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Unequal Information, Unequal Allocation: Bargaining field experiments in NE Brazil☆

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ABSTRACT

We assess how unequal information affects the bargaining within resource allocation, a stakeholder interaction that is critical for climate adaptation within the water sector. Motivated by water allocation among unequal actors in NE Brazil, within Ceará State, we employ 'ultimatum' field experiments in which one participant lacks information. We find that, despite having veto power, the less informed are vulnerable to inequity. When all are informed, we see a typical resource split (60% initiator–40% responder) that balances an initiator's advantage with a responder's willingness to punish greed. When instead responders have only a resource forecast upon which to base decisions, the fully informed initiators get 80% of resources for conditions of resource scarcity. Thus, despite each of the stakeholder types having an unquestioned 'seat at the table', information asymmetries make bargaining outcomes more unequal. Our results are widely relevant for adaptation involving the joint use of information, and suggest that equity can rise with dissemination of scientific outputs that are integral in adaptation.

1. Introduction

Assessments of adaptive capacity, in this instance meaning the ability to reduce vulnerability to shifts in climate, often suggest value from providing the output from scientific studies of climate for both private and public decision making (Hilton, 1981; Glantz, 1982; Rayner et al., 2005). Public decisions also are claimed, quite generally, to improve through

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participatory processes in which stakeholders inform decisions that affect them (Uphoff, 1992; Agrawal and Gupta, 2005; Peterson et al., 2010 reviews and challenges non-critical promotion of participatory approaches).

An integrated assessment of the impacts of climate shocks – allowing for management response – could combine natural-science analyses of climate with social-science analyses of participation. One might assume this would show double gain from new climate forecasts for participatory use. Yet integrated assessments may yield different conclusions if these touted interventions interact, for instance if the impact of the participation depends on the details of the information provided.

Here, we examine whether the outcomes of bargaining depend on who has relevant information. Even if every stakeholder is at the bargaining table – as much participation as often is hoped for – equity outcomes could vary with the distribution of access to and understanding of information. Even a perfect forecast could yield inequities, as who has that information could be asymmetric (see Barrett, 1998; Lemos and Dilling, 2007; Lemos and Rood, 2010). This is a practical challenge since information inequalities are widely documented (Broad et al., 2002 has relevant examples) and, given forecasting advances, scientific information is being promoted as an aid to decisions. We test for impacts upon resource-bargaining outcomes of asymmetries in resource information, using behavioral experiments that are motivated by ethnographic observations (e.g. Taddei, 2005) of water-management stakeholders and institutions within the State of Ceará in Northeast Brazil.

Our experiments are based on the study of this state's case (Section 2, Broad et al., 2007), which others also have studied extensively (e.g. Lemos et al., 2002; Nelson and Finan, 2007). Water is allocated given low and highly variable rain[2] plus rural–urban differences which affect efficiency and equity. Our new experimental design not only addresses particular features of this case study (e.g. Taddei, 2008, 2011, 2012) but also is relevant for other settings of resource bargaining.

We emphasize asymmetric information, observed to be a key issue for communication and use of technical output (e.g. Lemos and Oliveira, 2004; Lemos, 2008; Bell et al., 2011; Engle et al., 2011). The groups affected by water allocation – distinguishable by geography (upstream/downstream), income, sector (agriculture, industry, tourism), and more – clearly differ in terms of access to and understanding of climate information. For instance, agencies and industries in this state's capital produce and use information about water demands, current water supplies and expected rainfall that either is inaccessible or is not easily understood by most of the people in the state's interior.

Looking across many semi-arid regions, for all of which any information about rainfall is critical, access to relevant climate information often is unevenly distributed across the affected groups. Past research finds broadly that many lack access to or full understanding of climate information, e.g. advances in climate forecasts tend to be distributed on the internet and in forms understood only by those with technical backgrounds (see Pfaff et al., 1999; Washington and Downing, 1999; Letson et al., 2001; Kestin, 2002; Wolde-Georgis, 2002; Roncoli et al., 2009; Orlove et al., 2011). Further, such uneven access and understanding may well affect outcomes of resource bargaining; globally, information about the resources to be shared is known to be critical for the allocations determined through various participatory processes (see Ostrom, 1990 and many who followed).

There is good reason to study hypotheses about resource allocation using bargaining experiments where participants earn based on decisions made in settings reflecting actual allocation tensions:as is often the case, potential institutions we consider do not yet exist in Ceará; for other settings, such institutions at times exist yet often cannot be manipulated for learning's sake (Smith, 1994). Here, there are few or no empirical alternatives for our precise study of asymmetric information.

Use of laboratory and field experiments to study environment and resources settings is not new.[3] Concerning water, experiments explore upstream–downstream links in watersheds and irrigation (Cardenas et al., 2008a,b, 2009; Janssen et al., 2008; D'Exelle et al., 2009; Jack, 2009) and specific water-market institutions (e.g. Murphy et al., 2000; Dinar et al., 2000; Cristi, 2007; Alevy et al., 2009). Yet none of these explores the impact of asymmetries in relevant information (reviews in Cardenas and Carpenter, 2005; Levitt and List, 2007; Ostrom, 2010 convey that we are adding also to development and natural-resources work on policy and institutional designs).[4]

Our results reveal strategic use by one actor of private information, plus the public knowledge of the other actor's forecast information, to attain a high resource share when resources are scarce. When all are fully informed, we see a typical 60–40% initiator–responder split of the resources, one widely held to reflect the initiator's advantage plus responders' willingness to punish greed. With asymmetry, when the informed know that water is scarce they get almost 80% of resources. In a general, widely applicable way, this suggests that information dissemination affects equity.

The paper proceeds as follows: Section 2 sketches the water sector in Ceará, Section 3 describes our design, and Section 4 discusses results. Section 5 concludes, including with more links to our field setting.

2. Water in Ceará State, Northeast Brazil

Ceará, in Brazil's relatively populated yet relatively undeveloped semi-arid Northeast Region, has about 8.6 million

[2] Seasonal-to-interannual fluctuations (associated with ENSO (El Nino, La Nina)) in rain in Ceará are large enough for analysts to propose, e.g. the use of forecasts for adjusting reservoir releases (Sankarasubramanian et al., 2003).

[3] Experiments include work on enforcement and compliance (Cason et al., 2003; Stranlund et al., submitted for publication; Murphy and Stranlund, 2006, 2007, 2008) and climate change (Saijo et al., 2009; Gowdy, 2009). Reviews include Sturm and Weimann (2006) and Normann and Ricciuti (2009).

[4] And per asymmetric information, our design and information conditions extend prior work (see Mitzkewitz and Nagel, 1993; Rapoport and Sundali, 1996; Kagel et al., 1996; Straub and Murnighan, 1995; Croson, 1996).

Table 1 – Subject characteristics.

	Age	Female	Education[a]	% owning computer	#
Fortaleza	22	0.61	15	0.74	506
Limoeiro	24	0.56	13	0.24	458
Region frame	30	0.60	14	0.40	120
Water frame	24	0.54	14	0.54	116
Total	25	0.58	14	0.48	1200

[a] These data result from eliminating the outliers (i.e. apparent mistakes, such as >21) in the values for education. We asked about years of formal education. According to the Brazilian system the interpretation would be that: 4 completes elementary school; 8 completes middle school; 11 indicated finishing high school or a technical education, 16 completes undergraduate college education, and 18 completes graduate education.

inhabitants (IBGE, 2010). Its GDP has grown a lot in the last 20 years, though average agricultural productivity remained low, so the fraction of GDP from agriculture dropped from 30% in the 1950s to 6%. Industry and services in the capital city of Fortaleza are now responsible for over 85% of state GDP. Yet the fraction of the population dependent upon agriculture remains above 30% and even after a decade of growth over half the rural population is still considered to be 'poor' and the rate of rural illiteracy is still quite high (31%, IBGE, 2010).

The recurrence of droughts has long been a factor in the economy, ecology, culture and politics (see Girão, 1986; Prado, 1989; Parente, 2000, 2002; Neves, 2002; Magalhães, 2002). Persistent poverty, rudimentary agriculture practices and drought create ongoing vulnerability. Past actions to reduce vulnerability focused on reservoirs, canals and irrigation. The reservoirs are central to rural life and they also supply Fortaleza, home to another third of the population.

In 1992, Ceará's state law 11.996 created a system for management of water resources, calling for planning to be integrated, decentralized and participative. Management was to include the licensing of and charges for water but that has been little enforced. A partial decentralization of water management was effected (Taddei, 2011) and major institutional transformations included the creation of COGERH (the Company for Management of Water Resources in Ceará) and the rising importance of FUNCEME's (Meteorological and Water Resources Research Foundation) forecasts of upcoming rainfall within the planning for agriculture, water, health and drought.

After the 1986 elections, political changes with implications for the state water system occurred at both the national and state levels. In a local reflection of national debates, revenue generation, efficiency of use, and tariffs became more prominent (Lemos and Oliveira, 2004; Taddei, 2005) while by the late 1990s new participatory processes were enshrined within "water committees", one for each sub-basin of the Jaguaribe River and one for each of the other river basins. These groups select water-release rates for reservoirs, from a set of scenarios prepared by COGERH. Within Brazil, the push toward local water governance has been hailed in terms of democracy (Garjulli et al., 2002; Johnsson and Kemper, 2005) yet a growing literature, for Brazil and other sites, indicates mixed results (Abers and Keck, 2006, 2007; Lemos and Oliveira, 2004; Gutiérrez, 2006b; Kemper et al., 2005; Cooke and Kothari, 2001; Kothari, 2001; Mohan, 2001). Rigorous tests of impacts of participation or decentralization are rare (Bardhan, 2000).

Our experiment is motivated by allocation in the Jaguaribe-Metropolitana system. The Jaguaribe River is the source of water for over 45 municipalities including all the most important economic centers within the Jaguaribe Valley, which occupies about half the state and is home to over half of the state's interior population. Its occupants range from rainfed farmers to large agribusiness. The system is dominated by reservoirs and pumping run by COGERH. Water demands include: human consumption in Fortaleza and small valley towns; growing agribusiness; small farmers; riverbed farmers; and poor fishermen who require specific reservoir levels (Taddei et al., 2004).

Our design is inspired most by the newest and largest reservoir, Castanhão, soon to be linked to the capital city by a large new Integration Canal. That implies new transfer decisions – although no official allocation process has been given, despite obvious tradeoffs between the canal's ends. We note that, to date, bargaining about water has been dominated by the stakeholders' locations, for instance communities upstream of reservoirs have tended to disagree with those downstream. Unequal access to information also has been noted as a significant obstacle for full participation (see Bell et al., 2011; Engle et al., 2011; Lemos, 2008; Lemos and Oliveira, 2004; Taddei, 2011).

3. Experimental design

Our experiments are 'ultimatum' bargaining games (UG), to which we have added asymmetric information. UG feature specific, unequal roles with no clear property rights (Güth et al., 1982; Guth, 1995): a proposer asks for a specific resource quantity; then a responder accepts, or rejects. Rejection is a way to impose a cost on a proposer. It comes at a cost, as each actor gets nothing. This structure gives neither actor a right of control, i.e. no right to impose a resource allocation.

To increase our results' local relevance (Harrison and List, 2004), experiments were in the field in a setting of uncertain rainfall, uneven information, and highly consequential water allocation. As Levitt and List (2009, p. 2) state: "Field experiments provide a bridge between laboratory and naturally-occurring data in that they represent a mixture of control and realism usually not achieved in the lab or with uncontrolled data". Relevant populations are an important issue.

Experiments were conducted in the capital city of Fortaleza and the city of Limoeiro do Norte within the Jaguaribe Valley. A total of 1200 people participated. Unframed experiments had 506 participants in Fortaleza and 458 in Limoeiro and used

Table 2 – Experimental design.

Treatment	Proposer knows:	Responder knows:	No frame # Obs[a]	Water frame # Obs[a]	Region frame # Obs[a]
Quantity low, both know	6 chips	6 chips	79	30	30
Quantity low, forecast low	6 chips	70% on 6 30% on 10	71	–	–
Quantity low, forecast neutral	6 chips	50% on 6 50% on 10	70	28	30
Quantity low, forecast high	6 chips	30% on 6 70% on 10	26	–	–
Quantity high, forecast low	10 chips	70% on 6 30% on 10	27	–	–
Quantity high, forecast neutral	10 chips	50% on 6 50% on 10	64	–	–
Quantity high, forecast high	10 chips	30% on 6 70% on 10	72	–	–
Quantity high, both know	10 chips	10 chips	73	–	–

[a] An observation is a pair of individuals playing. Thus, water frame has 58 here but 116 in Table 1.

generic language about 'resource units'.[5] Framed experiments using language about 'water' had 116 participants and framed experiments across cities in which we highlighted 'region' had 120 participants. In the latter, the proposers were in Fortaleza, with the responders in Limoeiro. Neither location nor framing affected results.

Our subjects were mainly college students from local families with a mix of university staff, officers from public institutions and, in Limoeiro, farmers. In Limoeiro, most are part-time students from families whose main income is from farming within the local irrigation projects. Recruitment was through local contacts who advertised for any person older than 18 years old (Table 1).

In each game, for each pair, proposers requested a number of chips, from a bag of chips that is to be divided if agreement is reached. A bag has either 6 or 10 chips. In our benchmark treatment, proposers and responders are certain about the number of chips. The rest of our treatments have asymmetric information: proposers are certain of resource quantity (6 or 10); while responders are not, possessing only a forecast of the resource quantity that is to be divided. Thus, responders are uncertain about the resources that they would obtain if they accept any given proposal and we emphasize uncertainty is common knowledge, i.e. proposers know that responders do not know. Specifically, the proposers always know exactly which forecast was provided to the responders. Table 2 summarizes our different treatments and the number of observations we have in each.[6]

For our precise shifts in information conditions, i.e. in forecast uncertainty per resource quantity, it would be difficult to measure individuals' actual uncertainty through interviews, or in surveys. That constraint on other field approaches to these issues supports our use of experiments, yet an issue for experiments is whether participants grasp and respond to the elements that we focus on (even if so, different participants will perceive and frame a situation differently, just as in life). For our focus, what is critical is that the participants understand the information asymmetry and consciously consider the tradeoffs they face – whatever basis they use for making final choices. Our interviews and short survey with the participants, after experiments, suggest that is the case; e.g. proposers understood the asymmetry and thought about whether to exploit that advantage.[7]

[5] Croson (2005) gives reasons to prefer decision making experiments without specific context. If this reduces variance from reactions to a specific context, that raises the likelihood of revealing statistically significance across treatments.

[6] All details are readily available from the authors on request.

4. Results

Table 3 columns A and B report, for all observations, average requests from two points of view: proposer (column A), who knows the true quantity; and responder (column B), who other than in the top and bottom rows knows only an expectation of that quantity. Note average requests vary across the two columns, e.g. they are higher in column B in the uncertain-quantity low scenarios. The reason is that with low quantity (i.e. 6) proposers can ask for more than 6, e.g. can ask for 7. In that case, the proposers know they would earn 6 but the responders consider this as a request for 7; in the eyes of the responder, the quantity might actually be 10 so a proposer can receive 7. Column C reports acceptance fraction while columns D and E repeat A and B for all accepted offers. Columns C and D determine the returns each player gets, as rejection eliminates a return for any player while the accepted splits in D convey how the returns that remain in the game are divided. Thus, as noted in the table, F and G are computed from C and D ($F = C \times D$ and $G = C \times [1 - D]$). Since column C uses the actual quantity, F and G are correctly calculated using the actual gains.

4.1. *Ultimatum benchmark (all actors fully informed)*

In a benchmark, the field population that increases our local relevance behaved as have others.[8] Thus, there is no reason to

[7] Translating a few relevant quotes: "When I learned the bag had 6 chips, I asked for 5, so he would think the total was 10"; "I chose 8 so that he would think there were 10 in the bag and would accept"; and "I asked for all 6 in the bag so the other participant would think there were 10 in the bag"; and emphasizing some motivations behind such ploys, "...(I did that) because I knew how many tokens were there and I wanted to end up with all of them!!".

[8] Camerer (2003) reports mean offers of 30–40% with modal and median offers of 40–50%. Offers of 40–50% rarely are rejected while offers below 20% are rejected half of the time. Offers of 0–10% and 51–100% are rare. Further evidence is reviewed in Oosterbeek et al. (2004), which reports an average offer of 40% and 16% rejections. This in part represents proposers' strategic avoidance of rejection, although (lower) positive offers are common in dictator games, in which the responders have no veto (Forsythe et al., 1994). The larger offers in ultimatum games thus are attributed to both fairness and strategy. The results across our treatments indicate strategy's importance.

Table 3 – Unframed experiments.

	Treatment	A	B	C	D	E	F = C × D	G = C × (1 − D) [also = C − F]
		Average request/ quantity (all obs)	Average request/ expected (all obs)	Accepted fraction (all obs)	Accepted request/ quantity	Accepted request/ expected	Proposer return/ quantity (all obs)	Responder return/ quantity (all obs)
1	Quantity low, both know	3.72/6.0 = 62%	3.72/6.0 = 62%	0.95	3.65/6.0 = 61%	3.65/6.0 = 61%	3.47/6.0 = 58%	37%
2	Quantity low, forecast low	4.54/6.0 = 76%***	4.71/7.2 = 65%	0.89*	4.44/6.0 = 74%***	4.60/7.2 = 64%	3.94/6.0 = 66%**	23%***
3	Quantity low, forecast neutral	4.77/6.0 = 79%***	4.84/8.0 = 60%	0.91	4.73/6.0 = 79%***	4.80/8.0 = 60%	4.33/6.0 = 72%***	19%***
4	Quantity low, forecast high	4.73/6.0 = 79%***	4.88/8.8 = 55%**	0.96	4.68/6.0 = 78%***	4.84/8.8 = 55%**	4.50/6.0 = 75%***	21%***
5	Quantity high, forecast low	6.15/10 = 61%	6.15/7.2 = 85%***	0.74***	5.7/10 = 57%**	5.7/7.2 = 79%***	4.22/10 = 42%***	32%
6	Quantity high, forecast neutral	6.00/10 = 60%	6.05/8.0 = 75%***	0.83**	5.62/10 = 56%**	5.62/8.0 = 70%***	4.66/10 = 46%**	36%
7	Quantity high, forecast high	5.85/10 = 58%	5.84/8.8 = 66%***	0.97	5.77/10 = 58%	5.77/8.8 = 65%**	5.61/10 = 56%	41%
8	Quantity high, both know	6.05/10 = 60%	6.05/10 = 60%	0.94	5.98/10 = 60%	5.98/10 = 60%	5.66/10 = 56%	38%

In each column, we conducted t tests for equality of means (or proportions in C), comparing each treatment to its 'baseline' (low both know for low rows and high both know for high rows). Middle rows (low/high and high/low) have fewer observations and we did a Wilcoxon rank sum test (or Mann–Whitney two sample statistic test).
* Significance at the 10% level for all of these tests.
** Significance at the 5% level for all of these tests.
*** Significance at the 1% level for all of these tests.

consider these results as idiosyncratic based on this field population. In Table 3 benchmarks (top row (1) and bottom (8)), both players know the resource quantity. Proposer share on average is 62% for low quantity and 60% for high, much as in prior research, though acceptance is in the upper ranges versus typical reports (95% for low and 94% for high).

4.2. *Proposer gain from responder ignorance of resource scarcity*

When proposers know that quantity is low but responders are uncertain (as in Table 3, rows 2–4), some fairness preferences manifest themselves: responders reject greedier requests more often; while other proposers make the fairest requests that one could expect, for half of the resources.[9] On the other hand, just as in real life, the players not surprisingly employ quite varied strategies. With low quantity, some ask for more than 6 to deceptively signal that quantity is high, i.e. is 10; responders can be fooled and acceptances show that such high requests sometimes go over well.[10] On average, with uncertain responders, proposers no longer suggest 60–40% splits of resources but instead exploit private information (see Table 3 significant differences across treatments).[11]

Our core result is that proposers offer roughly 60–40% splits of a responder's *expected quantity* when the actual quantity is low. For a responder, this looks like a typical fully informed split.[12] With neutral forecasts, e.g. responders expect 8 and for low quantity requests are 4.8, 60% of 8. Since quantity actually is low, i.e. equals 6, this implies that proposers get 80% of the resources.

This approach by proposers can be seen in column B of Table 3. There, the amounts requested rise with the weight upon the high-quantity outcome within the forecast given to the responders however, with small variation, the rising requests (rows 1–4) remain right around the 60% level *as a fraction of expected quantity*. That is confirmed statistically within Table 4A's

[9] Tables with the behaviors by request level are in working paper versions and certainly are available upon request.

[10] "Potentially fair", i.e. fair under one realization of uncertainty, often is not rejected. Responders unsure if offers are unfair may well hesitate to reject. Responders also may wish to remove the burden, from their own shoulders, of enforcing the social norm. Rejection is costly so being able to claim that the offer might be fair could help them too.

[11] As in Mitzkewitz and Nagel (1993), Rapoport et al. (1996), Rapoport and Sundali (1996), although our games facilitate easier shares computations (in Straub and Murnighan, 1995; Croson, 1996 responders lack pie-size information). Huck (1999), Guth et al. (1996), and Guth and Huck (1997) have similar responder priors but not our information conditions.

[12] Responders know that proposers have better information. They also know that water quantity is never actually 8. Thus, consider a request for 5. Quantity may be 10, in which case ceding 5 means getting half the total resources. Yet if quantity is 6, ceding 5 implies getting under 20% of the pie. Given these possibilities and a neutral forecast, a responder blends a 50% chance of ceding half with a 50% chance of ceding 5/6 for an expected concession of about 2/3. For a request of 4, the expected concession is 53% (<60%). Thus accepting a request of 4 is very sensible and accepting a request of 5 not unreasonable. Our results are consistent with such 60–40% responder thinking.

Table 4A – Unframed experiments (extending Table 3 regression analysis of initiators' requests (low quantity)).

Independent variables	Dependent variables		
	(1) Prop. request/resp. exp. pie	(2) Prop. request/pie (*prop. knows pie*)	(3) Prop. request*/pie (*prop. knows 6 max*)
Forecast low (vs. full information)	0.0375 (0.0284)	0.168*** (0.0345)	0.141*** (0.0295)
Forecast neutral (vs. full information)	−0.0138 (0.0272)	0.189*** (0.0330)	0.176*** (0.0282)
Forecast high (vs. full information)	−0.0370 (0.0419)	0.226*** (0.0509)	0.191*** (0.0435)
Done in Fortaleza (vs. Limoeiro do Norte)	−0.0536* (0.0293)	−0.0653* (0.0356)	−0.0294 (0.0305)
Prop. age	0.00501** (0.00204)	0.00643** (0.00248)	0.00515** (0.00212)
Prop. female	0.000324 (0.00764)	0.000815 (0.00926)	−0.00124 (0.00793)
Prop. education	0.00131 (0.00377)	0.00111 (0.00457)	0.000692 (0.00391)
Prop. own computer	0.0158 (0.0267)	0.0223 (0.0323)	0.000857 (0.0277)
Constant	0.508*** (0.0705)	0.482*** (0.0855)	0.509*** (0.0732)
# Obs	239	239	239
R^2	0.07	0.20	0.20

Standard errors in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

column (1), in which forecasts do not differ from full information in the ratio of request to expected quantity.

Table 4A's columns (2) and (3), like Table 3 column A, show the implications for the resources captured by proposers, a fraction that also rises with forecasts up to about 20% more, i.e. to 80% since we know that the default information treatment, i.e. full information, yields a 60% share. Column (2) reflects this basic pattern while column (3) confirms what proposers actually gain.

One additional result seen within Table 4A is that the other factors we measure have little effect. While the information treatments have quite significant effects, personal characteristics do not (while age is significant in (3), even 20 years of difference would imply only a 1% difference). Even the location of the experiments, in the capital city versus the agricultural valley, is only somewhat significant when information is lacking, then is not significant in the final column (3) (and looking ahead to Table 4B, no characteristic or location is found to be significant there). Thus these regressions in Table 4A helpfully confirm the robustness of the ratios seen in Table 3, which indicate successful exploitation of proposers' private information about resource scarcity.

4.3. *Proposer loss from responder ignorance of resource abundance*

In Table 3 rows 5–7 and Table 4B, proposers know quantity is high but responders are uncertain. We see quite a different story – again some fairness but now we lack the big gains for proposers. In fact, if anything, proposers struggle to and fail to retain the 60% of resources from classic UG. The reason is that a responder's ignorance of high quantity significantly constrains the proposer.

Here, asking for 60% of the actual quantity (i.e. 6 of 10) appears to be asking for much more.[13] Yet, despite knowing that, in this case proposers essentially ignore the responder's perspective; one could infer that they employed essentially the exact opposite approach as for a low quantity. Table 3 column A suggests one explanation: proposers appear attached to getting 'their 60%'. Whether our random allocation of the proposer role somehow has conveyed a 'property right' to 'the 60% that is due a proposer', or instead other mechanisms are at play, proposers ask for 60%. This is very clearly confirmed by the insignificance of all treatments in Table 4B's column (2), controlling for the location of the experiments and the individual characteristics we measure.

Table 3 column B suggests that there is a downside to this seemingly stubborn '60% behavior'. Asking for 6 (60% of actual high quantity) implies rather higher shares of *expected quantities*, something confirmed by the sharply forecast-dependent fractions within Table 4B's column (1). Thus proposers are using a risky strategy, given that they get zero if a responder rejects a request; this is neither right nor wrong as payoffs depend on how rejections increase with rising requests. Table 3 columns C and F indicate that there is indeed a tradeoff, in terms of a proposer's gains: rows 5 and 6, where the worst-quality responder information makes these requests look highest, have highest rejections; that is consistent with Table 5, where higher requests lower acceptances. That yields lower proposer returns on average, as those rejections provide a return of zero to all.

Is this an irrational proposer attachment to 60%? Another explanation is that requests are signals. A high request could be an attempt to signal to a responder that there is a high quantity to share, despite the inability of responders (in a one-shot game) to confirm that such a signal was truthful. A critical constraint on private information is the fear of false signals – which we did observe.

4.4. *Learning from extremes*

The central (fourth and fifth) rows in Table 3 emphasize the points above using the extreme case of going beyond just the lack of a forecast better than a coin flip to 'bad forecast information'. For low quantity, here responders' expectations

[13] In Straub and Murnighan (1995) responders do not know quantity. We believe that in our games, relative to theirs and some with quantity information, responders can more easily evaluate shares. We may be empowering rejection.

Table 4B – Unframed experiments (extending Table 3 regression analysis of initiators' requests (high quantity)).

Independent variables	Dependent variables	
	(1)	(2)
	Prop. request/resp. exp. pie	Prop. request/pie (*prop. knows pie*)
Forecast low (vs. full information)	0.239*** (0.0416)	−0.000638 (0.0357)
Forecast neutral (vs. full information)	0.153*** (0.0298)	0.00142 (0.0256)
Forecast high (vs. full information)	0.0409 (0.0310)	−0.0368 (0.0266)
Done in Fortaleza (vs. Limoeiro do Norte)	−0.0344 (0.0275)	−0.0286 (0.0236)
Prop. age	0.000687 (0.00134)	0.000571 (0.00115)
Prop. female	−0.00254 (0.00793)	−0.000872 (0.00681)
Prop. education	−0.00550 (0.00402)	−0.00517 (0.00345)
Prop. own computer	−0.0104 (0.0258)	−0.00943 (0.0222)
Constant	0.699*** (0.0738)	0.692*** (0.0634)
# Obs	225	225
R^2	0.234	0.047

Standard errors in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

Table 5 – Unframed experiments (extending Table 3 regression analysis of responders' acceptance decisions).

Independent variables	Dependent variable	
	Responder acceptance (probit regression)	Marginal impacts from the probit
Request/resp. exp pie	−3.328*** (0.569)	−0.413*** (0.069)
Full information low (vs. full information of high quantity)	0.516 (0.413)	0.052 (0.033)
Forecast low (vs. full information of high quantity)	0.046 (0.337)	0.005 (0.041)
Forecast neutral (vs. full information of high quantity)	−0.131 (0.314)	−0.016 (0.040)
Forecast high (vs. full information of high quantity)	0.707* (0.404)	0.069** (0.030)
Done in Fortaleza (vs. Limoeiro do Norte)	−0.076 (0.242)	−0.009 (0.029)
Resp. age	0.020 (0.017)	0.002 (0.002)
Resp. female	0.308 (0.194)	0.038 (0.024)
Resp. education	0.016 (0.034)	0.002 (0.004)
Resp. own computer	0.019 (0.209)	0.002 (0.026)
Constant	2.800*** (0.824)	–
# Obs	458	–
Pseudo R^2	0.23	–

Standard errors in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

are far above that quantity, yielding a new result concerning equity in that it appears these proposers may be *limiting themselves* to obtaining 80% (Table 3, row 4, B shows that over 80% of the low quantity is under 60% of expected quantity). That is consistent with the results of Dictator Games (DG) where responders have no veto power (Guth and Huck, 1997); that makes sense, as poor information can render the veto power useless. Practically speaking, this result also highlights some strengths of the experimental field method: identifying a 'fairness threshold' requires an extreme case, where we know exactly the forecast; more generally, experiments allow us to ask "what if?" for settings that currently may not exist.

4.5. *Robustness to framing*

Returning to our main result – that the private information about resource scarcity is exploited – here we examine robustness to shifts in framing: first, using 'water' instead of generic resources; and second, identifying the other player as being in the region at the other end of the new canal. Table 6 gives results analogous to Table 3 for low-quantity: full knowledge; and neutral forecast.

Our central result is robust. Column A shows that requests clearly are greedier given a forecast, for either frame (we note that the full-knowledge results here are not, statistically, any different from the unframed ones in Table 3). Thus, our broad message is robust to these contextual cues: with private information about resource scarcity, informed actors capture higher resource shares.

5. Discussion

Employing ultimatum experiments, to examine the bargaining over re-allocations of resources, we find that the less informed

Table 6 – Framed experiments.

	Treatment	A Average request/ quantity (all obs)	B Average request/ expected (all obs)	C Accepted fraction (all obs)	D Accepted request/quantity	E Accepted request/expected	F = C × D Proposer return/ quantity (all obs)	G = C × (1 − D) [also = C − F] Responder return/ quantity (all obs)
1	Quantity low, both know, region frame	3.60/6.0 = 60%	3.60/6.0 = 60%	0.93	3.53/6.0 = 59%	3.53/6.0 = 59%	3.3/6.0 = 55%	38%
2	Quantity low, forecast neutral, region frame	4.73/6.0 = 79%***	4.73/8.0 = 59%	0.90	4.85/6.0 = 81%***	4.85/8.0 = 61%	4.37/6.0 = 73%***	17%***
3	Quantity low, both know, water frame	3.63/6.0 = 60%	3.63/6.0 = 60%	0.93	3.64/6.0 = 61%	3.64/6.0 = 61%	3.40/6.0 = 57%	37%
4	Quantity low, forecast neutral, water frame	4.96/6.0 = 83%***	5.32/8.0 = 66%	0.86	4.79/6.0 = 80%***	4.96/8.0 = 62%	4.11/6.0 = 68%***	17%***

In each column, we conducted t tests for equality of means (or proportions in C), comparing each treatment to its 'baseline' (i.e. quantity low, both know for the other low row & quantity high, both know for the other high row).
*Significance at the 10% level for all of these tests.
**Significance at the 5% level for all of these tests.
***Significance at the 1% level for all of these tests.

actors obtain fewer resources despite 'having a seat at the table'. Despite a veto on all proposed allocations, their share drops from 40% to 20% of resources when they have a forecast of resource quantity, instead of being fully informed about resource scarcity. Thus, asymmetric information affects equity in allocation, despite a high degree of participation. From water allocation within NE Brazil in Ceará State (which inspired our experimental design) to many other settings of resource bargaining where the interactions we highlight are relevant, this result suggests the importance of equal information for all participants, if equity is a concern. It suggests gains from extra dissemination to less informed members of key participatory groups, as these results show that simply 'having a seat at the table' does not guarantee one a 'fair share'.

For further related exploration, future research should make use also of repeated games in which several rounds are played in succession, as many participatory bodies meet repeatedly over time. That permits reputations to develop, e.g. proposer learns that responder punishes greedy requests, even at a cost to herself, by rejecting allocations yielding what are seen as excess proposer gains. From the responder's point of view, repeated play can help in interpreting proposers' requests, e.g. learning that a given proposer signals truthfully so a high request does indicate high quantity. In current or repeated form, these experiments contribute in the ways that economic theories do – yet experiments allow fairness to enter in ways often ruled out of mainstream economic models, and experiments with local field populations help to rule out one argument for local irrelevance. Our experimental results are relevant for many adaptation settings involving uses of information. Like general predictions about what happens when the supply or demand for a good rises or falls, they do not capture specific local details but yet can be relevant within many specific localities.

In this sense of broad relevance, we might draw some connections to the particular case of Ceará. We note the clearly unequal roles of city and valley, at the opposing ends of the large new canal. While the city – essentially represented by a government that is in fact seated mainly in the city – clearly has more power to suggest and at times even to implement water allocation along a canal (including the 1993 allocation in the Canal do Trabalhador that led to participatory committees), just as clear is the ability of the valley to resist and to impose costs through voting or protesting. One example of longstanding ability to resist the implementation of a policy in the water sector is the ongoing, almost complete failure of the state to collect significant water fees in rural areas almost two decades after their official creation (noting fees are well established in Fortaleza).[14]

[14] One natural objection to this analogy between actors in our experiments and regions in NE Brazil or elsewhere is that actual decision bodies involve many people and thus function differently than a single person making choices. While that is of course true, to the extent that those representing a region try to conceive of 'net gain for the region' when making decisions the analogy seems reasonable. Many descriptions of such settings employ such conceptions. Both mathematical models and newspaper articles on global treaties among nations employ language of this nature.

We would also wish to examine links concerning information asymmetry, the crux of our results. Very broadly, forecast dissemination by newspaper and more recently Internet both are unequal. Sticking in the present but moving to the well-known existing participatory water committees in the Jaguaribe Valley, it is clear that release scenarios presented are not equally understood by all (Taddei et al., 2004; Taddei, 2005, 2011). Agency technicians have had prominent roles (see Lemos et al., 2010; Broad et al., 2007; Gutierrez, 2006a) and while forecasts are not yet used within such discussions, the numerical information in water-release scenarios simply is not fully absorbed by all present. In fact, issues of control over information arose from the very beginning of forecast use in Ceará. In 1993, a political decision constrained an agency from disseminating its forecast of a drought (Orlove and Tosteson, 1999) yet another agency shifted its seed releases based on that forecast, illustrating unequal access to information (even though the public uses of it may be beneficent).

We stress that, even if beneficent, agency actions can involve considerable hidden information. In Ceará, while participants know that in years of resource scarcity water is set aside for the city, only the water agency actually knows the exact volumes and their impact on future water supply and such information could facilitate disagreement with or even rejection of allocation proposals. Concerning competing urban-rural demands, it was proposed in 2005 that the new Tabuleiro de Russas irrigation district get its water from a fully utilized stretch of the Banabuiú river instead of the Jaguaribe, which will bring water to the capital. This led groups in the valley to join to protest and indeed to successfully reject the proposal. Thus, a new link was built from the canal.

Perceptions of unequal roles and information may even have driven beneficent intervention when COGERH technicians – officially neutral within all water decisions – appeared to act in favor of a balanced negotiation of within-valley release decisions (described elsewhere; Taddei et al., 2004). Such intervention can include facilitating participation by floodplain farmers, located upstream from the main reservoirs, who are the poorest and most disempowered of all of the participants. That interpretation fits claims that people may not mind being less informed than technicians since highly informed technicians may be able to protect the uninformed (e.g. Engle et al., 2011).

In sum, many details – both climatic and socioeconomic – will affect climate adaptation in Ceará, just as in any other specific setting. Experiments that essentially augment and test broad theories cannot explicitly incorporate all of that detail nor generate predictions at that level of local detail. However, the issues that they examine can help generate predictions relevant for many settings. Further, they can consider, with local populations, institutions of interest which do not yet exist, in our case resource bargaining with equal information and with precisely measured inequalities. That unequal information yielded unequal allocation is feedback for the physical scientists who disseminate climate output and the social analysts who propose specific adaptation institutions.

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