Perceived Payoffs in the Ecology of Water Management Games

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Abstract

The ecology of games framework argues that policy systems consist actors participating in multiple policy institutions governing interdependent issues. This paper tests a fundamental hypothesis of this framework: boundedly rational actors have different perceptions of the payoffs associated with playing any particular policy game. We test for three possible sources for differences in perceived payoffs within a particular game: the diversity of actors involved, the number of actors, and the diversity of issues. In addition, we argue that individual actors view institutions as less effective when playing in games where players have diverse payoff perceptions. These arguments are comparatively tested through surveys of policy actors in water management in three different research sites: Tampa Bay, Florida; Parana, Argentina; and the San Joaquin-San Francisco Delta, California. The empirical findings have important implications for understanding institutional change in an ecology of games.
Diverse Payoffs Reduce Perceived Fairness in Ecologies of Water Management Games

This paper demonstrates that actors will perceive policy games to be less fair when they have different perceptions of the payoffs from participation. The ecology of games (EG) framework (Norton, Lubell, etc) argues that policy systems consist of multiple policy games, where a game consists of two or more actors making collective decisions in the context of a rule-structured policy institution. The structure of the institution defines the payoffs and action choices available to the actors (Gibbard 1973). A core hypothesis of EG framework is that actors are boundedly rational, and have different perceptions of the payoffs available in any given game. We will use the term “payoff diversity” to describe the situation where actors have different subjective perceptions of game payoffs.

Here we test the basic hypothesis about payoff diversity, and argue that it is linked in important ways to the perceived fairness of policy games. Procedural and distributive fairness have been shown to be essential ingredients in effective governance systems (Tyler etc). Cooperation with institutional rules is more likely when the process used to create the rules or how outcomes distribute costs and benefits are perceived to be fair. Actors who believe governance is unfair are less likely to comply rules and more likely to seek to change institutions using a variety of political strategies. Payoff diversity reflects an underlying heterogeneity of preferences; Hardin (XXX) demonstrates that ...

We test our hypotheses with data from a comparative study of water management in the Sacramento-San Joaquin Delta of California, Tampa Bay in Florida, and the Parana Delta in Argentina. Each of these research settings features a complex ecology of games governing different issues, but at different stages of development and overall structure. The California Delta has a highly developed but very decentralized and fragmented set of policy games, with no single actor or institution having the majority of power to shape decisions. Tampa Bay also has a highly developed set of institutions, but the system is very centralized around the games managed by a single actor. Parana is at a very early stage of development, with many fewer games, many of which are temporary and have little political authority to shape resource behavior.

Payoff Diversity and Institutional Change

Why do actors have different perceptions of the payoffs available in a policy game? Aoki(XXX) develops a theory of endogenous institutions and institutional change that rests heavily on the assumption of bounded rationality of individual actors. According to Aoki, institutions can be conceptualized “common knowledge at equilibrium”, where actors in a repeated game share common expectations about the links between actions and outcomes. The development of common knowledge over time requires updating of diverse individual beliefs. The bounded rationality of individual actors is thus the basic source of payoff diversity.

This argument is complicated by the EG framework because instead of just one institution, there is a system of linked interdependent institutions. One might conceptualized the entire system as “meta-institution”, but in reality individual actors pay attention to a limited subset of the policy games at any given time. Most actors do not even know about all the relevant policy institutions that exist. Some actors may have a more comprehensive view and general view than others, but bounded rational makes
it unlikely that any single actors can conceptualize the whole system. Hence for any single institution, different actors will be behaving according to different views of the system, and how that system impinges on the available actions and payoffs in a focal institution. This lead to our first hypothesis, which is really a foundational aspect of the EG framework:

_Hypothesis 1: Actors participating in particular institution within the broader ecology of games will have diverse beliefs about the potential payoffs._

Aoki’s (p.xx) describes how institutional change is accompanied by a breakdown of common knowledge: “When deviations from the existing patterns of playing occur beyond a certain threshold, hither-to-held individual perceptions about the ways in which the game is, and should be, played become problematic and may not be taken for granted any more. Shared behavioral beliefs become de-stabilized, signaling the crisis of institutions.” Thus one way to interpret payoff diversity is as a signal of institutional change, where actors with different subjective perceptions of payoffs are moving towards a new institutional equilibrium. The higher the level of payoff diversity, the more institutional change is occurring. The transition to a new equilibrium requires learning and the reconstruction of a new set of common knowledge and behavioral expectations. Institutional change is accompanied by conflict as different actors have different preferences over potential new institutions, with some actors seeking to maintain the status quo.

**Linking Payoff Diversity and Fairness**

The conflict associated with payoff diversity and institutional change undermines the capability of actors to agree on a set of policies and behaviors that are perceived to be fair and legitimate. In his classic book on collective-action, Russell Hardin (1980) demonstrates that when players have asymmetric valuations of a public good, there is no general cost-sharing rule for providing the public good that will be perceived fair in all situations. For example, a proportional sharing rule requires the costs of providing a public good are equally split among all group members. But if one group member does not value additional units of a public good at the same level, that member will be effectively subsidizing the other group members who continue to value additional units. While it is possible to find an equitable sharing rule in many situations, the difficulty of doing so would is greatly increased if actors have different perceptions of the available payoffs.

Payoff diversity is related to the long-running debate in the collective-action literature about the link between group heterogeneity and cooperation(Baland and Platteau 1997, 1998; Heckathorn 1993; Poteete and Ostrom 2004; Varughese and Ostrom 2001). The theoretical analyses and empirical studies suggests the effects of heterogeneity depend heavily on context. For example, Heckathorn (1993) shows that heterogeneity in how members of a group value a public good has a different effect than heterogeneity in the costs of providing a public good. However, there are other forms of heterogeneity besides the value and contribution of a public goods. Ethnicity and types of economic activities are oft-mentioned but not exclusive examples. Because different definitions of heterogeneity can be empirically correlated, it is hard to cleanly analyze the causal role of heterogeneity.
Regardless of how different types of heterogeneity affects incentives to cooperate, it is likely to have a negative effect on perceived fairness. For example, even if what Olson (1970) calls a “privileged” group values a public good highly enough to provide it in the presence of some free-riders, that group is likely to resent the free-riders and feel the situation is unfair. Hence, we expect that payoff diversity will be negatively associated with perceived fairness.

**Hypothesis 2:** Payoff diversity will decrease perceived fairness.

The Role of Organizational and Issue Diversity

Payoff diversity is not the only potential source of diversity in the context of policy games. Policy games involve many actors with different organizational cultures and backgrounds. Most public policy domains include government agencies from all levels of government, interest groups, universities, elected officials, and many other types of actors. Each actor may have different organizational capacities and policy preferences, which again increases the bargaining costs of finding a policy decisions that is considered fair by all stakeholders.

Organizational diversity is likely to affect perceived fairness, even controlling for differences in payoff perceptions. Organizations vary in terms of their policy preferences, organizational culture, ideological make-up, political power, and many other attributes. As with payoff diversity, organizational diversity makes it difficult to find a policy solution that is viewed as fair by all stakeholders.

**Hypothesis 3:** Organizational diversity decreases perceived fairness.

Another basic assumption of the EG framework is that policy games will often involve more than one underlying policy issue. A policy issue is defined as some type of substantive collective-action problem such as the overexploitation of a common-pool resource or provision of a public good. In the water management context of this paper, policy issues include water supply, water quality, flood management, biodiversity, and climate change. Policy issues are often linked via physical, social or economic processes, and thus behaviors affecting one issue can indirectly affect another. There is often competition among issues and negative cross-issue externalities, along with high levels of complexity in understanding linkages. Due to this complexity, institutions that address a diverse set of policy issues will have more difficulty arriving at a policy solution that is perceived as fair.

**Hypothesis 4:** Issue diversity decreases perceived fairness.

One counter-hypothesis to this argument is that in some cases, issue diversity may provide opportunities for integrated strategies that increase the benefits and thus potentially increased perceptions of fairness. For example, water management stakeholder often seek institutional arrangements for "conjunctive use" of surface water and groundwater so that groundwater storage can be used as a back-up when surface water is scarce. Another commonly advocated strategy is to develop off-stream water storage facilities to collect flood water, and then use the stored water to supplement in-stream flows during dry years. In addition to reducing flood risks, the in-stream flows can help with both water supply and for supporting bio-diversity. To the extent issue diversity provides opportunities
for integration and synergistic benefits, perceived fairness may be enhanced but only if the development of integrative strategies is able to overcome the inherent complexity of linked issues.

Potential Sources of Payoff Diversity

Payoff diversity is a function of the interests of the different actors and the types of issues involved in a particular game. Since different organization have different reasons for participating in a policy game, a diversity of organization types should also be linked to payoff diversity. A similar logic holds for issues—more issues create more potential cross-issue linkages and arrangements of policy solutions. This leads to our fifth hypothesis:

**Hypothesis 5**: Organizational and issue diversity are both increase payoff diversity.

Another potential source of payoff diversity is simply the total number of actors participating in a policy game. More actors introduce more preferences and beliefs; the diversity of those preferences may not matter as much. Since Olson (1970), one of the standard(albeit still debated) hypotheses in the collective-action literature is that large groups have a more difficulty time engaging in collective action. One potential reason for this is that larger groups have more diverse views of payoffs, and have a harder time converging on their beliefs about games.

**Hypothesis 6**: Larger numbers of players increase payoff diversity.

Empirical Case Studies: A Comparative Analysis Water Management Games

We investigate these hypotheses via a comparative quantitative analysis of three water management contexts: San Joaquin-Sacramento Delta in California (CA Delta), Tampa Bay in Florida, and Parana Delta in Argentina. Each of these cases focuses on water management of an estuary ecosystem, where freshwater from a river system enters the coastal salt water. Estuaries feature a complex mix of environmental issues, including water supply, water quality, climate change, biodiversity, flooding, navigation and others. All of these estuaries are governed by multiple institutions involving hundreds of policy actors. In short, each study area is a good example of an EG in action.

However, while we do not claim to have a clean quasi-experimental design, these estuaries vary in important ways. The CA Delta has a long history of conflict over water resources, and has the most complex and decentralized set of governing institutions. While many of the CA governing institutions are well-developed, they have also been changing quite quickly during the period of our study. In particular, one of the central policy institutions called CALFED was dismantled in 2009 and replaced by the Delta Stewardship Council; this represents a “recentralization” of the institutional arrangements with the new institution given more authority to compel the behavior of state agencies.

Tampa Bay is a well-developed but more centralized and less complex ecology of games. There are fewer overall institutions in Tampa Bay, and those institutions are heavily dominated the Southwest Florida Water Management District. The Florida water management districts are fairly unique agencies
in the United States because they have the authority to implement many of the state and Federal water management laws. Thus they become the organizational “host” to a number of different collective-choice institutions, including both collaborative and regulatory institutions. Tampa Bay has not experienced as severe of conflict as California, and is not going through as much institutional change.

Parana presents an interesting contrast to the United States estuaries because it is in an early stage of institutional development. National water laws in Argentina are not well-developed or enforced at the local level. During the period of our study, many of the institutions that did exist in Parana were only temporary and ephemeral, focusing mostly on information sharing rather than establishing strong operational rules governing resources. There is one fairly large watershed management program in Argentina that is poised to be a central and enduring policy game, assuming continued support by higher level institutions. Argentina is at an early stage of institutional development, and the institutional change that is occurring there can be conceptualized as multiple attempts to build more sustainable institutional arrangements. This type of process is likely similar to other developing countries.

Taken together, the empirical case studies represent ecologies of games at different stages and trajectories of institutional evolution. Parana has a nascent set of institutions, while California and Tampa Bay have a much higher level of development. But California has developed a large number of decentralized institutions, characterized by cycles of intense conflict. Tampa Bay has developed a fewer number of more centralized institutions, potentially with less conflict. The differences between California and Tampa Bay highlight the availability of multiple pathways of institutional development; the exact pathways take depend on many contextual factors such as the types of resources and macro-level political institutions.

Survey Delivery

(insert language from FSU paper here)

Identifying Policy Institutions

Each respondent to identify up to fifteen policy “forums” they were actively involved in during the past year. This question is similar to a name-generator network elicitation question. The term “forum” was used to operationalize the idea of a policy institution in the vernacular of real policy stakeholders; the survey defined a forum as “XXX”. Table X below shows the percentage of respondents who answered the forum nomination question, along with the minimum, maximum, and average number of forums nominated. Lubell et al (2012) used a similar question to represent the linkages between actors and institutions as a bi-partite social network. The number of times a policy institution is mentioned is equivalent to the degree of that institution in a policy network; high degree is one measure of centrality in a network.

This paper aggregates these responses to the level of individual institutions. The respondents provided the names of each institution, which were hand-coded to group together institutions that were named
in different ways. For example, one respondent might write-out the full name of the Southwest Florida Water Management District, while another would write SWFMD. Table X also reports the total number of unique forums identified through this process, as well as the number of forums mentioned by three or more respondents. The analysis below focuses on forums that are mentioned by at least three respondents, which is a proxy for the number of involved political actors. Many forums are mentioned only by one respondent; these are more peripheral to the system and not analyzed here.

**Dependent Variable: Payoff Diversity**

Hypothesis 1 postulates the existence of payoff diversity as a basic assumption of the EG framework; Hypotheses 5 and 6 treat payoff diversity as a dependent variable. However, payoff diversity is also a key independent variable predicting policy fairness. To measure payoff diversity, the survey asked each respondent to evaluate the payoffs available in the policy institution, using the following question:

*Which of the following statements best characterize the typical decision processes about water-related issues in each forum in the past year?*

1. (Mutually Beneficial) For most decisions in this venue, most groups can gain as long as they can develop a common policy.
2. (Kaldor-Hicks) Although most groups can gain from most decisions, there is conflict over who will gain the most.
3. (Zero-Sum) For most decisions, one group’s gain involves another group’s loss.

The first option means the payoff is perceived to be mutually beneficial, or Pareto-improving in the language of game theory. The second option captures a potential Pareto-improvement, where the involved players have an overall gain but some losers would potentially need to be compensated. This is often referred to as a Kaldor-Hicks efficiency criteria. Another way to think of the second option is where relative gains are important. The third option is a zero-sum game where any one group’s gain is at the expense of another groups; this is the highest level of conflict.

A Hirschman-Herfindahl index (HHI) measures payoff diversity at the level of each unique game. The HHI considers the proportion of political actors who mention each type of payoff, using the following formula: \( \sum_{i=1}^{N} s_i^2 \), where \( s_i \) is the proportion of actors mentioning each payoff type. The HHI ranges from \( 1/N \) to 1, with lower numbers indicating more diversity. For this paper, there are three different types of payoffs so \( N=3 \) and the HHI ranges from .33 to 1. One interpretation of the HHI is the probability that two randomly selected actors belong to the same category, in this case perceive the same payoffs. The HHI was originally developed to measure market concentration for firms (cite), and has also been used to measure ethnic diversity in cities or other geographic units (cite).

**Dependent Variable: Policy Fairness**

Hypotheses 2-4 treat policy fairness as a dependent variable, with payoff diversity as the most important independent variable. Policy fairness is measured with the following question: *How fair*
would you say that the process of reaching decisions in the forum is for all stakeholders (11-point Likert scale; 0=Very Unfair; 10=Very fair)?

**Independent Variables**

Three other independent variables are used in the analysis: organizational diversity, issue diversity, number of players. For organizational diversity, each respondent was asked to identify the type of organization they represent from a list of types. California has the broadest list (FL and Parana overlap noted in parentheses: Federal government (FL, P), State government (FL, P), regional government, local government, water infrastructure special district, environmental special district, environmental group, business interest, homeowner association, education/research, multi-stakeholder coalition, political party, recreational group, agriculture, and media. An HHI is then computed to measure organizational diversity, ranging from XX to 1. To reiterate, the HHI for organizational diversity can be interpreted as whether two randomly selected actors come from the same organizational category. Given local context, where was some diversity in the number of organizational types identified in each study site.

‘Issue diversity’ was measured by asking each respondent to indicate which issues they worked on from the following list, which again was largest from California: Water supply reliability, water quality, biodiversity, land-use, flood control, climate change, economic development, recreation, agricultural, administration, and environmental justice. If any of the actors participating in a particular institution indicated working on an issue, the issue was assigned to the institution. As with organizational diversity, an HHI index measures issue diversity and ranges from XX to 1.

**Number of players** is simply the count of the number of survey respondents who mentioned a particular institution as one in which they participate. Although the total number of actors involved in reality is smaller than the number of survey respondents, we assume the number of players measured here is proportional to the number of actual players.

**Results: Payoff Diversity Exists**

Table 1 reports the average frequency of different payoffs across all games by site. Tampa has the highest percentage of mutually beneficial payoffs, California has the highest frequency of zero-sum payoffs, while Parana has the highest frequency of Kaldor-Hicks payoffs. This suggests that California is experiencing the most conflict, while Florida has the most cooperation and Parana is somewhere in between. Figure 1 displays triangular plots to illustrate the distribution of payoffs across games, where each red circle in the tri-plot indicates one or more games with an observed distribution of payoff types. The tri-plots show that California not only has the most zero-sum games, but also has a wide diversity of payoff distributions. The tri-plots also show the concentration of mutually beneficial payoffs in Tampa, and the high incidence of Kaldor-Hicks payoffs in Parana. The bottom line message of these

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1 The issues economic development, recreation, agriculture, administration, and environmental justice were re-coded from written answers to an “other” category on the survey.
results is a clear confirmation of H1: Payoff diversity exists within the ecology of games in each of these sites.

<table>
<thead>
<tr>
<th>Site</th>
<th>Year</th>
<th>Freq.</th>
<th>Mean Mutual</th>
<th>Mean Kaldor</th>
<th>Mean Zero-Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parana</td>
<td>2010</td>
<td>26</td>
<td>51.52171</td>
<td>38.32812</td>
<td>10.15017</td>
</tr>
<tr>
<td>Parana</td>
<td>2012</td>
<td>13</td>
<td>57.79762</td>
<td>35.82231</td>
<td>6.380071</td>
</tr>
<tr>
<td>Tampa</td>
<td>2012</td>
<td>46</td>
<td>68.28462</td>
<td>20.64515</td>
<td>11.07023</td>
</tr>
<tr>
<td>California</td>
<td>2012</td>
<td>52</td>
<td>51.91982</td>
<td>24.06178</td>
<td>24.0184</td>
</tr>
</tbody>
</table>

There is an important relationship between the percentage of payoff types in each game and the HHI index for payoff diversity. There are negative correlations between payoff diversity and the percentage of both Kaldor-Hicks (r=-0.49) and zero-sum payoffs (r=-0.28). But there is a positive correlation with the percentage of mutually beneficial payoffs (r=0.60). This means that as perceived payoffs become more homogeneous, they are usually perceived to mutually beneficial. Increases in diversity are mostly
attributed to the entry of Kaldor-Hicks or zero-sum payoff perceptions. This is consistent with Aoki’s view that the decay in common knowledge is associated with conflict over institutional change.

**Results: Payoff Diversity Decreases Fairness Perceptions**

Table 2 below provides the first evidence about the relationship between perceived fairness and payoff diversity, by reporting the correlations between all of the key variables in the analysis. To begin with, there is a positive correlation between perceived fairness and the HHI for payoff diversity—as payoffs become more homogenous, the average fairness perceptions increase. A similar relationship is seen between organizational and issue diversity, and a negative relationship with the number of players. All of these relationships are consistent with our core hypotheses.

It is also interesting to note some of the bivariate relationships between the independent variables. Organizational diversity, payoff diversity, and issue diversity are all positively correlated. The number of players on the other hand is negatively correlated to the HHI indices for all three concepts. This suggests that as more players enter a game, they bring with them a diverse set of perceptions of payoffs, different issues of concern, and different organizational backgrounds. The strongest correlation is with organizational diversity, which means that perceptions of payoffs and issue concerns are more likely to span across multiple actors. Given the basic importance of the number of players in a game, it will be important to control for these variables to determine if any of the measures of diversity have an independent effect on perceived fairness.

<table>
<thead>
<tr>
<th>Table 2: Correlations Among Key Variables</th>
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<tr>
<td></td>
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<tr>
<td>Perceived Fairness</td>
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<tr>
<td>Perceived Fairness</td>
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<tr>
<td>Payoff Diversity</td>
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<tr>
<td>Organizational Diversity</td>
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<tr>
<td>Issue Diversity</td>
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<tr>
<td>Number of Players</td>
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</table>

Table 3, Column 2 provides a more robust test of hypotheses with a regression analysis using perceived fairness as the dependent variables and all measures of diversity plus number of players as independent variables. Dummy variables are included to distinguish between study sites, with Parana 2010 as the baseline comparison. The regression results provide the most support for H2 and H3, with payoff diversity and organizational diversity both having a relatively strong effect on fairness perceptions even controlling for number of players. The hypotheses regarding issue diversity and number of players are not supported. There is no difference in the average level of perceived fairness among the different study sites after taking into account the differences in payoff diversity across study sites.
Results: The Origins of Payoff Diversity

Table 3 reports the results of a regression model with payoff diversity as the dependent variable. The results partially support hypothesis 5, with organizational diversity being positively associated with payoff diversity. As with the relationship to fairness, issue diversity does not directly affect payoff diversity. This reiterates the point that differences in organizational cultures and preferences are a more important driver of potential conflict in the context of institutional change, in comparison to how different issues are combined. One potential explanation for the null effect of issue diversity is that the extra complexity introduced by multiple issues is balanced by the potential synergies associated with integration. Hypothesis 6 is also supported, with more players increasing payoff diversity.

Conclusions

Payoff diversity is a fundamental reality in the EG driven by bounded rationality and processes of institutional change.

As payoff diversity increases, it is hard to find fair solutions to policy problems as stakeholders maneuver to set up decision processes in ways that favor their preferred policy outcomes. Institutional change is thus associated with conflict and that conflict happens in the core of policy systems.

Payoff diversity is driven more by organizational cultures and differences rather that the set of issues.

There are potential differences across study sites that are signals of levels of cooperation. Tampa appears the most stable, while Parana and California are experiencing more change but
for different reasons. The preponderance of Kaldor-Hicks in Parana versus zero-sum in California is an intriguing finding with several potential explanations. Two of the most important are a stage of development argument, versus a cultural differences argument.

Dynamic hypotheses: as institutions change you should see higher levels of payoff diversity driven by zero-sum and trade-off types of perceptions. You should see actors shifting the patterns of participation in different institutions, and seeking to create and destroy institutions in line with their preferences. As a new equilibrium emerges, you should stability in these types of dynamics.
References