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Negotiating on Water:
Concern for Fairness and Incentives within a Non-Cooperative Bargaining Framework

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Abstract

In this paper, a unified framework is provided for analysing both the emergence of negotiated water allocation arrangements and the presence of incentives to cooperate in investment projects which improve water infrastructures. The two issues are closely related: on one hand, a growing number of conflicts over the allocation of water resources are resolved trough negotiations. On the other hand, the effective amount of water available is very likely to depend on the efforts that the parties devote to the construction, operation and maintenance of water infrastructures. However, in many real-life contexts it is not feasible for the parties to define in an early state of the affairs what contributions should be made, and how the potential surplus created by their investment should be shared at the end. When contracting possibilities are incomplete and the surplus from cooperation needs to be divided at an ex post stage, traditional literature predicts that severe hold-up problems may arise, which inevitably lead to underinvestment. The article shows that this is not always the case if one admits that the negotiating parties have some concern for fairness which depends on the level of effort they invested in the initial phase. Following outcome-based models of fairness, I assume that players have preferences entailing aversion for unequal distributions, and that their degree of aversion for inequality is increasing in their investments. Within this framework, the incentives to cooperate turn out to be higher than what traditional theory predicts. In particular, when the production technology is complementary in players' investments, full cooperation almost always emerges as an equilibrium of the game when it is Pareto-efficient. These results are consistent with recent findings from experimental literature and have interesting policy implications with regard to the design of assistance strategies for water infrastructure development. If resource users can overcome collective-action problems, as the model predicts, then promoting local investment in the development of water infrastructures may be more efficient than providing external founds. By creating a local sense of ownership of the resource, a substantial involvement of the resource users in project development may produce favourable results also in terms of water allocation arrangements.

1. Introduction

As recently stressed by many publications and international events[1], water resource is becoming increasingly scarce, both in terms of quantity and quality. Current estimates predict that, if the situation at the global and regional level is not altered significantly, by 2050 at least one in four people will live in countries affected by chronic or recurrent shortage of freshwater (Gardner-Outlow et al., 1997).

Water scarcity has many causes variously interrelated with each other. The exponential growth of human population of the past hundred years, and climate variability have certainly played a crucial role. However, the situation has been further aggravated by the inefficient management and allocation of the resource and the degradation of available water by pollution.

Traditional approaches to water management, rooted either in a central-planning/interventionist approach – e.g. command and control instruments – or in a market-based approach – e.g. the assignment of property rights for improving the workings of the market economy – have proved by and large ineffective.[2] These approaches fail to fully take into account intrinsic characteristics to water, first of all the multiplicity of its uses, which are a combination of economic and non-economic uses, often in conflict with one another and technically difficult to quantify. To complicate matters further, from a physical point of view water is unevenly distributed in time and space, is hard to transport and allocated and is often of transboundary nature.[3]

The limitations of traditional mechanisms, associated with increasing water scarcity, have led to tensions and conflicts within and among countries. At the international level, water has been cause of disputes between Arabs and Israelis, Indians and Bangladeshis, Americans and Mexicans, and all the riparian states of the Nile River. At the domestic level, conflicts over water typically involve agricultural, urban and environmental groups.

It is therefore urgent to find new ways and means for improving water management and enhancing the potentials of water as a catalyst for peace. In recent years, one of the responses has been to promote *collective negotiated decision-making procedures*. The idea is that negotiated decisions can lead to management choices which are better adapted to local conditions, and can result in easier implementation, less litigation and improved stability of agreements. Furthermore, negotiated policy making opens up the possibility of 'participatory planning', which is becoming progressively more important for policy makers worldwide.[4]

Despite the growing emphasis on negotiation that one can observe in real-life, relatively little is understood about the forces driving bargaining processes, and the interactions between the structure and the outcomes of negotiations. There is therefore a rising demand for investigation in negotiation theories and techniques, as well

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[1] See, for instance, the UN World Water Development Report (2003), UNEP's Global Environment Outlook 3 (UNEP 2002), the numerous reports by the World Water Council (http://www.worldwatercouncil.org), and references therein.

[2] See, for example, Margat (1989), London and Miley, Jr. (1990), and Frohlich and Oppenheimer (1994).

[3] About 40% of the 261 river basins in the world are shared among two or more nations, as indicated in Wolf et al., 2003.

[4] The concept of public participation as an important prerequisite for achieving sustainable development first emerged at the 1992 Rio Conference. In particular, Chapter 8 of Agenda 21 identifies 'information', 'integration' and 'participation' as key factors for sustainable development, to be implemented through the use of participatory planning approaches. More recently, in the field of water management, he EU Water Framework Directive (EU 2000) states that water users (as well as the general public) should be involved in developing and implementing river basin management plans.

as in applied models which can be used by decision-makers to better understand what factors may affect agreements and where and how bargaining processes can be shaped to obtain a more desirable state of affairs with respect to shared water resources.

Research on negotiation has, in fact, significantly increased in the last decades, involving several disciplines and techniques. In particular, game theory has been recognised as one of the most useful tools in the study of bargaining situations because it allows the incorporation of economic and political aspects and provides a formal language for describing the rules that govern interaction among agents. The branch of game theory called 'non-cooperative bargaining theory' is very suitable to analyse situations in which cooperation cannot be ensured and binding agreements are not a feasible option. This approach, indeed, explicitly models the strategic incentives of the actors involved in the bargaining process, and provides theoretical prediction of what agreement, if any, will be reached by negotiators in the absence of external interventions.[5]

These strategic aspects are crucial in the management of water resources, especially of transboundary nature, for which there is no supra-national authority that can impose a centralised solution and the parties involved are normally complex and with competing interests. Yet, although the characteristics intrinsic to water resources, as well as recent policy trends of participatory planning make the approach of non-cooperative bargaining theory particularly appealing for application in this field, few theoretical models have been applied to water issues and most of the existing applications fail to explicitly address the *process* through which an agreement is reached.[6]

This can be partially explained by the complexities involved in the negotiation processes: negotiation outcomes over water may be influenced in more or less subtle ways by the socio-economic and political situation in which the negotiation takes place, as well as by other, seemingly unrelated, issues. In theory, formal models of bargaining can integrate these exogenous factors, hence exploring their impacts on the negotiated outcome, but their identification, quantification, and introduction may be difficult from a technical point of view.

As recently stressed by Carraro et al. (2005), another and more plausible explanation for the low empirical application of non-cooperative bargaining theory to water issues can be found in some gaps that still exist in the theoretical literature.

Most of the existing works, for instance, assume that the 'pie' under negotiation is fixed and exogenously provided. Even in models where the size of the pie is allowed to vary stochastically, the nature of uncertainty is typically independent of players' actions.[7] In particular, the possibility and effects of complementary investments by the parties, that may influence the size of the pie under negotiation, has not been analysed satisfactorily yet. This aspect, however, is central in the case of water resources. Water by itself rarely gives utility: it must be stored, moved, channelled, pumped and piped to be useful. Hence, the amount (or the utility) of water will very likely depend on the level of investments chosen by the parties. Understanding players' incentives to invest and

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[5] See Harsanyi (1977) for a basic discussion of the relationship between cooperative and non-cooperative games, and Binmore, Rubinstein and Wolinsky (1986) and Krishna and Serrano (1996) for analyses of the connection between the axiomatic approach and the sequential strategic approach to bargaining.

[6] See Carraro, Marchiori and Sgobbi (2005) for a recent review of applications of non-cooperative bargaining theory to water-related issues.

[7] See, for instance, Merlo and Wilson (1995), Eraslam and Merlo (2002), and Furasawa and Wen (2001).

the implications of such investments for the conduct and outcome of negotiations is therefore fundamental when dealing with water problems.

Because water resource is so essential for physical survival and for the socio-economic development of every nation, another aspect which cannot be disregarded when studying water negotiations is the perception of fairness in bargaining. In recent years, the theoretical literature has proposed a number of mechanisms through which fairness may affect negotiators' behaviour. One mechanism is the 'fear of rejection': a negotiator would make a fair proposal not because of altruistic motivations, but rather because he believes the other party cares about fairness and he fears that an unfair proposal would be rejected. This is the path followed, among others, by Fehr and Schmidt (1999) and Lopomo and Ok (2001). In these works, fairness is modelled as 'self-centered inequality aversion': each bargainer's utility function depends positively on his share of the pie, relative to the median share.[8] Rabin (1993) provides a different approach, which focuses on an alternative manifestation of the concern for fairness: perceptions and beliefs about another party's intentions. The underlying idea is that people mainly care about the motives behind their opponent actions. In this case, players' utility functions work as follows: if one perceives hostility from his opponent, the optimal strategy is to answer with hostility; if, on the contrary, one perceives kindness, he should answer with kindness.

A limitation of these types of models is that players' concern for fairness is defined in an 'unambiguous' way, in the sense that it is exogenously assumed.

As previously noticed, in many real-life situations the pie under negotiation crucially depends (either in terms of its size, or of its utility/productivity) on players' level of investments (in the case of water, these may be dams, irrigation projects, reduction of emissions etc.). When this is the case, it seems reasonable to assume that a player concern for fairness will also be affected by his level of investment. In other words, the idea is that, when the surplus under negotiation has been (at least partially) created by the subjects themselves rather than provided for free, a player aversion for unequal distributions of the outcome is higher, the higher the effort he made. As a result, the final outcome of the negotiation may be different from the predictions obtained by models which do not take into consideration these aspects and/or their interaction.

In this paper, I will focus on players' incentives to invest and on their implications – through their *direct* and *indirect* effects – for the conduct and outcome of the negotiation. The aim of the analysis is to provide a theoretical framework which is more suitable to the study of water negotiations and can therefore better realise the potentials for policy support offered by modelling water problems using the theory of non-cooperative bargaining.

The rest of the paper is organised as follows. Section 2 describes in detail the structure of the model and its main assumptions. In section 3, the equilibrium of the game is derived for the traditional utility specification, i.e. assuming that players have no concern for fairness. The results are then discussed in light of existing experimental findings and empirical evidence from water negotiations. In section 4, preferences entailing inequity-aversion (as suggested by Fehr and Schmidt, 1999) are introduced and the relationship between players'

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[8] In fact, Fehr and Schmidt (1999) also allow for an altruistic component of fairness, i.e. their utility function is decreasing both in disadvantageous and in advantageous offers. The first effect, however, is always predominant.

levels of investment and their degree of aversion for inequality is defined and discussed. The two-stage game between inequity-averse players is therefore solved. Finally, section 5 summarises the main findings of the paper and its policy implications.

2. The Model

2.1 Structure of the game

Consider a water body (for instance, a river basin) shared by two nations or two different user-groups, *i* and *j*. The amount of water available within the basin is relatively scarce, but can be increased if agents engage in an investment project, such as the construction of a dam or reservoir, or the reduction of water pollution. The parties face two problems: on one hand they have to decide their level of investment, and on the other hand they have to agree on the partition of the surplus (in terms of water availability) resulting from the project.

In many real-life situations, it is not feasible for the parties to write down in an early state of the affairs what contributions should be made, and how the potential surplus created by their investment should be shared at the end. In other words, comprehensive contracting is often too difficult or too costly and the surplus from cooperation needs to be divided at an ex-post stage.

The problem will, therefore, be modelled as a two-stage game in which the parties first take, independently and simultaneously, their investment decisions, and then negotiate over the partition of the surplus produced. It will be assumed that there are only two possible levels of investment (or effort) among which to choose: e_L=0 (low effort) and e_H=1 (high effort).

The second stage, or *negotiation stage*, is represented as in an infinite-horizon, alternating-offer bargaining game. Formally, negotiation proceeds as follows. At time 0, agent *i* makes an offer to agent j, which consists in a proposal of a partition of the water available. If player j accepts the offer, then the bargaining ends, and the agreement is implemented. On the other hand, if player j rejects, then he makes a counteroffer at time Δ>0. If this counteroffer is accepted by agent I, then agreement is struck. Otherwise, player I makes a counter-counteroffer at time 2Δ. This process of making offers and counteroffers continues indefinitely until a proposal is accepted.

2.2 Definitions and assumptions

Let Z denote the size of the pie under negotiation – the quantity of water to be divided. This is a function of the level of investment chosen by the bargainers in the first stage of the game. Different specifications could be used to represent the potential surplus from the investment. In this analysis, the following functional form is assumed:

$$Z = 1 + k \min\{e_i, e_j\}$$

In the case of water resources, the development and realisation of an investment project often requires a considerable amount of resources and/or a long-term collaboration in which all the parties are essential (think, for instance, of investments for the reduction of water pollution: if one agent only engages in the abatement of its emissions while the other one continues to pollute, the final effect on the total amount of water available may be almost insignificant). It might, therefore, be reasonable to assume that unilateral contributions are not able to produce a (relevant) surplus and only joint investment is productive.

Costs of investments for agent *i* are denoted by $C_i(e_i)$ and defined as follows:

$$C_i(e_i) = \begin{cases} 0 & ,if e_i = 0 \\ c & ,if e_i = 1 \end{cases}$$, with $c>0$.

Finally, players' preferences and utility functions need to be specified. Following traditional literature, I first assume (section 3) that players have no preferences for fairness. In this case, their utility functions only depend on their own share of the pie. Formally:

$$U_i = z_i \times Z$$

$$U_j = z_j \times Z$$

where Z is the total pie and $z_i + z_j = 1$.

In section 4, I introduce preferences entailing inequity-aversion. Following Fehr and Schmidt (1999), players' utility functions will be defined as follows:

$$U_i(z_i, z_j) = [z_i - \alpha_i \max\{z_j - z_i, 0\}] \times Z$$

$$U_j(z_i, z_j) = [z_j - \alpha_j \max\{z_i - z_j, 0\}] \times Z$$

According to this specification, one player's utility does not only depend on the share of the pie he gets, but also on how this share compares with his opponent's outcome (in other words, the *distribution* of payoffs also matters). More precisely, I assume that each bargainer dislikes getting less than the other.[9] The parameters α_i and α_j represent respectively player I and player j's degree of aversion for disadvantageous offers. In most of the existing literature on fairness, these parameters are *exogenously* assumed. Here, on the contrary, they are *endogenous* to the model and defined as a function of players' efforts. The idea is that the investment levels chosen by the bargainers in the first stage of the game do not only have a *direct* effect on the size of the pie, but also an *indirect* effect on players' concern for fairness. This relationship will be formally specified and discussed in section 4.

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[9] Fehr and Schmidt (1999) also allow for an 'altruistic' component of fairness, i.e. their utility function is decreasing both in disadvantageous and in advantageous inequality. They argue, however, that the first effect is predominant. The experimental evidence that supports this conclusion and confirms that the main channel through which fairness influences bargainers is the 'fear of rejection' is the difference between results for ultimatum and dictator games. Although dictator games proposals also tend to exhibit a puzzling tendency towards equity (altruistic fairness), this effect is significantly lower than for ultimatum games. The difference comes from the absence of the fear of rejection channel in dictator games.

3. Resolution of the two-stage game in the absence of *fairness concern*

3.1 Negotiation game

To solve the model specified in the previous section, I will start from the second stage, or negotiation game, and then move *backward* to the first stage in which players' optimal investment decisions are determined.

Following traditional utility specification, it is first assumed that players have no concern for fairness. In this case, the negotiation game is a standard Rubinstein (1982) alternating-offer bargaining game with two players, *i* and *j*, negotiating over the partition of a pie *Z*.

Rubinstein (1982) has proved that the game admits a *unique* sub-game perfect Nash equilibrium in which agreement is reached in the *first round* and no resources are lost in delay. Players' equilibrium shares of the pie are as follows:

$$z_i^* = \frac{(1-\delta_j)}{1-\delta_i\delta_j} \quad ; \qquad z_j^* = \frac{\delta_j(1-\delta_i)}{1-\delta_i\delta_j}$$

where δ_i, δ_j represent players' discount factors[10], and $\delta_i, \delta_j \in (0,1)$.

Before moving to the first stage, I will briefly recall the main properties of the Rubinstein solution. This will be helpful to understand and interpret the results of the analysis.

First of all, the equilibrium partition which arises from the standard Rubinstein model is such that the shares obtained by a player is strictly increasing in her discount factor, and strictly decreasing in her opponent's discount factor. As suggested by Muthoo (1999), a player discount factor can be interpreted as a measure of his bargaining power. In particular, high discount factors confer great bargaining power. The intuition for this is simple: in an alternating-offers game, if a player does not wish to accept any particular offer and, instead, would like to make a counteroffer, then he is free to do so, but he has to incur a 'cost': this is the cost to him of waiting Δ time units. The higher is his discount factor, the smaller is this cost. Therefore, having a higher discount factor (that is, being relatively more patient) confers greater bargaining power.

If players' discount factor are identical ($\delta_i = \delta_j = \delta < 1$), then player I's equilibrium share $z_i^* = 1/(1+\delta)$ is strictly greater than player j's equilibrium share $z_j^* = \delta/(1+\delta)$. This result suggests that there exists a 'first-mover' advantage: if $\delta_i = \delta_j$, then the only asymmetry in the game is that player I is the first to make an offer. The first mover advantage becomes stronger as players' degree of impatience increases. In the limit case as $\delta \to 0$, that is when both players' costs of haggling is very high, the equilibrium partition is such that the proposer player gets all the pie and the responder gets nothing ($z_i^* \to z, z_j^* \to 0$).[11]

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[10] Formally, δ_i, δ_j are defined as follows: $\delta_i \equiv \exp(-r_i\Delta)$, $\delta_j \equiv \exp(-r_j\Delta)$, where r_i, r_j>0 are respectively player I and player j' s discount rates.

[11] However, it has been proved that the 'first mover advantage' disappears in the limit as the time interval Δ between two consecutive offers tends to zero. In such a case, two equally impatient players obtain one-half of the cake, independently on

3.2 Investment game

In the first stage of the game, players have to decide independently and simultaneously between two different levels of effort: e_L=0 or e_H=1.

The normal form representation of this simultaneous-moves game is as follows:

		Player J	
		e_j=0	e_j=1
Player I	e_i=0	$x_i^{(00)}, x_j^{(00)}$	$x_i^{(01)}, x_j^{(01)}$
	e_i=1	$x_i^{(10)}, x_j^{(10)}$	$x_i^{(11)}, x_j^{(11)}$

Player I's monetary payoff from the investment is defined as follows:

$$x_i = z_i \times Z - C_i$$

where z_i denotes the share of the surplus allocated to player I in the second stage, $Z=Z(e_i,e_j)$ represents the total pie (the amount of water available as a function of agents' level of investment), and $C_i=C_i(e_i)$ is player I's cost of the investment.

For simplicity, players are assumed to have the same discount factor: $\delta_i= \delta_j= \delta$, with $\delta \in (0,1)$. The payoffs of the investment game are summarised in Table 1.

Table 1. Payoffs of the investment game when players have no concern for fairness.

Players' levels of effort	*Players' payoffs*
(e_i=0, e_j=0)	$x_i^{(00)} = \frac{1}{1+\delta}\times 1$, $x_j^{(00)} = \frac{\delta}{1+\delta}\times 1$
(e_i=0, e_j=1)	$x_i^{(01)} = \frac{1}{1+\delta}\times 1$, $x_j^{(01)} = \frac{\delta}{1+\delta}\times 1 - c$
(e_i=1, e_j=0)	$x_i^{(10)} = \frac{1}{1+\delta}\times 1 - c$, $x_j^{(10)} = \frac{\delta}{1+\delta}\times 1$
(e_i=1, e_j=1)	$x_i^{(11)} = \frac{1}{1+\delta}\times (1+k) - c$, $x_j^{(11)} = \frac{\delta}{1+\delta}\times (1+k) - c$

* Remember that $Z = 1 + k \min\{e_i, e_j\}$, $C_i(e_i)= c \times e_i^2$, and $\delta_i= \delta_j= \delta$.

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their initial bargaining position (proposer/responder). If $\delta_i \neq \delta_j$, again the relative magnitude of the players' discount factors critically influences the equilibrium partition of the cake.

Before solving the game, let first identify the condition under which joint cooperation is Pareto-efficient. Efficiency is guaranteed when the total payoff from cooperation is higher than the total payoff when players do not engage in any investment project:

$$X^{(11)} \geq X^{(00)}$$

where,

$$X^{(11)} = Z(e_i = e_j = 1) - C_i(e_i = 1) - C_j(e_j = 1) = (1+k) - 2c$$

$$X^{(00)} = Z(e_i = e_j = 0) - C_i(e_i = 0) - C_j(e_j = 0) = 1.$$

Hence, the following needs to hold for full-cooperation to be Pareto-optimal:

$$c \leq \frac{1}{2} \times k \ .$$

By comparing, now, the payoffs of the investment game for each bargainer, one can obtain *players' best-response functions*, and derive the equilibrium solutions of the game.[12]

Table 2 shows that:

- For $c > \left(\frac{1}{1+\delta}\right) \times k$, the equilibrium of the game (e_i=0,e_j=0) is unique and always efficient. Joint cooperation, indeed, is not Pareto-optimal when the cost of investment is such that $c > \frac{1}{2} \times k$; and for $\delta \in (0,1)$: $\left(\frac{1}{1+\delta}\right) \in \left(\frac{1}{2}, 1\right)$.
- For $c \in \left(\frac{\delta k}{1+\delta}, \frac{k}{1+\delta}\right)$, the game admits a unique equilibrium (e_i=0,e_j=0), but this is not necessarily efficient. In particular, the solution is not efficient when $c \in \left(\frac{\delta k}{1+\delta}, \frac{k}{2}\right)$. Within this interval, joint cooperation should rather emerge.
- For $c < \left(\frac{\delta}{1+\delta}\right) \times k$, the game does not have a determined solution. Both full-cooperation and the non-cooperative outcome can emerge as an equilibrium. Only in the former case, however, the solution is efficient.

Therefore, efficiency (in terms of the equilibrium of the game) only realises when the implementation of the investment project is *not* Pareto-optimal.

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[12] Notice that I do not consider the notion of mixed strategy Nash equilibrium. A mixed strategy entails a deliberate decision by a player to introduce randomness into his behaviour: a player who chooses a mixed strategy commits himself to a random device that probabilistically selects members of his set of actions. The interpretation of this idea is clearly very hard in the context of this analysis.

Tables 3 and 4 show how the results of the game vary as $\delta \to 0$ and $\delta \to 1$. When both players are very impatient ($\delta \to 0$), the only possible equilibrium of the game is the non-cooperative outcome. In such a case, indeed, $\left(\frac{\delta}{1+\delta}\right) \to 0$, and the condition $c < \left(\frac{\delta}{1+\delta}\right) \times k$ never holds.

In the limit case as $\delta \to 1$ (bargaining is frictionless), the game does not admit a determined solution for $c \leq \frac{1}{2}k$, that is when the implementation of the investment project would be optimal.

This case, however, is less interesting in the context of this paper. If $\delta \to 1$, neither player cares about the time at which agreement is struck, which means that they do not incur any costs by haggling (i.e. by making offers and counteroffers). This assumption is clearly quite unrealistic, especially in the case of water resources which are so essential for physical survival and for the socio-economic development of every nation.

Table 2. Players' best-response functions and equilibrium outcomes of the *investment game* in the absence of fairness.

	Player I's best-response function a_i^*	Player J's best-response function a_j^*	Equilibrium outcomes of the *investment game*	Determinacy of the equilibrium	Efficiency of the equilibrium
$c < \left(\frac{\delta}{1+\delta}\right) \times k$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 0, e_j = 0)$ $(e_i = 1, e_j = 1)$	Multiple equilibria	Not guaranteed
$\left(\frac{\delta}{1+\delta}\right) \times k \leq c \leq \left(\frac{1}{1+\delta}\right) \times k$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = 0,\ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Not guaranteed
$c > \left(\frac{1}{1+\delta}\right) \times k$	$e_i = 0,\ \forall e_j$	$e_j = 0,\ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient equilibrium

Table 3. Players' best-response functions and equilibrium outcomes of the *investment game* in the absence of fairness, for $\delta \to 0$.

	$\delta \to 0$				
	Player I's best-response function a_i^*	Player J's best-response function a_j^*	Equilibrium outcomes *investment game*	Determinacy of the equilibrium	Efficiency of the equilibrium
$0 \le c \le k$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = 0, \ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Not guaranteed
$c > k$	$e_i = 0, \ \forall e_j$	$e_j = 0, \ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient equilibrium

Table 4. Players' best-response functions and equilibrium outcomes of the *investment game* in the absence of fairness, for $\delta \to 1$.

	$\delta \to 1$				
	Player I's best-response function a_i^*	Player J's best-response function a_j^*	Equilibrium outcomes of the *investment game*	Determinacy of the equilibrium	Efficiency of the equilibrium
$c \le \frac{1}{2}k$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 0, e_j = 0)$ $(e_i = 1, e_j = 1)$	Multiple equilibria	Not guaranteed
$c > \frac{1}{2}k$	$e_i = 0, \ \forall e_j$	$e_j = 0, \ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient equilibrium

3.3 Discussion of the results in light of experimental findings and empirical evidence from water negotiations

The results of the analysis (in the absence of fairness concern) conform to the prediction of traditional literature on incomplete contracting (Hart and Moore, 1988, Hart, 1995, Che and Hausch, 1999), which shows that, when contracting possibilities are incomplete, severe hold-up and underinvestment problems may arise due to the anticipation by the parties of a potential appropriation of quasi-rents.

This inefficiency outcome, however, is not satisfactory because it neither proves to be in line with recent experimental findings, nor with observations from real-life negotiations. Experiments on bargaining with prior production (Konigstein, 2000, Gantner, et al., 2001) have shown that when the surplus under negotiation is created by the subjects themselves rather than exogenously provided, the shares resulting from the bargaining tend to be increasing in players' relative investments. This suggests that the underinvestment problem may not be as universal and severe as predicted by traditional literature.

Evidence from real-life situations, on the other hand, suggests that a relationship may exist between agents' relative investments and what is perceived to be a legitimate or fair distribution of the surplus. In the case of water resources, for instance, interesting observations emerge from a recent study conducted by the International Water Management Institute (Douglas and Shaybani, IWMI, 2004). The study focuses on the development of small dam projects in a number of rural villages mainly located in north-central Yemen. The selected projects were of two types: 1) projects where the majority of investment was from local villagers, and 2) projects mainly based on external assistance.

When dam development was mainly realised through contributions from local villagers, water use rights were subsequently divided on the base of the relative shares of investment. On the contrary, a common feature of the cases with high proportions of external assistance was: underinvestment (or lack of commitment in investment) associated with the frequent emergence of disputes between the villagers about the distribution of water rights. Some projects were characterised by an initial phase of relatively high local investment and a second phase of significant external assistance. In these cases, farmers got sometimes involved in disputes when previous investments in the first phase of work were not taken into consideration in the process of allocation of water rights.

This study is relevant for the purpose of the present analysis because it suggests that agents tend to perceive their own investment as the basis for granting water property rights. This, in turn, tend to create a local sense of ownership that induces people to use the infrastructure in a more effective and sustainable way after completion.

In the next section, an alternative specification of the model is proposed, which takes into account these aspects in the attempt to mitigate the tensions between theoretical predictions and empirical findings.

4. Introducing *'fairness concerns'*

4.1 Definitions and assumptions

Following traditional bargaining literature, it was initially assumed (section 3) that players solely care about their own material payoff when negotiating. This assumption, however, is very limiting, especially in the case of a precious resource such as water. There is, in fact, substantial evidence that considerations of fairness affect economic behaviour. The numerous experiments on the ultimatum game, for instance, (see Guth and Tietz, 1990; Roth, 1995; Camerer and Thaler, 1995) have shown that fairness is prominent in bilateral negotiations and that this preoccupation for fairness may act as a regulatory mechanism of bargaining power because agents have to take it into account when making their offers.

What are the forces driving fairness behaviours is still the subject of debate among researchers. In recent years, a number of explanations and mechanisms have been proposed in the theoretical literature. In particular, it is possible to distinguish between two main approaches: the first one contains models in which people care about the distributions of payoffs (*outcome-based models*), while according to the second approach people care about the intentions of other players (*reciprocity-based models*).

Models of distributional concerns posits that people care about their own payoff and how it compares to other people's payoff. Specifically agents are 'difference averse', i.e., they do not like their payoff to fall behind (and to a lesser extent to be ahead too)[13]. This implies that a player may reduce his payoff if this leads to a reduction in the other players' payoff and reduces payoff inequality, but would never sacrifice to increase payoff inequality.

According to reciprocity-based models, people are motivated not only by their final outcomes, but also by the way the outcome has been achieved. A player cares about the intention that drives an action and may be willing to sacrifice material payoff to reciprocate, i.e. to reward fair behaviour and punish unfair behaviour (see Rabin, 1993; Falk and Fischbacher, 1999, Dufwenberg and Kirchsteiger, 2004).

Although recognising that intentions may play an important role, I will follow Fehr and Schmidt (1999) by modelling fairness as 'self-centred inequity-aversion'. Inequity aversion is self-centred if people do not care per se about inequity that exists among other people, but are only interested in the fairness of their own material payoff relative to the payoff of others. This notion does not require any strange assumption on players' behaviour and it seems, therefore, reasonable to adopt it in the context of this paper. Moreover, from a technical point of view, the formulation proposed by the authors is very tractable, and has proved to be successful in many bargaining experiments, even in experiments that previously have been viewed as showing the importance of intentions.

Hence, in the new specification of the model, the two bargainers are *inequity-averse* with preferences represented by the following utility functions:

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[13] Bolton (1991); Fehr, Kirchsteiger and Riedl (1998); Fehr and Schmidt (1999); Bolton and Ockenfels (2000).

$$U_i(z_i, z_j) = [z_i - \alpha_i \max\{z_j - z_i, 0\}] \times Z$$

$$U_j(z_i, z_j) = [z_j - \alpha_j \max\{z_i - z_j, 0\}] \times Z$$

The parameters α_i and α_j represent respectively player I and player j's degree of aversion for a disadvantageous offer. In this model, they are defined as a function of players' efforts and they are therefore *endogenous*.

More precisely, it is assumed that the level of effort chosen by a player in the first stage influences his degree of aversion for inequality in the following way: the highest the effort he made, the highest his sensitivity for disadvantageous offers becomes. In fact, in the model, effort is discrete and can only take two values: e_L=0 or e_H=1. In other words, the contribution is fixed and players' choice in the first stage can be interpreted as a decision about whether or not to participate in the investment project. The parameters α_s, therefore, are also defined in discrete terms. Formally: $\alpha_i = \begin{cases} 0, & e_i = 0 \\ \alpha, & e_i = 1 \end{cases}$

4.2 Negotiation game

4.2.1 The equilibrium of the game

To solve the negotiation game, I follow the insight due to Shaked and Sutton (1984), which allows to truncate the infinite horizon bargaining process and to apply the logic from the finite horizon case: the beginning of the infinite horizon game is equal to its subgame in the third round, should it be reached. In both cases, player I is in proposer position and then players alternate in making offers until an agreement is reached.

Consider then the sub-game starting at t=3, where player I plays the role of the proposer. Let (z_{i3}, z_{j3}) be the division that players obtain in any perfect equilibrium of this game.

In a bargaining model with inequity-averse players, it is necessary to make assumptions on how inequality develops over time in order to apply the Shaked and Sutton method. Let assume, for instance, that at each round the player who is in proposer position can secure himself an advantageous share of the pie. This implies: $z_{i1} > z_{j1}$; $z_{i2} < z_{j2}$; and $z_{i3} > z_{j3}$.

Players' utilities in t=3 are therefore as follows:

$$U_i(z_{i3}, z_{j3} | z_{i3} > z_{j3}) = z_{i3} \times Z$$

$$U_j(z_{i3}, z_{j3} | z_{i3} > z_{j3}) = [z_{j3} - \alpha_j (z_{i3} - z_{j3})] \times Z$$

In the preceding period t=2, player j, who is in proposer position, maximises his utility by offering player I his lowest acceptable partition (z_{i2}, z_{j2}). This partition can be easily derived by equating player I's utility from the second round offer with his outside option later, and then solving for z_{i2}:

$$U_i(z_{i2}, z_{j2} | z_{i2} < z_{j2}) = \delta_i U_i(z_{i3}, z_{j3} | z_{i3} > z_{j3}),$$

which implies:

$$z_{i2} = \frac{\alpha_i + \delta_i z_{i3}}{1+2\alpha_i}.$$

Now consider the first round. In the sub-game beginning from this point, player j will not accept anything less than his outside option later. Player I will, therefore, propose a partition (z_{i1}, z_{j1}), such that:

$$U_j(z_{i1}, z_{j1} | z_{i1} > z_{j1}) = \delta_j U_j(z_{i2}, z_{j2} | z_{i2} < z_{j2})$$

which implies:

$$z_{i1} = \frac{1}{(1+2\alpha_j)} \times \left[1+\alpha_j - \delta_j \left(\frac{1+\alpha_i - \delta_i z_{i3}}{1+2\alpha_i} \right) \right]$$

Under the previous assumption that the player who is in proposer position can always realise an advantageous share, the unique equilibrium of the game consistent with a SPE (z_{i3}, z_{j3}) in t=3, is as follows:

$$\left\{ z_{i1}^* = \frac{1}{(1+2\alpha_j)} \times \left[1+\alpha_j - \delta_j \left(\frac{1+\alpha_i - \delta_i z_{i3}}{1+2\alpha_i} \right) \right], z_{j1}^* = 1 - z_{i1}^*; Accept_j \right\}$$

Following Shaked and Sutton (1984), the game at point t=3 is identical to the game at t=1. Hence, it must be:

$$z_{i1} = f(z_{i3}) = z_{i3}$$

Dropping the time subscript, the equilibrium offer z_i of the infinite horizon game is: (see appendix AI for the derivation of this result)

$$z_i = \frac{(1+\alpha_j)(1+2\alpha_i) - \delta_j(1+\alpha_i)}{(1+2\alpha_i)(1+2\alpha_j) - \delta_i \delta_j}$$

One can prove that the initial assumption on the development of inequality over time is consistent with this equilibrium partition when players have the same discount factor, $\delta_i = \delta_j = \delta$ (see appendix AII).[14] The infinite horizon game then admits the following *unique* sub-game perfect equilibrium:

$$\left\{ z_i^* = \frac{(1+\alpha_j)(1+2\alpha_i) - \delta(1+\alpha_i)}{(1+2\alpha_i)(1+2\alpha_j) - \delta^2}, z_j^* = 1 - z_i^*; Accept_j \right\}$$

4.2.2 Properties of the equilibrium solution

For each bargainer, the equilibrium share derived in the previous section is increasing in his own degree of aversion for inequality and decreasing in his opponent's α (see appendix AII).

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[14] See Kohler (2005) for a discussion of the other time-paths that could be achieved for not symmetrically patient agents.

Moreover, when both players have a strictly positive degree of aversion for inequality ($\alpha_i>0$, $\alpha_j>0$), the equilibrium share that goes to the first mover, although advantageous, is still smaller than the share he can guarantee himself in the standard Rubinstein's alternating-offer game. Therefore, inequity-aversion biases the negotiation outcome towards a more fair split. The reason is that, given effort, concern for fairness increases the weaker player's relative bargaining power by making him more reluctant to accept unequal offers. As a consequence, the most 'powerful' player (the first-mover) can never fully exploit his advantage.

It is important to recall that, in this model, inequity-aversion is not introduced as an exogenous variable, but as a function of the efforts chosen by the bargainers in the first stage. This has another important implication on the negotiation outcome: unlike the standard case with no fairness concern, the equilibrium shares arising from the bargaining game with inequity-averse players, reflect prior contributions.

Table 5 summarises the equilibrium outcomes of the negotiation game for different levels of effort.

Table 5. Negotiation outcome with inequity-averse players

Players' efforts	Players' degree of aversion for inequality	Player I's equilibrium shares (z_i^*)	Comparative static	
			$\frac{\partial}{\partial \alpha}$	$\frac{\partial}{\partial \delta}$
$e_i=0$, $e_j=0$	$\alpha_i=0$, $\alpha_j=0$	$z_i^{00} = \frac{1}{1+\delta}$	$=0$	< 0
$e_i=0$, $e_j=1$	$\alpha_i=0$, $\alpha_j=\alpha$	$z_i^{01} = \frac{1+\alpha-\delta}{1+2\alpha-\delta^2}$	≤ 0 $0, \delta = 1$	?
$e_i=1$, $e_j=0$	$\alpha_i=\alpha$, $\alpha_j=0$	$z_i^{10} = \frac{1+2\alpha-\delta(1+\alpha)}{1+2\alpha-\delta^2}$	≥ 0 $0, \delta = 0, \delta = 1$	?
$e_i=1$, $e_j=1$	$\alpha_i=\alpha$, $\alpha_j=\alpha$	$z_i^{11} = \frac{(1+\alpha)}{1+2\alpha+\delta}$	≤ 0 $0, \delta = 1$	< 0

* Remember that player j's equilibrium share is given by: $z_j^*=1-z_j^*$.

By comparing the equilibrium shares computed above, the following unique ranking can be obtained: $z_i^{10} \geq z_i^{00} \geq z_i^{11} \geq z_i^{01}$.

Therefore, the proposer always gets a higher *share* of the pie when he plays against a responder who chose $e_L=0$ (low-effort) in the first stage of the game. The reason is that, the responder concern for fairness and, consequently, his bargaining power are increasing in his level of effort. Exactly the same is true for the responder player.

Moreover, given his opponent's level of investment, each bargainer independently from the role he plays (proposer or responder), gets a higher *share* of the pie if he is a 'high-effort' player.

4.3 Investment game

In the first stage of the game, players decide independently and simultaneously their level of effort (e_L=0; e_H=1). As before, the monetary payoff from the investment is given by:

$$x_i = z_i \times Z - C_i$$

where, z_i denotes the share of the surplus allocated to player I, Z represents the total pie, and C_i is player's cost of the investment.[15]

Players' payoff from the investment are summarised in Table 6.

Table 6. Payoffs of the investment game with inequity-averse players

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Players' levels of effort	*Players' payoffs*
(e_i=0, e_j=0)	$x_i^{(00)} = z_i^{00} \times 1, \quad x_j^{(00)} = (1 - z_i^{00}) \times 1$
(e_i=0, e_j=1)	$x_i^{(01)} = z_i^{01} \times 1, \quad x_j^{(01)} = (1 - z_i^{01}) \times 1 - c$
(e_i=1, e_j=0)	$x_i^{(10)} = z_i^{10} \times 1 - c, \quad x_j^{(10)} = (1 - z_i^{10}) \times 1$
(e_i=1, e_j=1)	$x_i^{(11)} = z_i^{11} \times (1+k) - c, \quad x_j^{(11)} = (1 - z_i^{11}) \times (1+k) - c$

* Remember that: $Z = 1 + k \min\{e_i, e_j\}$, $C_i(e_i) = c \times e_i^2$, and $z_i^{10} \geq z_i^{00} \geq z_i^{11} \geq z_i^{01}$

By comparing the payoffs in table 6 for each player, the following best-response functions can be derived:

$$a_i^* = \begin{cases} e_i = 1, \forall e_j & c < \Phi'_A \\ \begin{cases} e_i = 0 \quad if \quad e_j = 0 \\ \\ e_i = 1 \quad if \quad e_j = 1 \end{cases} & \Phi'_A \leq c \leq \Phi''_A \\ e_i = 0, \forall e_j & c > \Phi''_A \end{cases}$$

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[15] Remember, however, that the equilibrium share emerging from the bargaining game is now as follows: $z_i = z_i(\alpha_i(e_i), \alpha_j(e_j))$.

$$a_j^* = \begin{cases} e_j = 1, \forall e_i & c < \Phi'_B \\ \begin{cases} e_j = 0 \quad if \quad e_i = 0 \\ \\ e_j = 1 \quad if \quad e_i = 1 \end{cases} & \Phi'_B \le c \le \Phi''_B \\ e_j = 0, \forall e_i & c > \Phi''_B \end{cases}$$

where,

$$\Phi'_A = \left[z_i^{10} - z_i^{00}\right] = \frac{\alpha\delta(1-\delta)}{(1+2\alpha-\delta^2)(1+\delta)}$$

$$\Phi''_A = \left[z_i^{11}(1+k) - z_i^{01}\right] = \frac{\alpha\delta(1-\delta)}{(1+2\alpha-\delta^2)(1+2\alpha+\delta)} + \frac{(1+\alpha)k}{(1+2\alpha+\delta)}$$

$$\Phi'_B = \left[z_j^{01} - z_j^{00}\right] = \frac{\alpha(1-\delta)}{(1+2\alpha-\delta^2)(1+\delta)}$$

$$\Phi''_B = \left[z_j^{11}(1+k) - z_j^{10}\right] = \left[\frac{(\alpha+\delta)(1+k)}{(1+2\alpha+\delta)} - \frac{\delta(1+\alpha-\delta)}{(1+2\alpha-\delta^2)}\right]$$

It can be shown that: $\Phi''_A \ge \Phi'_B \ge \Phi'_A$, and $\Phi''_B \ge \Phi'_B$ (see appendix AIII). Therefore, two situations can occur: (I) $\Phi''_B \ge \Phi''_A \ge \Phi'_B \ge \Phi'_A$, (II) $\Phi''_A \ge \Phi''_B \ge \Phi'_B \ge \Phi'_A$.

In fact, players' best-response functions are exactly the same in case (I) and (II) because the ranking does not change for the individual players (Φ''_A is still greater than Φ'_A for player I, and Φ''_B is still greater than Φ'_B for player j). The two situations are, therefore, equivalent in terms of the equilibrium outcomes of the game, and the analysis can be limited to one case only.

Table 7 summarizes the results of the model for $\Phi''_B \ge \Phi''_A \ge \Phi'_B \ge \Phi'_A$. Tables 8 and 9 show how the equilibrium outcomes vary as $\delta \to 0$ and $\delta \to 1$.

Table 7. Players' best-response functions and equilibrium outcomes of the investment game with *inequality-averse* players (Case I).

	Player I's best-response function a_i^*	Player J's best-response function a_j^*	Equilibrium outcomes of the *investment game*	Determinacy of the equilibrium	Efficiency of the equilibrium
$c < \Phi'_A$	$e_i = 1, \forall e_j$	$e_j = 1, \forall e_i$	$(e_i = 1, e_j = 1)$	Unique equilibrium	Efficient
$\Phi'_A \leq c \leq \Phi'_B$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = 1, \ \forall e_i$	$(e_i = 1, e_j = 1)$	Unique equilibrium	Efficient
$\Phi'_B < c \leq \Phi''_A$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 1, e_j = 1)$ $(e_i = 0, e_j = 0)$	Multiple equilibria	Not guaranteed
$\Phi''_A < c \leq \Phi''_B$	$e_i = 0, \forall e_j$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient
$c > \Phi''_B$	$e_i = 0, \forall e_j$	$e_j = 0, \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient

Table 8. Players' best-response functions and equilibrium outcomes of the *investment game* for $\delta \to 0$ (Case I)*

	$\delta \to 0$				
	Player I's best-response function a_i^*	Player J's best-response function a_j^*	Equilibrium outcomes of the *investment game*	Determinacy of the equilibrium	Efficiency of the equilibrium
$0 \le c \le \dfrac{\alpha}{(1+2\alpha)}$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = 1,\ \forall e_i$	$(e_i = 1, e_j = 1)$	Unique equilibrium	Efficient
$\dfrac{\alpha}{(1+2\alpha)} < c \le \dfrac{(1+\alpha)k}{(1+2\alpha)}$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 1, e_j = 1)$ $(e_i = 0, e_j = 0)$	Multiple equilibria	Not guaranteed
$\dfrac{(1+\alpha)k}{(1+2\alpha)} < c \le \dfrac{\alpha(1+k)}{(1+2\alpha)}$	$e_i = 0,\ \forall e_j$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient
$c > \dfrac{\alpha(1+k)}{(1+2\alpha)}$	$e_i = 0,\ \forall e_j$	$e_j = 0,\ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient

* For $\delta \to 0$, Case (I) occurs when $k \le \alpha$.

Table 9. Players' best-response functions and equilibrium outcomes of the *investment game* for $\delta \to 1$.*

	$\delta \to 1$				
	Player I's best-response function a_i^*	Player J's best-response function a_j^*	Equilibrium outcomes of the *investment game*	Determinacy of the equilibrium	Efficiency of the equilibrium
$0 \leq c \leq \frac{1}{2}k$	$e_i = \begin{cases} 0, & e_j = 0 \\ 1, & e_j = 1 \end{cases}$	$e_j = \begin{cases} 0, & e_i = 0 \\ 1, & e_i = 1 \end{cases}$	$(e_i = 0, e_j = 0)$ $(e_i = 1, e_j = 1)$	Multiple equilibria	Not guaranteed
$c > \frac{1}{2}k$	$e_i = 0,\ \forall e_j$	$e_j = 0,\ \forall e_i$	$(e_i = 0, e_j = 0)$	Unique equilibrium	Efficient equilibrium

* For $\delta \to 1$, $\Phi''_A = \Phi''_B, \forall \alpha$. Therefore, Case (I) and Case (II) coincide.

4.4 Discussion of the results

The analysis conducted in the previous sections shows that, when players have concerns for fairness which depend on how much they invested in the initial phase, *joint cooperation* can emerge as an equilibrium of the game. More precisely, table 7 shows that, for $0 \le c \le \Phi'_B$, the game admits a unique equilibrium in which both bargainers choose a high level of effort (e_i=1, e_j=1), and the equilibrium is efficient. For $\delta \in (0,1)$ and $k \ge 1$, the condition $c \le \frac{1}{2} \times k$, which guarantees the Pareto-optimality of the investment, always holds within the interval $(0, \Phi'_B)$.

Therefore, unlike the standard case analysed in section 3, where players have no concern for fairness, in the new specification of the model efficiency does not only realise when the implementation of the project is *not* profitable, but can also emerge when the joint investment is optimal.

Some inefficient outcomes can still occur for $\Phi'_B < c \le \Phi''_A$: within this interval, the game admits multiple equilibria.

Tables 8 and 9 show how the equilibrium of the game varies as $\delta \to 0$ and $\delta \to 1$. Interesting observations emerge by comparing these tables with tables 3 and 4, which refer to the standard case where players have no preferences for fairness. For $\delta \to 0$, the only possible equilibrium of the game in the absence of fairness is the non-cooperative outcome. In the new specification, on the contrary, full cooperation emerges as a unique solution when $0 \le c \le \frac{\alpha}{(1+2\alpha)}$. Within this interval, player j (who is the second-mover) always finds profitable to invest. The intuition behind this result is as follows: when $\delta \to 0$, the first mover advantage becomes very strong. In the standard model, where previous contributions are not taken into account while negotiating, the first mover can fully exploit his advantage and assure himself the entire pie. Player j, knowing he will get nothing, always chooses e_j=0 in the first stage of the game. In the model introduced in this section, the investment decisions enter into the bargaining game through players' degree of aversion for inequality. By choosing a positive level of effort, the second mover can, therefore, increase his bargaining power and avoid the 'bad' outcome z_j=0.

As $\delta \to 1$, the two specifications analysed in this paper generate the same outcome: for $c \le \frac{1}{2}k$ (that is, when joint cooperation is Pareto-efficient) both full-cooperation and the non-cooperative solution may emerge as an equilibrium; while for $c > \frac{1}{2}k$, the unique and efficient solution is (e_i=0, e_j=0). This may seem, at first, counterintuitive. The intuition behind the result is as follows: assuming $\delta \to 1$ means that both players do not care about the time at which agreement is struck because they do not incur any costs by haggling (bargaining is frictionless). In such a case, the partition of the cake emerging from the bargaining process is the 'equal partition’, $\left(z_i^* = z_j^* = \frac{1}{2} \right)$, both in the case in which players have concern for fairness and in the case in which they do not. Therefore, the realisation of the bargaining outcome is absolutely *independent* of players’ degree of aversion for inequality. As a consequence, the *indirect* effect that, in the new specification of the model, investments had on players’ bargaining power– through their concern for fairness – is no longer there. Players’ decisions in the first stage are simply made on the base of the *direct* effect of their effort on the size of the pie, which is exactly the same as in the traditional model. As already discussed, however, the case $\delta \to 1$ is quite unlikely to occur in real-life because bargaining is never completely frictionless.

5. Conclusions

In this paper, a unified framework has been provided for analysing both the emergence of negotiated water allocation arrangements and the presence of incentives to cooperate in investment projects which improve water infrastructures. The two issues are closely related: on one hand, a growing number of conflicts over the allocation of water resources are resolved trough negotiations. On the other hand, the effective amount of water available is very likely to depend on the efforts that the parties devote to the construction, operation and maintenance of water infrastructures.

However, in many real-life contexts, it is not feasible for the parties to define in an early state of the affairs what contributions should be made, and how the potential surplus created by their investment should be shared at the end. The analysis has, therefore, focused on situations in which complete contracting is not possible and the surplus from cooperation needs to be divided at an ex-post stage. The prediction of traditional literature when contracting possibilities are incomplete is that severe hold-up problems may arise, which consequently lead to underinvestment.

In this article, I have shown that this is not always the case if the negotiating parties have some preferences for fairness. In contrast to traditional models where players solely care about their own material payoff, I have assumed that they also have a concern for the distribution of payoffs. More precisely, they dislike receiving less than the others and their aversion for disadvantageous offers increases with the level of effort they invested in the initial phase.

Within this framework, players’ incentives to cooperate are higher than what traditional theory predicts because a high level of effort does not only increase the size of the pie under negotiation, but also (through players’ concern for fairness) the shares resulting from the bargaining game. In particular, it has been shown that when the production technology is complementary in players’ investments, full cooperation almost always emerges as an equilibrium of the game when it is Pareto-efficient.

These results are consistent with recent findings from experimental literature and have interesting policy implications with regard to the design of assistance strategies for infrastructure development. If resource users can overcome collective-action problems, as the model predicts, then promoting local investment in the development of water infrastructures may be more efficient than providing external founds. By creating a local sense of ownership of the resource, a substantial involvement of the resource users in project development may produce favourable results also in terms of water allocation arrangements.

The model proposed in this paper relies on a number of simplifying assumptions. First of all, individual efforts are assumed to be perfectly observable. If this is not the case, a player's degree of aversion for inequality, which is a function of his level of investment, will also be unobservable. Introducing incomplete information would add a further significant dimension to the problem. Another assumption of the model is that players are symmetric. It would be interesting in future work to allow for some kind of inequality among the parties – inequality in term of their physical share of the basin, their access to safe water, their economic wealth, their outside options and so on. A more straightforward extension of the analysis is to consider different production technologies, where the degree of complementarity of players' efforts can varies.

Appendix

AI: Solving for the equilibrium offer, z_i, in the infinite horizon game with inequity-averse players.

$$z_i = \quad f(z_i) = \frac{1}{(1+2\alpha_j)} \times \left[1+\alpha_j - \delta_j \left(\frac{1+\alpha_i - \delta_i z_i}{1+2\alpha_i} \right) \right]$$

$$\Leftrightarrow$$

$$z_i = \quad \frac{(1+2\alpha_i)(1+2\alpha_j)}{(1+2\alpha_i)(1+2\alpha_j) - \delta_i \delta_j} \times \frac{1}{(1+2\alpha_j)} \times \left[\frac{(1+\alpha_j)(1+2\alpha_i) - \delta_j (1+\alpha_i)}{(1+2\alpha_i)} \right]$$

$$= \quad \frac{(1+\alpha_j)(1+2\alpha_i) - \delta_j (1+\alpha_i)}{(1+2\alpha_i)(1+2\alpha_j) - \delta_i \delta_j}$$

For $\delta_i = \delta_j = \delta$, and $\alpha_i = \alpha_j = \alpha$, this becomes as follows:

$$z_i = \frac{(1+\alpha)(1+2\alpha - \delta)}{(1+2\alpha)^2 - \delta^2} = \frac{(1+\alpha)(1+2\alpha - \delta)}{[(1+2\alpha)+\delta][(1+2\alpha)-\delta]} = \frac{(1+\alpha)}{(1+2\alpha+\delta)}$$

AII: Uniqueness of the equilibrium outcome of the infinite-horizon game with inequity-averse players, when $\delta_i = \delta_j = \delta$.

This appendix shows that, when players are equally impatient $(\delta_i = \delta_j = \delta)$, the development of inequality over time assumed in section 4.2.1 is the only path consistent with the equilibrium partition derived from the infinite-horizon bargaining game:

$$z_i^* = \frac{(1+\alpha_j)(1+2\alpha_i) - \delta_j (1+\alpha_i)}{(1+2\alpha_i)(1+2\alpha_j) - \delta_i \delta_j}$$

By differentiating z_i^* with respect to α_i and α_j, we have that both partial derivatives are well defined and have a *unique* sign when players have the same discount factor. Formally:

$$\frac{\partial z_i^*}{\partial \alpha_i} = \frac{\delta(1-\delta)}{[1+2\alpha+\delta]^2[1+2\alpha-\delta]} > 0 \quad \text{for } \delta \in (0,1), \alpha \in (0,\infty)$$

$$\frac{\partial z_i^*}{\partial \alpha_j} = -\frac{(1+2\alpha)(1-\delta)}{[1+2\alpha+\delta]^2[1+2\alpha-\delta]} < 0 \quad \text{for } \delta \in (0,1), \alpha \in (0,\infty)$$

Moreover:

$$\lim_{\substack{\alpha_i \to 0 \\ \alpha_j \to \infty}} z_i^* = 0.5$$

$$\lim_{\substack{\alpha_i \to \infty \\ \alpha_j \to 0}} z_i^* = \left(1 - \frac{1}{2}\delta \right) \in (0.5, 1) \text{ for } \delta \in (0,1)$$

Therefore, $z_i^* \in (0.5,1)$ for all $(\alpha_i, \alpha_j) \in [0,\infty)$ and $\delta \in (0,1)$.

AIII: Proof of the inequalities: $\Phi_A^{''} \geq \Phi_B^{'} \geq \Phi_A^{'}$, *and* $\Phi_B^{''} \geq \Phi_B^{'}$

$$\Phi_A^{''} \geq \Phi_B^{'}$$

$$\Leftrightarrow$$

$$\frac{\alpha\delta(1-\delta)}{(1+2\alpha-\delta^2)(1+2\alpha+\delta)} + \frac{(1+\alpha)k}{(1+2\alpha+\delta)} \geq \frac{\alpha(1-\delta)}{(1+2\alpha-\delta^2)(1+\delta)}$$

$$\frac{\alpha\delta^2(1-\delta)}{(1+2\alpha-\delta^2)(1+2\alpha+\delta)(1+\delta)} + \frac{(1+\alpha)k}{(1+2\alpha+\delta)} \geq 0$$

Always verified for $\delta \in (0,1)$.

$$\Phi_B^{'} \geq \Phi_A^{'}$$

$$\Leftrightarrow$$

$$\frac{\alpha(1-\delta)}{(1+2\alpha-\delta^2)(1+\delta)} \geq \frac{\alpha\delta(1-\delta)}{(1+2\alpha-\delta^2)(1+\delta)}$$

$$\frac{\alpha(1-\delta^2)}{(1+2\alpha-\delta^2)(1+\delta)} \geq 0$$

Always verified for $\delta \in (0,1)$.

$$\Phi_B^{''} \geq \Phi_B^{'}$$

Remember that $\Phi_B^{''}, \Phi_B^{'}$ are defined as: $\Phi_B^{''} = z_j^{11}(1+k) - z_j^{10}, \Phi_B^{'} = z_j^{01} - z_j^{00}$. The following needs therefore to be verified:

$$z_j^{11}(1+k) - z_j^{10} \geq z_j^{01} - z_j^{00}$$

It is easier to decompose the above inequality in two parts, and prove them separately:

(i) $z_j^{00} \geq z_j^{10}$

(ii) $z_j^{11}(1+k) - z_j^{01} \geq 0$

If both (i) and (ii) hold, then the original inequality is verified:

(i) $z_j^{00} \geq z_j^{10}$

$$\Leftrightarrow$$

$$1 - \frac{1}{(1+\delta)} \geq 1 - \frac{1+2\alpha-\delta(1+\alpha)}{1+2\alpha-\delta^2}$$

$$\frac{\alpha\delta(1-\delta)}{(1+\delta)(1+2\alpha-\delta^2)} \geq 0$$

Always verified for $\delta \in (0,1)$.

$(ii)\quad z_j^{11}(1+k) \geq z_j^{01}$

$$\Leftrightarrow$$

$$\left(1-\frac{1+\alpha}{1+2\alpha+\delta}\right)(1+k) \geq \left(1-\frac{1+\alpha-\delta}{1+2\alpha-\delta^2}\right)$$

$$\frac{\alpha(1-\delta^2)(1+k)+2\alpha^2(1+k+\alpha\delta)+\delta k(1-\delta+2\alpha)}{(1+2\alpha+\delta)(1+2\alpha-\delta^2)} \geq 0$$

Always verified for $\delta \in (0,1)$.

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