensus decision making is crucial for effective collaboration to resolve environmental disputes (see, for example, Wondolleck and Yaffee 2000). Explicit coalitions between a few stakeholders are usually prohibited. In our testbed experiment, consensus was required of the collaborative group to form a negotiated agreement. Formal 2-person coalitions were prohibited.[14] The subjects were given the following instructions:

> A consensus outcome is achieved when all three players in your bargaining group reach an agreement. . . If the three players cannot reach a consensus agreement before the end of the 10-minute bargaining session the controller shall exercise her controller's right.

In practice, collaborative groups that cannot form consensus on one issue typically move on to another issue in a multi-issue management plan. They then return to the sticking point issue later. This suggests the endogenous nature of the composition and ordering of the decision making agenda can effect efficiency and distribution. Our testbed design abstracts away from the multi-issue process, and therefore does not provide an opportunity to measure this impact since only one agreement is made per bargaining round.

2.3. Discrete Delay Costs

The bargaining costs that stakeholders face in a collaborative framework cannot be ignored. These costs are real resource outlays like travel expenses, and reflect the opportunity cost of stakeholders' time. Following Shogren (1998), we capture these bargaining costs in the experimental design by using discrete delay costs: a constant cost for each minute of bargaining is assessed to each subject. Before each bargaining round, each player was given a non-transferable endowment, $M = \$2.00$. For each minute of bargaining, a cost, $C = \$0.20$, was assessed to each player in the bargaining group, reflecting the real commitment of resources required by each participant in the bargaining process. Note all offers were written on offer sheets. No verbal communication was permitted. The structure of the discrete delay costs is shown in the following table.

For example, no costs were assessed for the first 59 seconds of bargaining. Suppose a

14 While coalition formation is not a feature expressly encouraged in practice, coalitions are sometimes used in situations when groups agree to be represented by one person within the collaborative setting. Each member of the coalition can thus contribute to the representative's decision-making process (see Crowfoot and Wondolleck 1990).

Bargaining Time Elapsed (minutes)	Total Delay Cost for Each Player	Endowment Remaining for Each Player
0:00–0:59	$0.00	$2.00
1:00–1:59	$0.20	$1.80
2:00–2:59	$0.40	$1.60
3:00–3:59	$0.60	$1.40
4:00–4:59	$0.80	$1.20
5:00–5:59	$1.00	$1.00
6:00–6:59	$1.20	$0.80
7:00–7:59	$1.40	$0.60
8:00–8:59	$1.60	$0.40
9:00–9:59	$1.80	$0.20
10:00	$2.00	$0.00

bargaining group agreed to distribute all 100 lottery tickets after 4 minutes and 30 seconds had elapsed, each player would pay $0.80 in delay costs, leaving each with a $1.20 endowment. The winner of the lottery would then add $10.00 to his remaining $1.20 endowment. With a 10-minute time limit on a bargaining session, the initial endowment dropped to zero if time expired.

2.4. Key Protocol Issues: Final Authority and Information Symmetry

We now describe how our experimental design captured the two key elements of collaboration protocol. We test sensitivity of bargaining behavior to three levels of final authority and two levels of information symmetry to create a 2×3 experimental matrix, yielding six experimental treatments (see table 2). Two identical sessions of each treatment were performed, with nine subjects in each session.

Final authority. The three levels of final authority were defined as when the transfer contract was enforced with 100, 90, or 25% probability (see Shogren and Kask 1992). Here the number contract represents available regulatory options, and the risky transfer contract represents negotiated agreements that require outside regulatory approval before implementation. If the transfer contract is upheld, final authority holds. The agreed distribution of lottery tickets then holds, and each player receives the number of lottery tickets stated in the negotiated agreement. But if the transfer contract does not hold, final authority is lost. Now each player receives the number of lottery tickets stipulated in the original number contract selected. If final authority does not hold the

Table 2. Treatment Conditions and Number of Groups in Each Treatment

	Balanced Power	Unbalanced Power
100% enforcement of final authority	24	24
90% enforcement of final authority	24	24
25% enforcement of final authority	24	21

players might not receive the same number of lottery tickets that they agreed upon in the negotiation.

We anticipate that increases in the risk of upholding the transfer contracts will reduce efficiency—more risk should induce the controller to take her outside option. The 90% enforcement level is intended to elicit bargainers' sensitivity to a relatively small—and almost negligible in practical terms—decrease in the possibility of their agreement being upheld. The question is how will bargainers react to this relatively low risk of losing final authority as compared to the high-risk case of 50% enforcement. The 25% enforcement level allows a check on the rationality of the controller. A rational controller should never bargain in this case—she should always take her outside option at time zero since it exceeds the expected value of any negotiated agreement.[15]

Information symmetry. Experts in collaboration like Crowfoot and Wondolleck (1990) note that equal access to information for all stakeholders is a fundamental requirement to resolve environmental disputes. We test this by including two levels of knowledge about the payoffs of the other stakeholders—information symmetry and asymmetry. In the information symmetry treatment, each bargainer knew with perfect certainty the payoffs of each member in the collaborative trio. In the information asymmetry treatment, two bargainers knew their own payoff with complete certainty, but only knew with 50:50 odds the payoffs to the other players at the start of the bargaining session. The third player had complete information about the payoffs of all members.

Table 3 provides an example of an information asymmetry treatment. Player A knows the payoffs for each player with complete certainty—the two payoff schedules listed for both player B and C are identical. Players B and C each know their own payoffs with complete certainty. These two players (B and C) also have two different payoff schedules for the other two players (either A and C, or A and B). One payoff schedule is the actual payoff schedule; the other is not. The odds are 50:50 that the first payoff schedule is the actual schedule. Through the course of bargaining, players B and C can learn which player types he or she is bargaining with through negotiation.

2.5. Procedures

108 undergraduate and graduate students from the University of Wyoming participated in the experiment. Each subject was inexperienced in face-to-face Coasean bargaining. Crowfoot and Wondolleck (1990) stress that face-to-face group interaction is one of three key elements of environmental dispute resolution. Understanding face-to-face bargaining in the experimental lab is a useful exercise since many of the negotiations in the

15 To see this, assume the controller is player C and uses lottery ticket distribution schedule #3 in table 1. She would get 70 lottery tickets (a 70% chance of winning the large prize) if she exercised her controller's right and selected number 3. If she negotiated an agreement that redistributed 30 lottery tickets from player B to player C in number 1, she would get 90 lottery tickets in the agreement, but only expect to have a 67.5% chance of winning the large prize $(67.5 = (60 \times 0.75) + (90 \times 0.25))$ because of the relatively large probability that the transfer contract will not be upheld.

Table 3. Example of Unbalanced Power in Lottery Ticket Distribution Schedule #1

Lottery Ticket Distribution Schedule #1-A

Number	A's Lottery Tickets (%)		B's Lottery Tickets (%)		C's Lottery Tickets (%)	
1	0		0	0	70	70
2	25		15	15	30	30
3	40		55	55	5	5
4	0		70	70	0	0
5	5		25	25	40	40
6	70		0	0	0	0

Lottery Ticket Distribution Schedule #1-B

Number	A's Lottery Tickets (%)		B's Lottery Tickets (%)		C's Lottery Tickets (%)	
1	0	15	0		70	30
2	25	40	15		30	35
3	40	0	55		5	0
4	0	15	70		0	15
5	5	20	25		40	30
6	70	50	0		0	20

Lottery Ticket Distribution Schedule #1-C

Number	A's Lottery Tickets (%)		B's Lottery Tickets (%)		C's Lottery Tickets (%)	
1	0	15	0	5	70	
2	25	40	15	20	30	
3	40	0	55	35	5	
4	0	15	70	85	0	
5	5	20	25	15	40	
6	70	50	0	20	0	

environmental arena are face-to-face in nature.[16] As subjects entered the lab, each was randomly assigned an identification number to cycle them through the rounds and given an identical set of experimental instructions.[17] A monitor read aloud the instructions and answered all questions to ensure comprehension. Twelve total sessions were conducted. In each session, three groups of three bargainers were seated at a table along with a monitor. The monitor administered the ''Trivia Quiz'' to each bargaining trio as they sat together and assisted in determining their scores.

Each subject participated in four bargaining rounds and had two new bargaining partners in each group.[18] A subject never bargained with another subject more than one

16 Roth (1995) discusses face-to-face versus anonymous bargaining in the experimental lab. Also see Shogren (1998).

17 Actual instructions are available from the authors on request.

18 In one of the sessions for the imbalanced power and 25% enforcement of the transfer contract treatment, the nine subjects each only participated in three bargaining rounds.

time, which eliminated reputation effects. Recall all offers were written, and any offer was first directed through the monitor to ensure validity before being presented to the other members in the bargaining trio. Within each bargaining round, the sequencing of offers and counter-offers was endogenous. An offer that was accepted by the two players not making that offer ended the bargaining round. The time was recorded and delay costs were calculated. The winner was determined by a random draw. The process was repeated three more times, so each subject participated in four bargaining rounds. One treatment was examined during each session.

3. Results: Distribution of Wealth

We first examine our bargainer's level of rationality relative to earlier Coasean bargaining experiments by considering how they choose to distribute wealth between the controller and non-controllers. While theory suggests a rational controller in a Coasean bargain should capture at least the expected wealth provided by the outside option, a predominant behavioral pattern observed in previous Coasean bargaining experiments is captured by the notion of constrained self-interest (see, for example, Kahneman et al. 1986; Shogren 1998). Constrained self-interest implies a controller's payoff is a weighted average of pure self-interest and equal splits on the expected reward. Since we can make reasonable predictions of controller behavior in this bargaining environment, we focus on the distribution of wealth of the controller from three perspectives: (1) constrained self-interest; (2) a random effects model of the distribution of lottery tickets, controlling for round and subject effects; and (3) how controller experience in the bargaining environment affects her capture of lottery tickets. Consider each perspective in turn.

First, constrained self-interest is defined as a weighted combination of pure self-interest and equal splits of expected wealth, $\kappa = (p^0 - \gamma)u(3\mathrm{M} + \mathrm{Z} - 3c)/[p^0 u(\mathrm{M} + \mathrm{Z}) - \gamma u(3\mathrm{M} + \mathrm{Z} - 3c)]$, where $\gamma = [1/3 - (p_{\mathrm{H}}/3)]$. We use constrained self-interest as a useful performance measure to interpret our conditional panel model (equation (1) below). The controller demonstrates pure self-interest and receives at least her outside option when $\kappa \geq 1$; the controller shows constrained self-interest if $0 < \kappa < 1$; $\kappa < 0$ indicates that the controller receives less lottery tickets than at least one of the two non-controllers; $\kappa = 0$ suggests an equal split (e.g., fairness).[19]

Second, we estimate a random effects model for the distribution of lottery tickets. This model examines treatment and controller effects on the distribution of lottery tickets, while controlling for subject and round effects. We also include interactive effects to understand the joint impact of controller effects, information symmetry and authority. The model is estimated as

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19 Because this experiment involves three people dividing 100 lottery tickets, which cannot be divided three ways into an equal integer, equality is defined as a (34, 33, 33) split when all of the lottery tickets are distributed. Equal splits can also be seen in cases when the subjects do not distribute all of the lottery tickets. For example, a (30, 30, 30) split of the lottery tickets is considered equitable when subjects leave 10 lottery tickets for the house.

$$\mathrm{DIV}_{jk} = \alpha_j + \lambda_k + \sum_i \beta_i Z_{ijk} + u_{jk}, \tag{1}$$

where DIV_{jk} measures the divergence in actual captured lottery tickets from the predicted Nash bargaining solution to subject j in each round k. We refer the reader to our Nash bargaining model in the Appendix that establishes a benchmark against which we score the behavior of our subjects. Let Z_{ijk} be the explanatory variables that incorporate all the possible combinations of interactive effects for the dummy variables CONT, SYM, ρ_{90} and ρ_{25}. CONT is a dummy that takes a value of 1 if subject j is the controller in a negotiation, SYM is a dummy variable that takes a value of 1 for symmetric information, and ρ_{90} and ρ_{25} are dummies taking a value of 1 for 90% and 25% final authority.[20] The Nash bargaining model captures the information advantage of the controller or the non-controller. The predicted number of lottery tickets for each subject is adjusted for controller and information advantage, so the information advantage is incorporated in the model and appears as the coefficient of the variable SYM. Negative estimates for the coefficients of the explanatory variables are consistent with a movement away from pure self-interest and towards constrained self-interest or altruism. With symmetric information among the players, the Nash bargaining solution predicts that the controller receive 80 of the 100 lottery tickets. For example, if the controller (player 1) receives 75 lottery tickets in a negotiation, $\mathrm{DIV}_1 = -5$. α_j and λ_k are unobserved subject and round effects, β_i are coefficients and u_{jk} is an error term. Errors, however, are expected to be heterogeneous because the variances of DIV_{jk} are likely to be unequal. Therefore, standard errors of estimated β_i coefficients are corrected for heteroskedasticity using the method proposed by White (1980).

Third, we estimate an ordinary least squares equation to reflect learning through participation in prior rounds. This model examines controller and round effects on the distribution of lottery tickets, and is estimated as

$$\mathrm{DIV}_j = \alpha + \beta_1 \sum_j \mathrm{CONT}_j + \beta_2 \sum_j \mathrm{TWO}_j + \beta_3 \sum_j \mathrm{THREE}_j + \beta_4 \sum_j \mathrm{FOUR}_j + u_j, \tag{2}$$

where DIV_j measures the divergence in actual captured lottery tickets from the predicted Nash bargaining solution to subject j in each round. $CONT_j$ is a dummy that takes a value of 1 if subject j is the controller in a negotiation. Three round dummies are given—TWO, THREE and FOUR take a value of 1 if the observation is in the second, third or fourth

20 Time-to-agreement may have interesting implications on the distribution of lottery tickets given heterogeneous risk preferences. For example, we note that time-to-agreement is unexpectedly higher in the 25% enforcement case relative to the 100% enforcement case. While this is consistent with constrained self-interested behavior on the part of the controller, it raises the question of how risk preferences for non-controllers should be modeled. Since our model does not allow us to perform a test with heterogeneous risk preferences we do not include a time-to-agreement variable in the current analysis. But it does point out a research question worthy of future consideration since it is likely that lengthier negotiations can favor a risk-loving stakeholder over a risk-averse stakeholder.

round. The variances of DIV_j are likely to be unequal and standard errors of estimated β_i coefficients are corrected for heteroskedasticity.

Using these three performance measures, we now summarize our results on the observed distribution of wealth.

Result 1: *Overall, constrained self-interest best organizes the behavior in our Coasean bargains. With risky final authority, information asymmetry drives the controller to more self-interest, whereas information symmetry leads to less self-interested distributions. The controller gives up 25 lottery tickets beyond what the benchmark Nash solution predicts. Experience with the bargaining environment does not move subjects closer to the benchmark Nash solution. Overall, the results suggest the behavior of the controllers in these experiments was not arbitrary, but rather was consistent with the notion of constrained self-interest that has been the observed behavior in other Coasean bargaining treatments.*

Table 4 presents the descriptive statistics summarizing the unconditional effects. Constrained self-interest dominates the bargaining sessions—nearly 64% (90 of 141) of all bargains are best organized by the notion that people balance self-interest with fairness. Selten's (1991) measure of predictive success, *m*, tells a similar story.[21] Table 5 shows constrained self-interest *m* ranged from 24.3 to 49.3%; pure self-interest *m* ranged from -23.4 to 14.1%; and other distributions of *m* ranged from -21.7 to -38.3%. Constrained self-interested bargains had the highest predicted success in all the asymmetric information treatments.

Table 6 presents the estimated coefficients of the random effects model in equation (1). The coefficient for the controller, CONT, is significant and suggests that the marginal effect of becoming a controller is to receive 25 lottery tickets below the predicted amount from our benchmark Nash bargaining solution. Again, constrained self-interest appears to dominate negotiation behavior. With 100% and 90% final authority, we reject the notion that controller self-interest was independent of the symmetric information. For instance, in the 90% final authority case, compare the coefficient of $CONT\rho_{90}$ (-25.208) to that of $CONTSYM\rho_{90}$ (45.646). Information symmetry among players significantly impacted the distribution of lottery tickets by altering the degree of self-interest observed in the controller.

We also find that final authority affects the self-interest of the controller. With guaranteed final authority, asymmetric information dampens the controller's pure self-interest. Evidence of this impact on behavior is found by comparing the coefficient of CONT (-25.938) to CONTSYM (-16.187) in table 6. Asymmetric information also promotes a movement away from controller self-interest with risky final authority—compare the coefficient of $CONT\rho_{90}$ (-25.208) to $CONTSYM\rho_{90}$ (45.646). People were

21 Selten's measure is $m = hr - ar$, where *hr* is the relative hit-rate of a theory—the number of observations according to the theory divided by the total number of observations, and *ar* is the area of the theory divided by the total area. Note that *hr* is a gross rate of predictive success, while *m* is a net rate of success.

Table 4. Summary Statistics of Experimental Results

Information Asymmetry	N	Efficiency R Mean	Efficiency R S.D.	Efficiency Γ Mean	Efficiency Γ S.D.	Distribution of Wealth # of 100% prob.	Pure S-I	Constr S-I	Other	Time to agreement (minutes) Mean	S.D.	Range Max.	Range Min.	# within 1st min.
None														
100% Final authority	24	0.57	0.51	0.67	0.48	16	10	13	1	0.54	0.83	2	0	16
90% Final authority	24	0.19	0.49	0.56	0.50	13	1	19	4	2.04	1.65	6	0	5
25% Final authority	24	0.04	0.46	0.25	0.44	6	6	15	3	1.33	1.69	5	0	11
Subtotal	72	0.27	0.53	0.49	0.50	35	17	47	8	1.31	1.55	6	0	32
Partial														
100% Final authority	24	0.01	0.61	0.50	0.51	12	2	17	5	2.96	2.26	9	0	3
90% Final authority	24	0.00	0.44	0.25	0.44	6	9	13	2	1.50	2.13	9	0	11
25% Final authority	21	−0.31	0.50	0.10	0.30	2	6	13	2	2.81	2.87	10	0	7
Subtotal	69	−0.09	0.54	0.29	0.46	20	17	43	9	2.41	2.48	10	0	21
Grand total	141	0.09	0.56	0.39	0.49	55	34	90	17	1.84	2.12	10	0	53

Table 5. Distribution of Wealth and Selten's Measure of Predictive Success

Information Asymmetry	Wealth Distribution	*N*	Hit Rate (#)	Hit Rate[a] (%)	Area[b] (%)	Predicted Success (%)
None						
100%	Pure S-I*	24	10	41.7	27.6	14.1
Final	Constrained S-I	24	13	54.2	29.9	24.3
Authority	Other	24	1	4.2	42.5	−38.3
90%	Pure S-I	24	1	4.2	27.6	−23.4
Final	Constrained S-I	24	19	79.2	29.9	49.3
Authority	Other	24	4	16.7	42.5	−25.8
25%	Pure S-I	24	6	25.0	27.6	−2.6
Final	Constrained S-I	24	15	62.5	29.9	32.6
Authority	Other	24	3	12.5	42.5	−30.0
Partial						
100%	Pure S-I	24	2	8.3	27.6	−19.3
Final	Constrained S-I	24	17	70.8	29.9	40.9
Authority	Other	24	5	20.8	42.5	−21.7
90%	Pure S-I	24	9	37.5	27.6	9.9
Final	Constrained S-I	24	13	54.2	29.9	24.3
Authority	Other	24	2	8.3	42.5	−34.2
25%	Pure S-I	21	6	28.6	27.6	1.0
Final	Constrained S-I	21	13	61.9	29.9	32.0
Authority	Other	21	2	9.5	42.5	−33.0

Notes. [a] Relative hit-rate: number of theorized observations divided by the total number of observations;
[b] Relative area: theorized area of the theory divided by the total area;
*S-I: Self-interest.

less likely to act as rational self-interested controllers when final authority was at risk and they had private information. While Croson (1996) and Straub and Murnighan (1995) found players making offers in ultimatum games were more self-interested when information asymmetries persist, our design allows information symmetries to emerge with more offers. The results in table 6 suggest that mandating information sharing in some regulatory contexts could alter the behavior of stakeholders—particularly property owners—and the current distribution of wealth, depending on the degree of final authority that is present. Regulators should note this behavior when pursuing a particular form of information sharing.

Table 7 presents the estimated coefficients for the least squares model testing the distributional impacts of experience (equation (2)). The significant coefficient for the controller indicates a player gives up almost 36 lottery tickets as a controller in a negotiated agreement, consistent with the estimate from the random effects model in table 6. Round-specific variation does not differ significantly from zero at conventional levels. These results suggest that experience, as measured by participation in more rounds, did not affect the captured lottery tickets. While bargaining behavior can become more distinct

Table 6. Estimated Coefficients for Random Effects Distribution Model: Divergence of Actual Tickets From Prediction

Variable	Coefficient
Constant	5.801*
	(1.558)
CONT	− 25.938*
	(3.779)
SYM	3.729
	(3.085)
ρ_{90}	7.292*
	(3.085)
ρ_{25}	0.104
	(3.085)
CONTSYM	− 16.187*
	(5.344)
CONTρ_{90}	− 25.208*
	(5.344)
CONTρ_{25}	− 14.062*
	(5.344)
SYMρ_{90}	− 16.604*
	(4.363)
SYMρ_{25}	− 7.120
	(4.441)
CONTSYMρ_{90}	45.646*
	(7.557)
CONTSYMρ_{25}	22.973*
	(7.691)
N	423
R^2	0.585

Notes. *indicates statistically significant at the 2% level. Standard errors are in parentheses.

and move towards the predicted equilibrium prediction as players gain experience from participation in more rounds, experience alone is not always a reliable basis for achieving perfect equilibrium.[22]

4. Results: Efficiency

Based on the distribution of wealth results, we conclude that our bargainers behaved similarly to most people in past Coasean bargaining experiments—controllers typically did not exploit the full power of the outside option or surrender to equal splits of expected

22 Learning and the role of experience in a bargaining setting can be both game- and context-dependent (see Roth 1995, pp. 288–292) and remains an active research topic.

Table 7. Estimated Coefficients for Ordinary Least Squares Distribution Model with Experience

Variable	Coefficient
Constant	5.801*
	(1.558)
CONT	− 35.738*
	(1.816)
TWO	− 0.741
	(2.045)
THREE	0.278
	(2.168)
FOUR	0.354
	(2.157)
N	423
F-statistic	120.16

Notes. *indicates statistically significant at the 1% level. Standard errors are in parentheses.

wealth. Knowing our subjects behave within the standard Coasean bargains norms, we now focus on the efficiency impacts given final authority and information asymmetries. Following Shogren (1998), define reward efficiency as

$$R = \frac{(p_A + p_B + p_C)(Z - 3c) - p^0(Z)}{(1 - p_A^0)(Z)}, \tag{3}$$

R is interpreted as the actual expected gain as a percentage of the potential gain due to bargaining. As a comparative benchmark, reward efficiency is maximized when $p_H = 0$ and $c = 0$, such that $R = 1$. This occurs if the bargaining trio comes to a consensus agreement that distributes all 100 lottery tickets within the first minute of bargaining.[23]

We summarize our main efficiency results as follows.

Result 2: *As expected, efficiency is the greatest when collaborative groups have guaranteed final decision-making authority and information is symmetric among subjects.*

23 We also consider probability efficiency, $\Gamma = \{[p_A + p_B + p_C] - p_A^0\}/(1 - p_A^0)$, which captures the extent to which subjects ignore delay costs and instead focus on maximizing the joint probability of winning the reward. Probability efficiency measures whether bargainers focus simply on the distribution of the available lottery tickets rather than considering both probabilities and rewards. If subjects ignore probabilities and instead focus on the delay costs, protocol can be designed to enhance efficiency of the collaborative decision-making process. For example, if the subjects distribute all 100 lottery tickets among themselves, $\Gamma = 1$. Alternatively, if the controller exercises the controller's right, $\Gamma = 0$. Many bargaining groups are able to achieve $\Gamma = 1$, an indication that these bargaining groups captured all available lottery tickets.

Unexpectedly, on average, efficiency drops by two-thirds once we introduce a 10% probability that the final decision will be rejected, even with information symmetry. Mean efficiency levels drop by about another 75% when the chance of rejection increases to 75%, again with symmetric information. But while guaranteed final authority is necessary for high efficiency, it is not sufficient. Information asymmetries caused large efficiency losses, even with full final authority. Insecure final authority only serves to deepen the efficiency losses from asymmetric information.

Consider the supporting evidence of the unconditional results. Table 4 shows that consensus is most efficient when the group has both final authority and information symmetry, as one should expect (mean $R = 0.57$). The general Coasean bargaining literature supports this finding—reward efficiency is relatively high when no economic impediments exist (see, for example, Prudencio 1982; Hoffman and Spitzer 1982).[24] Reward efficiency falls significantly, however, once final authority is no longer guaranteed, keeping symmetric information. Mean efficiency falls to $R = 0.19$ for a 90% chance of keeping final authority, and $R = 0.04$ for the 25% case. While a large efficiency decline was expected for the 25% case, such a steep drop in efficiency from the 100% to 90% final authority was not. This substantial decline in efficiency for a relatively low threat to final authority suggests that bargainers were not exempt from the behavioral notion of a certainty effect (see Roth 1995; Camerer 1995). The certainty effect says people are unduly attracted to a certain outcome relative to a highly likely but uncertain outcome.

This unconditional analysis of reward efficiency is supported by our conditional analysis. We estimate a Tobit model to test whether the differences in reward efficiency were due to the level of final authority, the presence of symmetric information, or round and subject effects.[25] We use a Tobit model because reward efficiency is bounded below by -1.4 and above by 1.0. Ordinary least squares estimates would thus be biased. The model we estimate is

$$R = \beta_0 + \xi_{90}\rho_{90} + \xi_{25}\rho_{25} + \psi_j \mathrm{SYM} + \sum_{k=2}^{4}\gamma_k r_k + \sum_{l=2}^{6}\omega_{1l}A_{1l} + \sum_{l=1}^{6}\omega_{2l}A_{2l} + \sum_{l=1}^{6}\omega_{3l}A_{3l} + \sum_{l=1}^{6}\omega_{4l}A_{4l} + \sum_{l=1}^{6}\omega_{5l}A_{5l} + \sum_{l=1}^{6}\omega_{6l}A_{6l}, \tag{4}$$

where ρ_{90} and ρ_{25} are dummies taking a value of 1 for 90% and 25% final authority, SYM is a dummy variable that takes a value of 1 for symmetric information, r_k are the $k-1$ rounds, and A_{zk} are the $(N-1)$ A players—a group that includes controllers and non-

24 Regarding probability efficiency, the results from table 4 show that mean probability efficiency for all rounds for all treatments was 0.39, ranging from 0.10 to 0.67.

25 We do not estimate a random effects model for reward efficiency because OLS estimates are biased and it is expected that subject effects will primarily influence a player's accumulation of lottery tickets and not group efficiency.

Table 8. Estimated Coefficients of Tobit Reward Efficiency Model

Variable	Coefficient
Constant	0.161*
	(0.095)
ρ_{90}	– 0.257**
	(0.117)
ρ_{25}	– 0.501***
	(0.119)
SYM	0.424***
	(0.096)
N	141
Log *L*	– 123.15

Notes. *, ** and *** indicate statistically significant at the 10%, 5% and 1% level. Standard errors are in parentheses.

controllers—from the six treatments, $z = 1, 2, 3, 4, 5$, or 6. Subject effects are most likely to influence the distribution of lottery tickets for individual players and have a dampened effect on the reward efficiency level for the group. Dummy variables for the $(N - 1)$ A players serve as a proxy for subject effects.

Focusing on the restricted model,[26] table 8 shows again that reward efficiency is significantly greater with symmetric information and final authority. Overall, we find that removing final decision-making authority from collaborative groups significantly decreased efficiency. A 10% risk that a negotiated agreement will not be upheld results in a significant drop in reward efficiency—on average, efficiency dropped by two-thirds, even with information symmetry. As the collaborative group had any risk of losing final decision-making authority, efficiency fell. They were sensitive to the risk to their management plans. In our lab setting, we find secure final authority is necessary for efficient collaboration. The results suggest that a decision to not allow final authority in the collaborative process should be motivated by strong evidence suggesting the costs associated with granting final authority would be excessive. Eliminating information asymmetries can significantly increase efficiency.

5. Conclusions

Conflicts over collaboration as regulation continue to persist. Experts see two elements of consensus-based environmental protection as crucial for effective regulatory outcomes: final authority, such that a collaborative agreement is binding; and information symmetry,

26 The restriction that reward efficiency was independent of both round and player, $\gamma_{Round2} = \gamma_{Round3} = \cdots = \omega_{12} = \omega_{13} = \cdots = \omega_{66} = 0$, was not rejected at the 5% level ($\chi^2 = 42.78$).

in which bargainers create a common information pool about player payoffs. But in many environmental disputes, federal and state agencies are reluctant to surrender final authority to a local group, witness the Quincy Library case; and many private landowners have little incentive to share information about their payoffs with others they perceive as threatening their way of life. Our results are consistent with the experts—we find final authority and information symmetry are necessary conditions for efficient Coasean bargaining agreements at the local level. When final authority is taken away—even by a small amount, mean levels of efficiency are cut by two-thirds, which drops even further with asymmetric information. Our bargainers responded very negatively to small levels of risk. This suggests that regulators promoting collaboration without final authority or symmetric information might need a rationalization other than bargaining efficiency to justify their choice of protocol.

Our results suggest final authority is a necessary but not a sufficient condition for efficiency, which suggests that regulation through collaboration might not be a panacea for efficiency. Creating a regulatory environment in which stakeholders are encouraged to share private information may not lead to efficiency gains if final authority is not present. And it is this final authority that drives our efficiency results. Symmetric information agreements with final authority increased efficiency in the lab; but symmetric information without final authority fell considerably short. If the policy objective is to make the negotiated agreement more efficient, a regulator's challenge will increase the larger a natural resource management plan is since final authority will be less likely to be granted.

We have used the lab to testbed two key elements of bargaining protocol for regulation through collaboration in the environmental arena. More lessons can be learned in the lab about how the collaborative decision-making process can impact efficiency in policy arenas besides natural resource management. From air traffic management and educational planning to health care provision, collaborative decision-making is used more and more to resolve conflict and develop management plans without regard to the types of regulations and problems being examined. Just like in auctions and market design, future research could use the laboratory to dissect and examine the incentive properties and efficiency outcomes of the collaborative processes proposed in these different arenas.

Appendix

We establish a benchmark against which we score the rational behavior of our participants. We use a Nash bargaining model configured to our experimental design. Suppose player A is the controller and players B and C are the non-controllers. All are risk-neutral bargainers. Let **M** be a vector of the initial endowment for each player, \$2.00, for each bargaining round. Symmetric delay costs are the same for each subject in a bargaining group and are defined as c. Finally, allow $\rho \in (0, 1]$ to be the probability the transfer contract holds with $\rho = 1$ indicating guaranteed final authority; and $(1-\rho)$ being the probability the transfer contract does not hold implying risky final authority.[27]

Let p_A be the negotiated probability the controller wins Z (i.e., the number of lottery tickets determined through negotiation). Now let $\omega \in [0, 1]$ and $(1-\omega)$ be defined as the probabilities that A is a type 1 or a type 2 player while $\bar{p}_{A1}$ and $\bar{p}_{A2}$ are the pre-transfer probabilities that A will win Z if a type 1 or a type 2 player. Then $\bar{p}_A = [\omega\bar{p}_{A1} + (1-\omega)\bar{p}_{A2}]$ is the pre-transfer probability the controller wins the large reward, Z. Define $\hat{p}_A \in [0, 1]$ and $(1-\hat{p}_A)$ as the probabilities the controller wins the large or small reward, $Z > \mathbf{M} > z = 0$, given the enforcement level of the transfer contract. Finally, $\hat{p}_A = \rho p_A + (1-\rho)\bar{p}_A$. Normalizing utility such that $u(Z + \mathbf{M} - c) = 1$ and $u(z + \mathbf{M} - c) = 0$, player A's expected utility from a negotiated agreement is $E_{u_A} = \hat{p}_A u(Z + \mathbf{M} - c) + (1-\hat{p}_A)u(z + \mathbf{M} - c) = \hat{p}_A$. Define p_A^0 as the probability the controller wins Z provided she exercises her controller's right. If the controller exercises the controller's right, expected utility is $Eu^{c-0} = p_A^0 u(Z + \mathbf{M} - c)$.

Let p_B and p_C be the negotiated probabilities the non-controllers win Z, either player B or C. Define γ, $(1-\gamma)$ and δ, $(1-\delta)$ as the probabilities that B and C are type 1 or type 2 players. Define $\bar{p}_{B1}, \bar{p}_{B2}$ and $\bar{p}_{C1}, \bar{p}_{C2}$ as the pre-transfer probabilities that B and C wins Z if a type 1 or type 2 player. This gives $\bar{p}_B = [\gamma\bar{p}_{B1} + (1-\gamma)\bar{p}_{B2}]$ and $\bar{p}_C = [\gamma\bar{p}_{C1} + (1-\gamma)\bar{p}_{C2}]$ as the pre-transfer probabilities the non-controllers win Z. Now define $\hat{p}_B, \hat{p}_C \in [0, 1]$ and $(1-\hat{p}_B), (1-\hat{p}_C)$ as the adjusted probabilities that B and C win the large or small reward. Then $\hat{p}_B = \rho p_B + (1-\rho)\bar{p}_B$ and $\hat{p}_C = \rho p_C + (1-\rho)\bar{p}_C$. Again normalize utility so that $u(Z + \mathbf{M} - c) = 1$ and $u(z + \mathbf{M} - c) = 0$. The measures of expected utility for B and C from a negotiated agreement are $Eu_B = \hat{p}_B u(Z + \mathbf{M} - c) + (1-\hat{p}_B)u(z + \mathbf{M} - c) = \hat{p}_B$ and $Eu_C = \hat{p}_C u(Z + \mathbf{M} - c) + (1-\hat{p}_C)u(z + \mathbf{M} - c) = \hat{p}_C$. Finally, let $p_H = 1 - p_A - p_B - p_C$. If the controller exercises the controller's right, players B and C have an outside option of zero lottery tickets. In this case, the measures of expected utility for B and C are $Eu_B^{nc-0} = (1 - p_A^0 - p_H - \hat{p}_C)u(z + \mathbf{M} - c)$ and $Eu_C^{nc-0} = (1 - p_A^0 - p_H - \hat{p}_B)u(z + \mathbf{M} - c)$.

Bargainers are given information regarding each other's outside option in the case of information symmetry.[28] Now examine the case of perfect contract enforcement and asymmetric information. All subjects have an incentive to revise their information set to find the one lottery number that distributes all 100 lottery tickets. Because the pre-transfer number of lottery tickets does not enter the bargainer's decision set in the case of perfect contract enforcement, the outside option for each bargainer is the only information that is required to determine the distribution of lottery tickets. It follows that the pre-transfer number of lottery tickets does not become a part of the Nash bargaining solution; bargainers are only concerned with the negotiated agreement.

Alternatively, imperfect contract enforcement does not provide strong incentives for bargainers to revise their information set in the same manner as in the perfect contract

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27 The case of $\rho = 0$ is a special case and is not considered here. Without enforcement of a transfer contract, rational players will not negotiate a transfer of lottery tickets among themselves. The only negotiation that can occur is to decide the lottery number to select.

28 Rhoads and Shogren (2001) examine this case under perfect contract enforcement.

enforcement case. Therefore, bargainers have no incentive to fully reveal private payoff information in cases of imperfect contract enforcement since this information does not generate higher private expected payoffs. The pre-transfer number of lottery tickets becomes a part of the Nash bargaining solution.

The Nash bargaining problem for the collaborative decision-making process in the benchmark bargaining game is

$$\max_{p_A, p_B, p_C, p_H} [(Eu_A - Eu^{c-0})(Eu_B - Eu_B^{nc-0})(Eu_C - Eu_C^{nc-0})]. \tag{A1}$$

The solution to the maximization problem (5) yields

$$p_A = \frac{1 + (2p_A^0/\rho) - p_H}{3} - \frac{1-\rho}{3\rho}\{2[\omega\bar{p}_{A1} + (1-\omega)\bar{p}_{A2}] - [\gamma\bar{p}_{B1} + (1-\gamma)\bar{p}_{B2}] - [\delta\bar{p}_{C1} + (1-\delta)\bar{p}_{C2}]\}, \tag{A2}$$

$$p_B = \frac{1 - (p_A^0/\rho) - p_H}{3} - \frac{1-\rho}{3\rho}\{2[\gamma\bar{p}_{B1} + (1-\gamma)\bar{p}_{B2}] - [\omega\bar{p}_{A1} + (1-\omega)\bar{p}_{A2}] - [\delta\bar{p}_{C1} + (1-\delta)\bar{p}_{C2}]\}, \tag{A3}$$

$$p_C = \frac{1 - (p_A^0/\rho) - p_H}{3} - \frac{1-\rho}{3\rho}\{2[\delta\bar{p}_{C1} + (1-\delta)\bar{p}_{C2}] - [\omega\bar{p}_{A1} + (1-\omega)\bar{p}_{A2}] - [\gamma\bar{p}_{B1} + (1-\gamma)\bar{p}_{B2}]\}, \tag{A4}$$

where equation (A1) is maximized when all 100 lottery tickets are distributed, $p_H = 0$. Equations (A2)–(A4) indicate the lottery tickets each subject should get in negotiations. The first term in each equation shows the distribution of lottery tickets if the transfer contract is upheld with complete certainty ($p_A = 0.8$, $p_B = 0.1$, and $p_C = 0.1$). The second term adjusts the tickets acquired due to asymmetric information and risky final authority. This term is the expected value of the pre-transfer number of lottery tickets for the one lottery number that distributes all 100 lottery tickets for each player in the collaborative group. Given our experimental design, the second term equals zero with perfect contract enforcement, $\rho = 1$.

For example, using the lottery ticket distribution schedule in table 3 and focusing on distribution number 3 with 100 lottery tickets, if $\rho = 0.90$ and symmetric information, the Nash bargaining solution is $p_A = 0.844$, $p_B = 0.050$, and $p_C = 0.106$. Relative to the guaranteed final authority/information symmetry case [$p_A = 0.8$, $p_B = 0.1$, and $p_C = 0.1$], the controller (A) now receives 84.4 tickets and player C gets 10.6 tickets—this reflects a premium paid to A given the relatively small number of pre-transfer tickets in the lottery schedule. In contrast, player B receives 5 tickets—a penalty relative to the original distribution in the lottery schedule because of the relatively high pre-transfer number of lottery tickets.[29]

Now let information asymmetries exist such that $\omega = 1$ and $\gamma = \delta = 0.50$. Given $\rho = 0.90$, the Nash bargaining solution is $p_A = 0.844$, $p_B = 0.042$, and $p_C = 0.094$.[30] Note the slight penalty to players B and C—the number of tickets they receive in the Nash bargaining solution relative to player A drops given asymmetric information.

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29 Subjects did not have the option of receiving fractions of a lottery ticket.

30 Probabilities do not sum to unity given how we constructed the lottery schedule with asymmetric information.

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