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Investigating the Effect of Different Institutional Arrangements in a Irrigational Behavior Experiment with Power Asymmetries

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Abstract

Economy is full of opportunities through which individuals have to decide based on different rules. Modeling individuals' behaviors under these additional rules is pursued in laboratory economics. The present paper addresses some critical institutional questions in governance in the Iranian economy, utilizing laboratory economics. The data were collected and created out of 480 simulation runs of common pool resource harvesting where resource users had asymmetric power for harvesting the resource. Alternative institutional arrangements, each representing different governance of natural resources, were simulated in these experiments. This paper concentrates on three factors of harvesters communication, the origin of rules (the harvesters or the government), and rule enforcement (the amount and probability of violators' fines). The results indicate that in situations where participants are allowed to regulate, harvesting the natural resource is more equal than where the government is in charge of regulating. For an external regulation, the worst way to harvest, is when the government fails to guarantee the rule enforcement (the probability of a fine is low). Under such circumstances, resource harvesting is even more unequal than the open-access state. Exogenous regulation leads to crowding-out altruistic motivations.

Highlights

- We investigated the effects of different institutional arrangements using laboratory economics.
- In this paper upstream and downstream harvesters had no interdependency.
- We compared water harvesting under external and internal regulation.

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1. Introduction

Water shortage crisis is one of the central and long-standing issues that Iranians have faced in their millennial civilization. Solving this problem needs the creation and digging of substantial physical infrastructure such as aqueducts and irrigation canals of tens and sometimes several hundred kilometers (Beaumont, 1971). These hard infrastructures have required soft infrastructures as operating instructions called local governance systems (Anderies et al., 2016). The increase in the Iranian population, the development of water harvesting technologies, the expansion of agriculture, and the nationalization of natural resources such as water and land reforms paved the ground for eliminating or weakening these governance systems, and the entry of the central government into policy. Currently, the Iranian government is the primary developer and implementer of guidelines and rules in surface and groundwater resources, such as water harvesting quotas, licensing of wells, relocation of wells, construction of dams and irrigation canals, etc. (Al-Mohammad et al., 2016). However, the vastness of Iran, the government's limited budgetary resources to manage water resources and monitor the proper law enforcement, the lack of adequate deterrence of rules, and the introduction of new technologies allow harvesters to engage in unauthorized harvesting quickly and secretly. In local water governance systems, the harvesters themselves regulated water harvesting quotas of each user (water right), monitored the harvesting, and punished the violators (Ostrom, 1990). Therefore, the abolition of the former institutional rules due to the government's engagement in bureaucracy has made it possible for the violators to escape from local surveillance and avoid local due punishments.

Water provision by creating the necessary infrastructure such as aqueducts, wells, or canals is the first irrigation system issue. These infrastructures are public goods (Janssen et al., 2010; Janssen et al., 2011). Therefore, since they are exposed to free riding by people who have not participated in its construction, they can be exempted by appropriate rules (such as defining authorized participants and controlling and punishing unauthorized ones) and turn them into club goods. The second issue concerns the distribution of water provided among authorized harvesters according to their share. This issue requires appropriate soft (rules) or hard (physical) technologies. In water self-governance systems, these two issues are solved by the farmers. Nevertheless, in countries with a central government, such as Iran, government regulation is the remedy.

In recent decades, the government's policies have concentrated on direct investment in constructing hard and soft water supply infrastructures such as the construction of dams, canals, desalination of seawater, restriction of drilling water wells, and harvesting water from them, and determination of authorized harvesters. Thus, the problem of free riding was solved and somewhat dissolved so that there is no conflict among harvesters. Water resource management has sought to reduce and even cut off connection among harvesters by taking full responsibility for managing water resources to solve disputes among harvesters (Farzaneh et al., 2017).

Water resources are translated to power asymmetry among the harvesters. It is one of the common causes of conflict among harvesters. This issue is because of the natural, social, and political position of water harvesters, including their asymmetric positions for harvesting water resource from different geographical (upstream and downstream), political (large provinces and small ones), population (large cities and small ones), economic (the industry versus agriculture and drinking water needs), knowledge, technological, and socially hierarchal perspectives. Power differences among harvesters are the most crucial factors influencing stakeholders' investment and water harvesting decisions (Otto & Wechsung, 2014).

One of the historical relics leftover from power asymmetry among the harvesters is a written document of the division of Zāyandé-Rūd River called the Sheikh Baha'i scroll. This document deals with water distribution between the upstream and downstream during the growing season (Hosseini Abri, 1998). This conflict in small-scale irrigation systems (Janssen et al., 2011) is mainly due to geographical location. Conflict reduction is mostly possible through interdependence between upstream and downstream harvesters. For example, the first group needs the labor force of the second group for dredging the canals. Thus, they should not over-harvest water. Otherwise, they will be punished. In rice fields in Bali, Indonesia, upstream farmers may even need downstream farmers' participation to control pests (Lansing & Miller, 2005). This interdependency enables negotiation and regulation between them for successful resource management (Ostrom, 1990; Ostrom & Gardner, 1993; Anderies & Janssen, 2013). However, in reality, there are many cases where the water supply has little or no dependence on downstream residents' participation, for example, when the government takes over the construction and maintenance of infrastructures. In this case, downstream communities cannot usually influence water harvesting in upstream communities. Suppose the government solved the water supply problem. Is it better to leave the issue of power asymmetry regarding water harvesting to the government - as is currently the case- or the beneficiaries can manage them by creating internal institutions successfully. This article uses experimental economics to address this question. Experimental economics has been widely employed in studies on the governance of common-pool resources. In a controlled laboratory environment, it is possible to observe certain variables such as internal and external rules, the impact of the relationship among harvesters, and penalties on how the common-pool resource is managed. All these are not possible in field studies. Besides, this method complements field studies, and when both methods can be used to answer theoretical questions, the scientific community becomes more confident in the results (Ostrom, 2006).

In recent years, institutional studies have won a special status in Iran. For example, Hosseini Abri (1998), Bayat et al. (2015), Motevasseli and Hosseini (2015), Mohammadi Kangarani and Rafsanjani Nejad (2015), Farzaneh et al. (2017), Farzaneh et al. (2016), and Palouch and BaniAsadi (2018) can be mentioned. All these studies commonly deal less with empirical analyses and remain more at macro-institutional rules and abstract analyses.

The present study is one of the few experimental institutional studies using laboratory methods in Iran that examines the effects of different institutional arrangements on irrigation by harvesters' behavior, based on the predominant nature of surface water resources governance in Iran. It is organized in the following sections: the second section deals with the theoretical research framework; the third addresses the laboratory experimental research design in detail; the fourth concerns data analysis; and finally, the concluding remarks are presented in the fifth section.

2. Theoretical Framework

Irrigation experiment is a game in which participants decide how much water is harvested in a laboratory experiment or field experiment. Experimental laboratory studies of collective action in common-pool resource dilemmas typically focus on scenarios in which players have identical or symmetrical positions concerning the water resource (Ostrom et al., 1994; Janssen et al., 2010). However, in some common-pool resources, the relationships among the participants can be asymmetric. For example, in an irrigation system where the water reaches farmers through canals, agricultural lands are located along the canals running from upstream to downstream. Therefore, their ability to influence common-pool irrigation action issues, including system maintenance and harvesting, is different (Ostrom & Gardner, 1993). One solution to the coordination problems in large irrigation systems is the assumption of a central power that dictates each farmer's water quota and labor force to guarantee its implementation. Wittfogel, in *Oriental Despotism*, cites some civilizations along with water sources such as the Nile, Mesopotamia, and the Yangtze Qiang only if there is a central power that can use the vast labor force for constructing extensive water supply networks for agricultural consumption. Using an abundant workforce requires a centralized and robust organization that can guarantee its implementation. Thus, some powerful governments, hydraulic empires Wittfogel calls them, were established (Wittfogel, 2013).

However, there are many examples of large irrigation systems around the world that have evolved without such central coordination and only based on the collective action of the water harvesters in creating rules and regulations, monitoring the proper implementation of these rules, and punishing violators (Lansing, 1991; Hunt, 1988; Ostrom, 1992). These local organizations and the two well-known institutional government-market arrangements are called the self-organization of the common-pool resource (Ostrom, 2010), dating back to human birth. Many successful examples over history (Ostrom, 1990) have puzzled the generations of social scientists. These systems are particularly vulnerable to selfish rational players who may misuse intrinsic asymmetries in the system (e.g., upstream deployment or take a free ride on public infrastructure provision (Janssen et al., 2011).

Irrigation systems need to solve many problems from supply to consumption. Therefore, legal and social systems in the field of water supply, transmission, and harvesting, especially in arid and semi-arid regions such as Iran, may be constructed (Azkia & Rostamalizadeh, 2014). Depending on the physical resource characteristics, the type of problems that these systems must solve varies. The main problem facing asymmetric irrigation systems is how to solve two problems of collective action related to each other:

(1) Construction of physical infrastructures required to harvest the water resource such as aqueducts, dams, canals, called the supply issue;

(2) The difference in water harvesters' access to the resources due to their asymmetric position along the canals; therefore, the asymmetric power in water harvesting, known as the asymmetric common-pool resource problem (Ostrom & Gadner, 1993).

If the irrigation infrastructures are considered public goods, they take a free ride on it unless used with appropriate institutions or technologies to prevent unauthorized individuals from using it (an exceptionality feature). In this case, it becomes a club good. As a reducible commodity, water may become a private commodity if distributed in such infrastructure so that a certain amount can be allocated to each farmer who can harvest or sell his water right. However, it is difficult to solve the two problems of providing and sharing asymmetric resources in practice. Exposing the irrigation system to such damage raises how such systems came into being and have lasted for so long.

One possible solution to this dilemma is the interdependence between upstream and downstream participants. If upstream users need downstream users to supply water, the latter will have a bargaining chip. Otherwise, game theory predicts that upstream societies will take over from the source as far as physical constraints allow. To explain this situation, one can use the metaphor of the "roving bandit" and the stationary bandit (Olson, 1993, 2000) and their relationship with their subordinates and subjects in an economy. A roving bandit has only been in the economy for a while. Therefore, it plunders and consumes all the economic resources of its subjects, thus maximizing its benefits.

Furthermore, a stationary bandit or ruler maximizes the present value of the income of their current and future periods from the tax. For this, they need to create economic infrastructures, especially security for the people. He must find the optimal tax rate so that his subjects are willing to continue to participate in building public infrastructures. If the tax rate is too high, people will revolt and no longer participate in building the infrastructures, and the bandit's income will decrease in later periods. The lower the need for upstream communities to participate, the more similar their behavior becomes to that of the roving bandit and distances themselves from the stationary bandit. The mystery of the asymmetric common-pool resource extends beyond irrigation systems and is a common political economy problem that all societies experience differently. In many dilemmas of real common-pool resources, there are differences among the participants' abilities to access common-pool resources. Such asymmetries can be due to geography, social hierarchy, skills, knowledge, and other interactional environment characteristics (Janssen & Rollins, 2012).

Because Rational Choice Theory cannot predict the creation and sustainability of such systems, and as the social experiments have illuminated it over the past few decades, a selfish rational choice theory is not a good representation of human behavior for explaining the behavior observed (Camerer & Fehr, 2006). The rational human being seeks free-riding from others that make such systems impossible. Simultaneously, numerous experiments have clarified the social dilemma that, contrary to Rational Choice Theory, a significant level of cooperation is found in the laboratory conditions (Bicchieri, 2002). A lot of laboratory research has been done to discover the players leading to the collaboration among harvesters and differences in the degree of cooperation using the game of public goods and common resources (Chaudhuri, 2011).

The interdependence between upstream and downstream communities is the key to designing power asymmetry experiments in access to common-pool resources. In an abstract game with five players located along an irrigation canal (Figure 1), each player can invest a portion of the ten tokens they receive at the beginning of each round in maintaining the general irrigation infrastructure, which determines the amount of water produced in the next period. He can then invest the rest privately. The total investment of five players determines the amount of water produced in the next period, from which each player harvests in the arrangements.

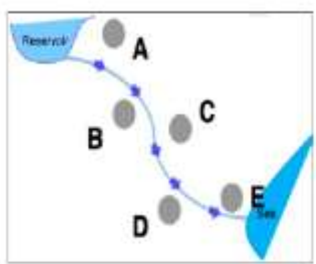

Figure 1. Location of players along an irrigation canal (Otto & Wechsung, 2014)

A key component of public infrastructure projects such as irrigation systems is a minimum threshold of the amount of input required to provide infrastructures. Therefore, before that, the amount of investment reaches a certain level (point), very little, or no public infrastructure is created. This component has been considered in studies of power asymmetry by taking an s-shaped threshold function (sigmoidal production function) between investment and public goods production (Janssen et al., 2011). In small and even medium-sized investments, the amount of public infrastructure produced is not large (Figure 2). This issue helps upstream communities - especially in the past when the capital market was inefficient. Most of the capital required by local labor was to harvest the resources required by downstream communities. If upstream communities over-harvest water, downstream communities punish them with not participating in water production, and so-called game theory, the ultimatum game is played among the players.

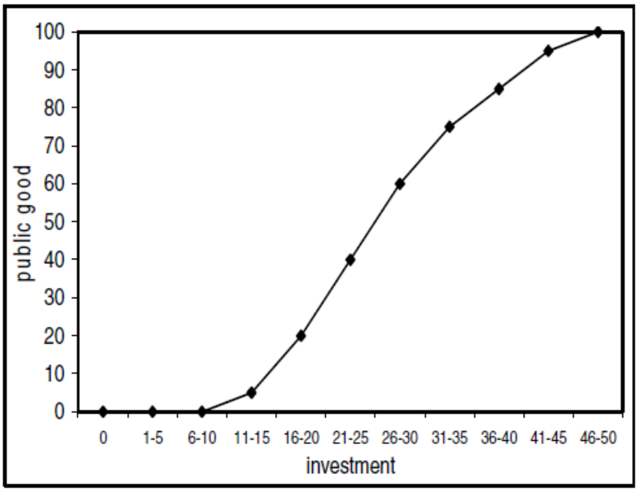

Figure 2. Water production function (Cardenas et al., 2015)

However, the situation in which the players' interdependence is weak cannot be ignored, including when the government solves the provisioning issue. In this case, the ultimatum game gets closer to the dictator game. So, the question arising here is how the problem of asymmetric access to the resource can be solved or reduced if the provisioning issue is resolved in any way. Numerous experimental studies have been conducted on the players affecting the harvest rate divided into three general categories: regulation, fines, and connection (Otto & Wechsung, 2014). But before that, the dictator game and its difference with the ultimatum game and its laboratory results are stated.

The ultimatum game and dictator game

The ultimatum game is one of the simplest bargaining games of the prisoner's dilemma (PD) family that has been widely studied in experimental economics. In this typically two-party game, parties in the primary mode interact anonymously and without any connection only once. At the beginning of the game, some money is given to player 1 (the proposer). He makes an offer to divide it between himself/herself and player 2, and player 2 (responder) has the opportunity to reject or accept the offer of player 1. If the player's offer one is left, both players' income will be zero, and if it is taken, the money will be divided according to the method proposed by player one. The dictator game is similar to the Ultimatum game, except Player 2 has no choice to accept Player one's offer. Game Theory, based on which economic players that maximize profits are assumed, predicts that in the dictator game, player one will not give any share of the resource to player 2. In the ultimatum game, he offers the lowest possible non-zero value to player 2, and he accepts this minimum amount. But repeated experiments refute this prediction. In ultimatum game experiments, player 1 offers an average of 30 to 50 percent of the asset (many suggest half), and player 2 rejects about 20 percent in nearly half of the cases. The offers are about 20% of the dictator game's assets, which is about 20% less than that of the ultimatum game (Camerer & Fehr, 2001). Game outcomes are a way of measuring social preferences (altruism or taking into account others' well-being, such as fairness or altruism). That is because in the ultimatum game, the first player's offer can be both a fear of rejection by the second player and a result of pure altruism. The dictator's game, which removes the first motive, can measure pure altruism (Camerer, 2003).

Internal and external rule

Economic institutions are designed to change behaviors. They can encourage and motivate actions that aim to produce socially superior actions to actions resulting from selfish individual choices. A clear example is the prisoner's dilemma solution that, in the absence of rules, has consequences for both players that are worse than the results of bilateral cooperation. That is why governments come in and start regulating. If effective institutions can be designed to punish offenders, it will be possible to achieve the desired social outcome for both players. However, numerous experimental studies have shown that the rule is crucial and its origin. The rule that individuals in a group have set for interaction (internal rule) affects the individuals' cooperation than the rule set outside the group (external rule). The empirical literature shows that institutions designed to produce Pareto consequences may influence individual choices surprisingly and unexpectedly. Whereas rules designed to improve social welfare typically begin with the assumption that individuals pursue their self-interest, evidence shows that individuals generally do not behave in this way, seeking to balance between self and group interests (Cardenas et al., 2000). However, when confronted with an external rule, they become somewhat less concerned and more individualistic about the group's interests; whereas, an internal rule does not do such harm. The idea that an external regulation crowds out users' main motivations of common-pool resources to avoid over-harvesting seems to have strong evidence support (Abatayo & Lynham, 2016).

Communication

Experimental games can be played in different ways. One of the essential players influencing players' behavior is allowing them to communicate among different game periods. Allowing some groups to share stems from the fact that local collaborative efforts are often an alternative to external regulation in developing countries. Many local environmental and natural resource problems are addressed through residents' joint efforts (Ostrom, 2000). Non-cooperative game theory predicts that non-binding communication (cheap talk) does not affect individuals' behavior. It does not change the payoff structure of a finite repetition game with complete information. The players have no means to guarantee their promises not to harvest more than their source's quota. As a result, collaboration is not a dominant strategy, and a non-collaborative strategy will be the players' equilibrium selection (Ostrom et al., 1994; Müller & Vickers, 1996). However, reality shows the role of cost-free and non-binding communication, that is, cheap talking in increasing the level of cooperation in common-pool resources and public goods experiments (Ostrom et al., 1992; Hecktt et al., 1994; Ladyard, 1995; Cardenas et al., 2000; Koukoumelis et al., 2009; Janssen et al., 2010). For example, a meta-analysis of more than 100 experiments showed that communication increased cooperation by about 45% (Sally, 1995).

Contrary to the theoretical assumption, CPR experiments have found that communication positively affects harvest reduction (Janssen, 2010). Most texts on this subject have been summarized by Ostrom et al. (1994) and Ladyard (1995). In summary, the findings indicate that communication increases the likelihood of individuals moving from relatively self-interested decisions to other-regarding ones. This issue means that decentralized governance of common-pool resources and public goods is possible as long as members of a single group can communicate regularly, and their interests do not conflict with those of other groups derived from the same common-pool source.

Sanctioning

One of the characteristics of any institution is enforcement; it means that there are sanctions for individuals who do not comply with that institution. Theoretically, it seems that rules without enforcement in the social dilemma have no effect on the game's payoff structure, and therefore do not change a game's equilibrium. However, in a cooperative game with two equilibria, such rules can help players achieve a better equilibrium (Pareto). Enforcement can be free of charge and can be applied as social sanctions (such as shame and embarrassment) or monetary fines to violators, called costly sanctioning (fine). Social sanctions do not change the game's financial structure, but can change violators' behavior (Glöckner et al., 2018). Because they change the game's monetary structure, sanctions may enhance cooperation and change it to full underlying equilibrium (Ostrom et al., 1994).

There is considerable research on the use of fines in games of public goods and common-pool resources (Ostrom et al., 1992; Fehr & Gächter, 2000; Janssen et al., 2010). In an asymmetric CPR game with interdependence among harvesters, downstream participants can punish upstream participants by reducing their investment in providing public infrastructure. However, the effect of the sanction is not entirely clear. In combination with other factors (such as the relationship and origin of the rule) and the amount of the fine itself (more or less), it will have different effects on the users' level of cooperation. For example, Beckenkamp and Ostmann (1999) report that intermediate levels of fines reduce a common-pool resource harvesting. Nevertheless, more fines can lead to overdrafts because people may think significant punishments are unfair. Ostrom (2000) argues that the enforcement of the external rules may undermine internal cooperative behavior, as it may weaken the formation of social norms for problem solving and, at the same time, may encourage players to deceive the system. Communication can also complement formal regulations, such as providing social pressure on individuals to achieve more efficient outcomes for poorly enforced regulations (Velez et al., 2010).

3. Lab Experiment Design

3.1 Cases and the Laboratory Environment

The experiments were performed on 16 groups (80 undergraduate students) in the academic year 2019 at the University of Isfahan. All students have taken at least one course in economics. One of the professors informed the students of such experiments. Therefore, they participated in it after announcing their readiness. Each experiment lasted a maximum of 2 hours, and received money based on their scores. They were initially told that they made decisions in an "economic choice" environment and that their income depended on their decisions on water harvesting and other participants' decisions in the group. Before starting each stage (each stage = 10 rounds of the game), instructions were read to the students, explaining the experiment in full detail. After the experiments, the data obtained were analyzed via Stata software.

Description of the experiment

The experiment is designed for a group of 5 players A, B, C, D, and E, whose fields are located along a river (Figure 1). Player A is the closest player to the headstream, and player E is the farthest from the headstream. The game is played in several rounds. The players have to decide how much water to draw from the river in each round. This decision starts with the upstream players, with player A first determining how much water to draw from the river, then player B, and so on until player E. The amount of water harvesting depends on the water remaining in the river, harvesting technology (physical constraints), and institutional arrangements (monitoring, fines, communication, etc.). The water entering the river from the headstream is constant at 100 units per round. It is assumed that the technology limit allows the player to draw only 40 units of water per round. After player E's water harvesting, if there is any water left, it enters the sea. The players' decisions are entirely confidential, and each player, in turn, is informed only of the amount of water available to him/her. When the first player registers his/her decision, the remaining water is announced privately to the second player. The second player tells the amount of their water harvesting from the headstream, and the same process is repeated for the next players. Each player's income per round is equal to the amount of water harvested multiplied by two.

Since the present study investigates the effect of different institutional arrangements on a player's decision (water harvesting rate), each experiment has different stages. Each stage hastens rounds of play and is equivalent to an institutional arrangement, during which the rules do not change. Since it is impossible to conduct all of them (60 rounds of play) in a single test, each test is conducted in a maximum of 3 stages of 10 rounds. Institutional arrangements 1 (basic or open access mode) is done in all games in stage 1. The primary stage has two applications: first, the participants are informed of how to play, and second, it is used as a basis for comparing the effects of different institutional arrangements on players' decisions after the end of the first ten rounds (completion of stage 1).

Institutional Arrangements 1: Basic game or open access (no communication, no monitoring, no sanctioning)

This stage lacks rules and is casually called "Institutional Arrangements". Each player is considered a "dictator" for the player or players after him/her, except the last player.

Since the dictator game does not have any rules, any manipulation can be considered moving towards the ultimatum game. Therefore, other institutional arrangements seek to solve this dilemma by comparing the consequences of the game. Internal and external regulation, communication, and sanction are the most significant factors affecting the water harvesting rate.

Institutional Arrangements 2: external regulation (no communication, random monitoring, low degree of fine)

In this case, an external figure such as the government seeks to guarantee the execution of each player's legal right as 20 units of water. The violator is fined, but based on the government law. There is a possibility that individuals evade the law, so a 20% chance was set for reviewing each individual's choices. This type of monitoring is called random monitoring. In addition, the fine degree is chosen low because, in developing countries, monitoring and punishment tools are often weak (Cardenas et al., 2000). Both the probability of identifying the violator and the degree of penalty are low. When a player is selected for review, a monitor checks his/her choices. If a player breaks the law, 20 points are deducted from his/her income in that round. Although the rest of the players know whose choices have been reviewed, they are not aware of whether they have broken the law. Individuals play ten rounds under these institutional arrangements.

Institutional Arrangements 3: Internal regulation after the experience of an external regulation (communication, consensual monitoring, costly punishment)

Some are selected to participate in the internal rule section from the participants who have participated in the non-communication external regulation stage. The cases are allowed for a 10-minute conversation to agree on the monitoring type and sanctioning mechanism (presence or absence of monitoring, monitoring the decision of all or some by random, monitoring by the government or participants, as well as the degree of punishment). However, they have no right to threaten each other or offer to pay each other after the game. At the beginning of the round, a vote is taken on the type of monitoring. A rule is chosen for which the majority of participants have voted. After voting, ten rounds of the game are played based on the monitoring mechanism chosen and the sanctioning selected. If the selected monitoring mechanism follows a person-to-person or all-person selection approach, then the player's requesting for the monitoring must pay a fee for the review. The fee is determined by the government, which are ten units here. Note that issues like the placement of participants and the income function structure are unchangeable in this case. Individuals only determine the amount of the violator's fine and the method of monitoring.

Institutional Arrangements 4: External regulation (communication, random monitoring, a high degree of fine)

From those participants who have participated in the open-access stage, some are selected to participate in this section. As before, participants have a 10-minute conversation. During these 10 minutes, they have the opportunity to talk about the amount of water harvesting. In the case of random monitoring, the probability of reviewing each individual's choice is 20%, and in case of violation, their amounts of water harvesting is reduced three times. Participants then enter ten decision-making rounds.

Institutional Arrangements 5: external regulation (communication, random monitoring, low degree of sanctioning)

From those participants who have participated in the open-access stage, some are selected to participate in this stage. Samples are given a 10-minute opportunity to talk to each other about the amount of water harvesting. For random monitoring, the probability of monitoring each individual's choice is 20%, and in case of violation, 20% of their amount of water harvesting is reduced. They then enter ten decision-making rounds. The difference between this stage and stage 2 is in the input of the communication factor.

Institutional Arrangements 6: internal regulation without experiencing an external regulation (communication, monitoring, sanctioning)

These institutional arrangements, inspired by Ostrom et al. (1992), are similar to institutional arrangements 3, with the only difference being that these arrangements occur immediately after institutional arrangements 1. Some participants who have participated in the baseline experiments enter this stage, while the institutional arrangements 3 are followed by institutional arrangements 2.

4. Data Analysis

Since the present study aims to compare the effects of different institutional arrangements on the water harvesters' behavior and the laboratory experiment data allows to control some features (location, institution, time), the following econometric model is used:

$$Y_{i,j,t} = \alpha + \Omega * round_t + \sum_{j=2}^{6} \beta_j * rule_j + \sum_{k=1}^{4} \theta_k * position_k$$

$$+ \sum_{j=2}^{6} \sum_{k=1}^{4} \delta_{jk} * rule_j * position_k + \varepsilon_i \quad (1)$$

Where Y_{it} indicates the amount of water harvesting from a common-pool resource for the i^th player in the t^th round. This water harvesting also depends on the position of a player in a river route. In this study, the position variable represents an individual's position, defined as a dummy variable for each position, so that when the player is in the relevant position, it has a value of 1 and otherwise a value of 0. The round represents the desired period allowing us to control the time effects. The rule is a dummy institutional variable that changes according to different institutional arrangements. If a desired institutional arrangements exist, it has a value of 1 and, otherwise a value of 0. ε is an error sentence with common properties. We make the first differences to eliminate the time-constant effects and then use the ordinary least squares (OLS) for estimation.

The above model makes it possible to statistically test the average water harvesting difference under different institutional arrangements. To this end, a set of rules, positions, position*rule variables are prepared for a ll other positions of institutional positions and arrangements. According to Equation 1, it can be concluded that if a player is in the third position and institutional arrangements 1 are implemented for him, he/she has water harvesting as follows:

$$y_{3,1} = \alpha + \theta_3 \quad (2)$$

And if this player (with the same position) is subjected to institutional arrangements 2, he/she has the water harvesting as follows:

$$y_{3,2} = \alpha + \beta_2 + \theta_3 + \delta_{3,2} \quad (3)$$

By calculating the difference between these two effects, it can be claimed that compared to institutional arrangements 1, the effect of institutional arrangements 2 for a player in the third position is $\beta_2 + \delta_{3,2}$. Accordingly, the difference in water harvesting by the player in the first position can be obtained through institutional arrangements 1 and 2 (β_2). By calculating the difference between these two effects, the difference between the institutional arrangements for the first and third positions can be calculated, which is $\delta_{3,2}$.

According to the method mentioned, the amount of water harvesting in different positions and institutional arrangements can be calculated (see Table 1).

Table 1. Result of estimation

Variable	Coefficient	Std. Error	*p*-value
RULE2	4.694048	2.220515	0.0265
RULE3	9.627381	6.640148	0.0000
RULE4	5.885714	3.443186	0.0006
RULE5	-5.764286	-5.045081	0.0000
RULE6	12.48571	10.30101	0.0000
POSITION1	22.17143	12.79844	0.0000
POSITION2	21.60714	12.80649	0.0000
POSITION3	15.80714	10.28672	0.0000
POSITION4	5.182143	3.017756	0.0026
RULE2*POSITION1	-7.346429	-2.156147	0.0312
RULE3*POSITION1	-18.97976	-9.375525	0.0000
RULE4*POSITION1	-9.221429	-2.440458	0.0148
RULE5*POSITION1	6.778571	2.332304	0.0198
RULE6*POSITION1	-21.27143	-11.41417	0.0000
RULE2*POSITION2	-10.38214	-3.020837	0.0026
RULE3*POSITION2	-18.14881	-9.11504	0.0000
RULE4*POSITION2	-12.65714	-3.179227	0.0015
RULE5*POSITION2	5.092857	1.158113	0.2470
RULE6*POSITION2	-20.64048	-11.42259	0.0000
RULE2*POSITION3	-3.49881	-1.254808	0.2097
RULE3*POSITION3	-8.165476	-3.412487	0.0007
RULE4*POSITION3	-7.157143	-3.127002	0.0018
RULE5*POSITION3	13.14286	4.718293	0.0000
RULE6*POSITION3	-16.77381	-9.130696	0.0000
RULE2*POSITION4	-2.24881	-0.73778	0.4608
RULE3*POSITION4	-2.715476	-1.235979	0.2166
RULE4*POSITION4	0.267857	0.119337	0.9050
RULE5*POSITION4	4.967857	0.884098	0.3768
RULE6*POSITION4	-4.482143	-2.43075	0.0152
ROUNDP1	0.272727	0.337212	0.7360
ROUNDP9	0.142424	0.194314	0.8460
ROUNDP2	0.221212	0.256512	0.7976
ROUNDP3	0.181818	0.222602	0.8239
ROUNDP4	0.230303	0.273283	0.7847
ROUNDP5	0.112121	0.140472	0.8883
ROUNDP6	0.024242	0.030317	0.9758
ROUNDP7	0.278788	0.358792	0.7198
ROUNDP8	0.163636	0.242729	0.8082
C	6.651558	5.562696	0.0000

***Source**: Authors' investigations*

As Table 1 shows, the coefficients of positions and institutional arrangements on resource harvesting are significant for $(p < .01)$, except rule 2 that is significant for $(p < .05)$. When participants decide under third and sixth institutional arrangements, the coefficients are significant $(p < .01)$. We did not find any significant relationship between rounds and resource harvesting.

To compare the effects of positions and institutional arrangements on resource harvesting, we first changed the institutional arrangements and recorded the results by assuming the position constant. These results are shown in Figures 3 (3-1 to 3-5). In these diagrams, the individuals' positions are constant while institutional arrangements change from 1 to 6.

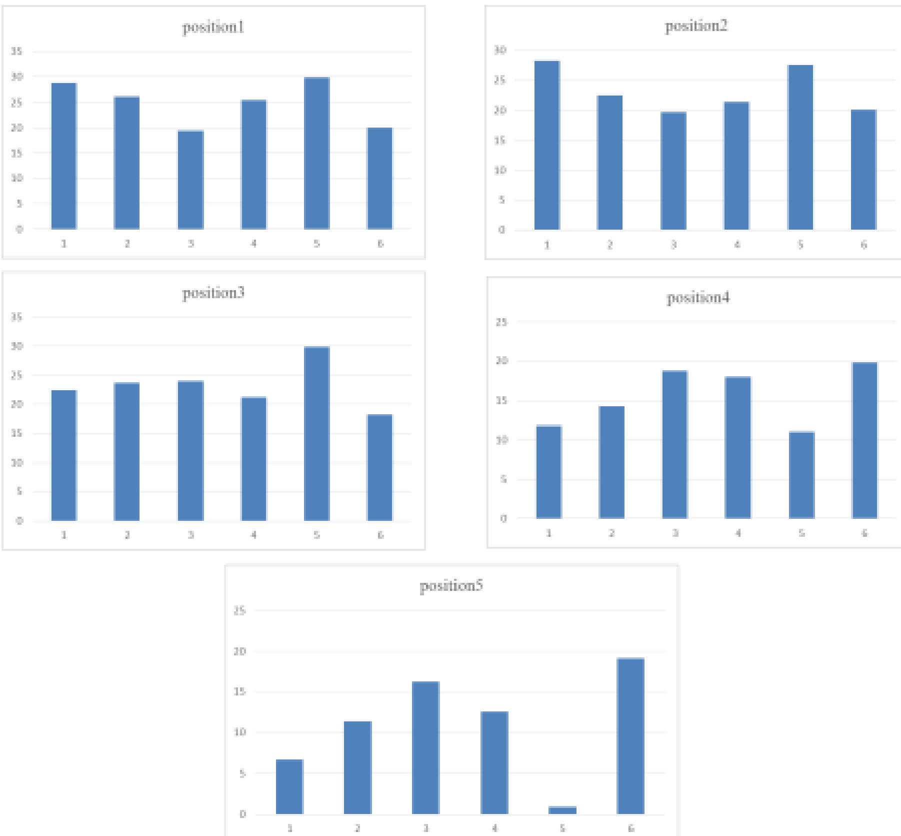

Figure 3. Average water harvesting of individuals in position 1-5

The following figures can also be obtained by taking the institutional arrangements constant and individuals' positions changing:

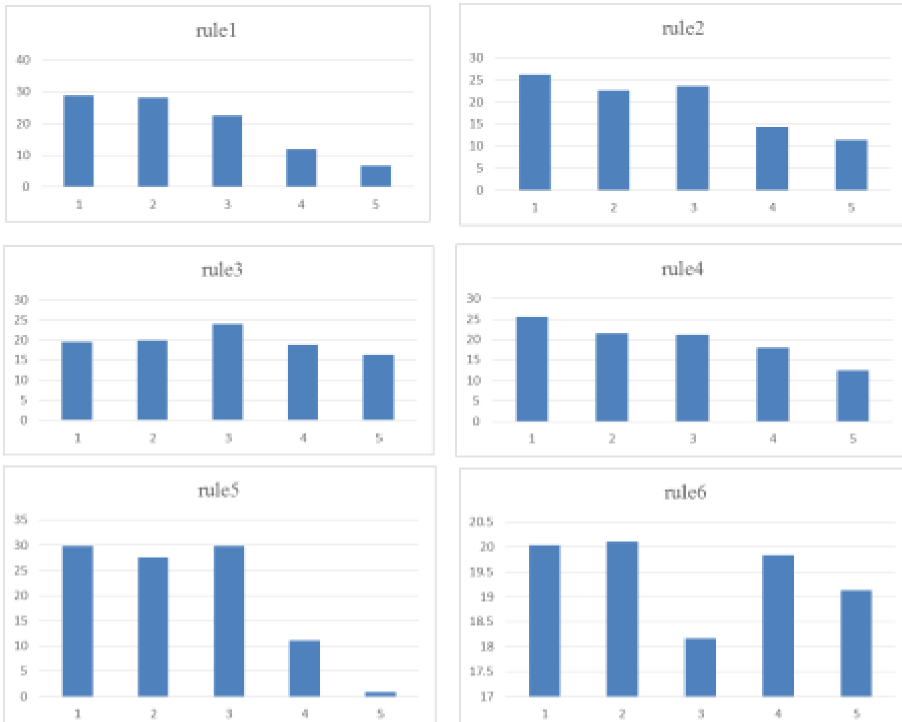

Figure 4. Average water harvesting of individuals in regulations1-

Figures of group 3 represent the individuals' amount of water harvesting in different situations and under six institutional arrangements. Figure 3 shows that the average water harvesting of the first individual, who is in a dictator's position, is much less than 40 units (maximum possible water harvesting) in all institutional arrangements. Even under open access conditions, where a player is expected to harvest water as much as possible (i.e., 40 units), the average water harvesting is only 28.8. This result is a reaffirmation of the results of the dictator game (Sally, 1995). The findings of previous studies in public goods and trust games (Janssen et al.,2010; Janssen et al., 2011; Camerer & Fehr, 2006) suggest that individuals are fair in their water harvesting. However, this amount is more than the average amount reported in games played in different parts of the world, which may be due to the announcement of 20 units per individual. Unlike conventional dictator games played by two players with no right and enforcement, in the present study dictator game is played by five players. By changing the institutional arrangements of open access to the external regulation, the first individual average water harvesting decreased to 26.1.

In contrast, their average water harvesting in institutional arrangements 3 (external institutions) reached 19.4, indicating a more significant external institutions' effect than internal ones for controlling the first individuals' water harvesting. Other institutional arrangements also show a more significant effect of the internal regulation than the external one to equalize the five players' water harvesting. The first individual's average water harvesting in external regulation conditions with a low degree of sanctioning (29.83) is about the average water harvesting in open access conditions (28.82).

The player's harvesting behavior in the second position is very similar to the person in the first position (see figures 3-1 to 3-2). The second player's lowest water harvesting is when there are internal institutions (regulations 3 and 6), and their highest water harvesting is in the institutional arrangements 1 (open access) and 5 (external regulation with a low degree of penalty).

The amount of water harvesting of the player in position 3 does not fluctuate much. It is slightly more than 20 units (except in institutional arrangements 5. i.e., external regulation with communication and low degree of sanctioning, which increased significantly). Given the reduction in water available to them, this is not surprising. Still, in institutional arrangements 5, whose only difference is the communication, this significant increase is incredible because contrary to the results of experiments, it shows a positive effect of communication on water harvesting.

As expected, the most amount of water harvesting of the fourth and fifth positions is in institutional arrangements 3 and 6 (internal regulation). The most important reason for this is the increase in the amount of water available for these positions in these institutional arrangements. When there is an internal institution, water harvesting decreases significantly for the first and second positions. This issue increases the water available for the fourth and fifth positions.

Viewing water harvesting from the institutional arrangements window, one can draw figures 4-1 to 4-6. In these figures, a change in position is considered by taking the symbol constant. We have the highest equality of water harvesting in institutional arrangements 6 and 3 (internal regulation). In these cases, the difference between the maximum and minimum amounts of water harvesting is 3.2 and 9 units, respectively, which are less than other institutional arrangements (the maximum range of changes is seen in the open-access case with 22.17 units). The Gini coefficient of water harvesting according to Table 2 is at its lowest in these two cases. Besides, it is possible to obtain the difference in individuals' income in any institutional arrangement type.

Table 2. The Gini coefficients of different institutional arrangements

institutional arrangements	1st	2nd	3rd	4th	5th	6th
The Gini coefficient	0.248	0.1593	0.0663	0.1192	0.3093	0.0196

***Source**: Authors' investigations*

The income distribution results are obtained with the assumption that the amount of product is proportional to the amount of water harvested. The price of products is considered constant for simplicity. A comparison of the Gini coefficients reveals the least inequality in the third and sixth regulations mandated by internal institutions.

5. Conclusion

Internal institutions have historically provided the path for behavioral adjustment and public facilities distribution among different individuals. These institutions were tailored to each region's physical and human conditions, preventing varied phenomena such as the tragedy of the commons and free riding. With the establishment of central governments, the weakening of these institutions began in some countries. With the increase in central governments' power, the role of these institutions in economic management declined. The marginalization of these institutions, population growth, and technological changes gave individuals the ability to harvest individually and extensively, leading to significant changes in the sustainable harvesting of common-pool resources.

Moreover, no efficient monitoring system and insufficient knowledge of the central expert system rather than the local system caused the commons' tragedy. Free riding has also added to the problems. Meanwhile, the harvesters' power asymmetry has caused these problems to reach challenging common-pool resources management points.

Presenting solutions via choosing from different institutional arrangements requires extensive theoretical and empirical studies. The present study evaluated the effects of various institutional arrangements on harvesting common-pool resources in power asymmetry conditions. Since there is no reliable laboratory data for comparison in Iran, this study uses experimental economic studies, as a developing method widely used in laboratory experiment, to solve this problem. The research focuses on three factors of communication, the origin of the regulation (internal and external regulation), and the degree of sanctioning. Experiments were performed on undergraduate students of the University of Isfahan in the academic year 2019. The results indicated that internal regulation improved the situation better than the external regulation and open-access conditions. In the case of external regulation, poor enforcement (i.e., low degree of penalty) has even greater water harvesting inequality than open-access conditions. These conditions are very similar to the real situation of Iran's economy. The government often interferes in economic and social affairs by setting rules without sufficient enforcement, ultimately leading to the widespread prevalence of irregularities. The unfavorable open-access conditions clarify that the players' altruistic motives cannot rely on governing society. Communication between players is also desirable when there is an internal regulation because external regulation leads to the crowding out of altruistic motives. As a result, only high degrees of fine can guarantee the execution of external regulation. Moreover, due to the game structure, which is of the dictatorial type, it is argued that in order to form the cooperation, there is no necessary for interdependency between the upstream and downstream participants.

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