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Contract Choice and Trust in Informal Groundwater Markets

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To my lovely husband,

my dearest parents, and

my beloved sisters

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Introduction

Dependency on groundwater as a source of fresh water has increased dramatically in the twentieth century (van der Gun, 2012). Based on UN-IGRAC (2010) estimates at country level, the world's aggregated groundwater extraction is approximately 1,000 km^3 per year, of which about 67 percent is used for irrigation, 22 percent for domestic purposes and 11 percent for industry. Two-thirds of global extraction occurs in South-Asian countries, such as India, China, Pakistan, Iran and Bangladesh.

Dependency on groundwater is even more intensive in India, which accounts for one-quarter of the world's groundwater extraction, around 250 km^3 per year (World Bank, 2010). More than 60 percent of irrigated agriculture and 85 percent of drinking water supplies depend on groundwater (World Bank, 2011). This dependency on groundwater has led to unsustainable extraction of the non-renewable groundwater resource. A national assessment in 2011 found that 30 percent of the groundwater blocks in India are semi-critical, that is, the groundwater extraction rate exceeds the rate of recharge (CGWB, 2014). The World Bank (2010) warns that if the present extraction trends continue, 60 percent of India's aquifers will be in critical condition by 2030. Further, climate change could put additional stress on groundwater resources, which would have a serious implication for national food security and the livelihoods of agrarian communities. In response to the concerns over the growing depletion of aquifer levels, the Indian government has constituted an expert committee to adopt a number of appropriate policies to manage demand and sustainable extraction of groundwater (Planning Commission, 2007).

Among the demand management strategies, economists generally argue that market-based approaches to resource extraction and allocation provide proper incentives for extraction and improve the efficiency of water use. One such response to the growing demand for groundwater is the establishment of '*water markets'* to manage water resources, in such a way as to improve the reallocation of water to high-value uses (Easter et al., 1999). In most developed countries, like the USA and Australia, water markets are well established and organised formally, with a prescribed volume and share of water to be sold for a period of time. Water rights have been assigned to the users, and the contracts are enforced through the legal system. In developing countries, formal institutional mechanisms are often weak or do not exist, which can hinder market-based allocation of water. Instead, informal institutional arrangements often act as an alternative means to facilitate such allocation (Meinzen-Dick,

1996). Informal groundwater sharing and trading have become increasingly common in arid and semi-arid tropics of the world. Informal groundwater markets are bilateral contractual agreements between farmers, where farmers who have surplus water (sellers) in their private irrigation system ('tubewell') trade with farmers who are in need of it (buyers). The contractual agreements between farmers are verbal, unregulated by any authorities and are self-enforced agreements. These contracts are common in South Asia and some parts of China (Meinzen-Dick, 1996, Saleth, 1998).

Informal groundwater markets are very important in India, as these markets provide irrigation to 15 percent of the total irrigated area, covering about 6 million hectares (Saleth, 1998). Anecdotal evidence suggests that groundwater markets improve water access for the poor, who are unable to invest in tubewells, and increase the irrigated area and food production (Meinzen-Dick, 1996, Mukherji, 2004). This has been seen as one of the important demand management strategies as it reduces the additional tubewells and increases the efficiency of water use (Palanisami, 2009). However, some concerns have been raised about over-extraction and thus there have been calls for some form of regulatory actions to combat over-extraction (Jacoby et al., 2004). As a long-term solution, the establishment of water rights based on quantity extraction and allocation of such rights based on resource availability has been recommended. Therefore, trading of water rights would implicitly consider the scarcity value of water to reduce the overdrafts (Easter et al., 1999). Some studies hold that informal groundwater contracts are imperfect and differ significantly from a competitive market. They argue that the price charged for delivering water is higher than the cost of extraction of water (Jacoby et al., 2004, Kajisa and Sakurai, 2003). The exorbitant price charged by water sellers makes them resemble 'water lords' (Janakarajan, 1993, Shah, 1993, Jacoby et al., 2004).

The first two chapters of this thesis deal with informal water contracts in rural India. The purpose is to understand how these markets work, how agents behave and how their relative bargaining power influences decision-making and the choice of contract type. In the third, chapter we analyse the role of kinship and trust among the agents who are involved in the groundwater market.

The increased scarcity of water has direct implications on the power balance between agents of groundwater contracts. Rosegrant and Binswanger (1994) stress that as a good

becomes scarce, a number of issues arise in the establishment of a market, and one such problem is the development of market power.

The first chapter of my dissertation, *Bargaining and Contract Choice: Evidence from Informal Groundwater Contracts*, aims to analyse the relative bargaining power of sellers and buyers in informal groundwater contracts. This is an important question, as it allows us to understand how sellers and buyers in informal bilateral agreements exert their power in deciding on the contract, which provides an indicator of how competitive the informal groundwater markets are. To the best of our knowledge, ours is the first of its kind to aim at eliciting the relative bargaining power of sellers and buyers in informal agrarian contracts. We follow a novel approach by carrying out a lab-in-the-field experiment using actual sellers and buyers who had contracts at the time of the study. In the experiment, sellers and buyers made series of decisions choosing between an output-shared and a fixed contract, first individually and then jointly.

We find a high degree of disagreement between sellers' and buyers' individual preferences and this decreases as the high and low output price risks become closer to each other. Further, we observe that contract choice in the joint decision depends on the relative risk preferences of sellers and buyers. When the buyer is more risk-averse than the seller, the buyer is more likely to choose an output-shared contract. Comparing individual decisions with the joint decision, we find that the sellers have more bargaining power in deciding on the type of contract. Given the output price risk, the choice of contract is mostly favourable to the seller that ultimately has an influence the equity distribution of groundwater market arrangements. We identified what characteristics improve the bargaining power of buyers. Buyers have more influence if they share interpersonal relationships with sellers, such as kinship ties, are more educated than the seller and have a long contractual history with the seller.

Our findings have two important implications. First, it is not surprising to find that sellers have more influence in the choice of contracts given the usufructuary right to extract groundwater and the scarcity of water in India. As these contracts are unregulated, the poor and marginal farmers who depend on these contracts for food production are exploited, which is a great concern in the rural areas. This raises the question of equity implications of these contracts. Second, present trends of decreasing rates of aquifer levels in India further increase future water scarcity (World Bank, 2010). This might further widen the bargaining power gap

between buyers and sellers. The study provides information about the relative bargaining position of agents in these markets to consider into groundwater policy interventions that are needed to bring the present form of groundwater markets towards the competitive market.

From our survey, we observed that 87 percent of observed groundwater contracts in the study area are the output-shared contract type. The conventional contract theories suggest that output-shared contracts are inefficient compared to other contracts (Stiglitz, 1974, David, 1977). It is important to understand what factors influence the agents to choose a particular contract over others and why we observed the output-shared contract as a dominant type of contract in the groundwater market.

The second chapter of my dissertation, *Contract Choice and Risk Preferences: Evidence from Informal Groundwater Contract Choices in Rural India*, analyses the factors that affect the choice of groundwater contracts in rural India. Empirical evidence on agents' risk-sharing incentives on the choice of contract is mixed, which is mainly depends on type of proxy variables used. The study contributes to the contract choice literature while dealing with two important issues, that is, endogenous matching of agents and agents' relative power to influence the contract decision.

We find that there are few additional potential sellers and buyers available around the deliverable area due to the topographical constraint of water delivery. Therefore, endogenous matching is less of an issue in our study area as pointed out by Aggarwal (2007). We use the buyers' characteristics in relation to the sellers' as proxy measures to deal with the relative power of agents to influence the contract decision. We find that the risk preferences of both sellers and buyers influence the choice of a contract, which suggests a risk-sharing motive in the contract choice decision. Further, we find that a situation with a buyer who is more educated and older than the seller is associated with a lower probability that a contract is an output-shared contract, which implies the agents' relative power to influence the contract decision.

The results of our study have a number of implications. A majority of water buyers are marginal farmers and are more risk-averse than sellers; thus, buyers prefer an output-shared contract in which that they can share the risk with sellers, although such a contract gives them lower profits compared to a fixed contract. Although an output-shared contract acts as a risk-sharing mechanism for buyers, it affects the distribution of income resulting from

groundwater sharing. The risk and uncertainty are a result of both production risk and output price volatilities. Crop insurance might be a risk-coping strategy to overcome the production risk. To overcome price volatilities, Fafchamps (1992) recommends the integration of local markets into state or national level markets so that the local supply would not affect the price. These efforts could cushion risk-averse buyers in agrarian markets, allowing them to make better choices and improving the equity effects of local informal trading.

The terms and conditions of informal groundwater market agreements are verbal in nature and no third party is involved either in monitoring or enforcing the terms and conditions of the contracts. Trust among the agents is important for selection of contract type as well as for the success of the contract. The third chapter in the thesis, *Trust, and Kinship: Experimental Evidence from Rural India*, investigates the role of kinship in trust behaviours of groundwater contracts. Evidence of the role of kinship in trust and cooperation is mixed. One group of studies argues that kinship ties increase the trust and moral obligation which reduced the transaction cost of agreement (Sadoulet et al., 1997, Peng, 2004), while another group of studies argues that kinship invites free-riding and evasive behaviour, and is therefore a hindrance to the development process (Kassie and Holden, 2007, Di Falco and Bulte, 2011). We observed that 40 percent of groundwater contracts occur within the kinship boundaries, which invokes the question does differential trust towards kin exist when compared to non-kin groups? If it exists, which direction would the difference take?

We carried out a lab-in-the-field experiment using an investment game to elicit trust and trustworthiness of kin and non-kin village members and a standard dictator game to elicit altruism towards kin and non-kin village members. We use a within-subject design, where each sender plays against a kin and a non-kin group of receivers. We find that kin are trusted more compared to non-kin. We also find that the high altruistic concern towards the kin group explains a large fraction of the variation in the observed trust difference towards kin and non-kin. The difference in the trustworthiness of kin and non-kin receivers is small. However, kin receivers' trustworthiness depends on how close they are within their kin network. Senders believe that kin receivers are more trustworthy that non-kin, but in the experiment there is no difference in the trustworthiness between kin and non-kin groups.

There are several implications of this study. First, the study has put forward a new perspective on looking into the effects of kinship. The study recommends considering the social closeness within the kin network in disentangling the effects of kinship. Second,

groundwater contract agents have misconceptions about non-kin trustworthiness, which reduces interaction between individuals in comparison to what it might have been if they had more trust in each other. This may restrict informal trade and sharing of resources within the group. Thus, false beliefs about the trustworthiness of non-kin might reduce the overall welfare of agents in informal markets.

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Chapter I

Bargaining and Contract Choice: Evidence from Informal Groundwater Contracts

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Abstract

Informal market arrangements are often in place when formal institutions are too weak to establish a formal mechanism for resource allocation. In this paper, we study informal groundwater contracts in India, in particular, the bargaining power of sellers and buyers. We conduct an economic experiment with actual buyers and sellers of groundwater contracts, where agents make a series of choices between output-shared and fixed-price contracts, first individually and then jointly. Output-shared contracts are chosen more often when the decision is joint. Further, the likelihood of choosing an output-shared contract depends on the relative risk preferences of sellers and buyers. Sellers have a strong influence in deciding the joint contract. However, buyers' bargaining power increases when they share interpersonal relationships with sellers, such as kinship ties, or have a long contractual history together.

JEL codes: C83, C93, D86, Q13, Q25

Keywords: Output-shared contract, Fixed-price contract, Lab-in-field experiment, Random parameter model

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1. Introduction

Markets are widely regarded as a mechanism that allocates resources for their best use. When formal institutional mechanisms are weak or do not exist to establish a market-based allocation, informal institutional arrangements often act as an alternative means to facilitate such resource allocation (Meinzen-Dick, 1996, Saleth, 1998). The most commonly seen and well reported informal institutional arrangements for resource exchange are land-rental markets and water markets.

Sharing and trading of water have become increasingly common in arid and semi-arid tropics of the world due to scarcity. Informal groundwater contracts are bilateral agreements between farmers, where farmers who have surplus water (sellers) in their private irrigation systems ('*tubewells*') trade with farmers who are in need of water (buyers). These contracts are common in South Asia and some parts of China, e.g., these contracts cover over 15 percent of total irrigated area in India (Saleth, 1998).[2] Anecdotal evidence suggests that groundwater contracts improve water access for the poor, who are unable to invest in tubewells, and increase the irrigated area and food production (Meinzen-Dick, 1996, Mukherji, 2004). However, concerns have been raised about over-extraction of groundwater in the area of intensive groundwater contracts, resulting in calls for some form of regulatory action to combat the over-extraction (Jacoby et al., 2004). As a long-term solution, the establishment of water rights on quantity extraction and allocation of such rights based on resource availability has been recommended, which would implicitly consider the scarcity value of water in order to reduce the overdrafts (Easter et al., 1999). Some studies argue that informal groundwater markets are imperfect and differ significantly from a competitive market. They argue that the price charged for delivering water is higher than the cost of extraction of water (Jacoby et al., 2004, Kajisa and Sakurai, 2003). The exorbitant price charged by water sellers makes them resemble 'water lords' (Janakarajan, 1993, Shah, 1993, Jacoby et al., 2004).[3]

[2] It is estimated that 20 percent of 14.2 million tubewells in India are involved in water trading, covering around 6 million hectares of irrigated land (Saleth, 1998). In Pakistan, 25 percent of tubewell owners sold water (NESPAK, 1991).

[3] This is similar to the conventional notion of 'landlord'. The price-to-cost ratio has been found to vary between 1.9 and 3.0, depending on locality and method of calculation (Fujita and Hossain, 1995; Kajisa and Sakurai, 2003). Somanathan (2006) found 40 percent of sellers charge a price above the average cost of water in Karnataka and Andra Pradesh. In addition, this trade is restricted by topographical constraints. Because water can be economically delivered only within a certain radius, this restricts the number of sellers and buyers who can have a contract, resulting in a *spatial monopoly* (Easter et al., 1999)

The most commonly observed types of contracts in groundwater sharing are output-shared, fixed-price and hourly rate contracts (Aggarwal, 2007). Conventional contract theories suggest that output-shared contracts are inefficient compared to other contracts, because they require output to be shared, which reduces agents' efforts below the optimal level (Stiglitz, 1974, David, 1977). Therefore, in the long run, with the development of input markets, it has been argued that output-shared contracts eventually would become less prevalent (Otsuka and Hayami, 1988). However, output-shared contracts are frequently encountered (Fujita, 2004, Manjunatha et al., 2014) and the price paid for water under output-shared contracts is generally higher than under fixed-price/hourly rate contracts (Fujita and Hossain, 1995, Kajisa and Sakurai, 2003). Efforts have been made to understand the choice of contract type (Aggarwal, 2007), contract efficiency (Kajisa and Sakurai, 2005) and incentives to agents under each contract type. However, explicit investigation of agents' relative bargaining power in the contract decision-making process has not been undertaken (David, 1977, Stiglitz, 1974).

As water is becoming a scarce resource in many tropical parts of the world, including a decrease in the groundwater level in India (WorldBank, 2010), this might have direct implications in the power balance between agents of groundwater contracts. Rosegrant and Binswanger (1994) stress that as a good becomes scarce, a number of issues arise in the establishment of a market, and one such problem is the development of market power. This suggests the importance of understanding the relative bargaining power of sellers and buyers in informal groundwater contracts, which might call for the development of law and institutions to overcome such market power. Along the lines of demonstrating the bargaining relationship between buyers and sellers, Kajisa and Sakurai (2003) used survey data to investigate a two-person bargaining model for price determination in groundwater contracts, and found that sellers' characteristics significantly explain the price variation in Indian villages, and that price varies greatly between contract types. Use of survey data to investigate the bilateral bargaining process provides information about what the matched agents have already decided; however, it does not provide information about individual agents' preferences from which conclusions about the bargaining power could be drawn.

In this study, we investigate the individual contract preferences of sellers and buyers and explore the relative bargaining power of agents in the context of groundwater contracts. We use actual buyers and sellers from existing groundwater contracts in Karnataka state,

India. A lab-in-the-field experiment was employed with 177 matched pairs of buyers and sellers. The participants are matched based on the observed contract relationships. In the experiment, the sellers and buyers made a series of decisions in choosing between output-shared and fixed-price contracts under varied output price probabilities. Both sellers and buyers made decisions first individually, then jointly. Our experimental design allows us to examine two aspects of subjects' preferences for contracts. Firstly, we can explain how the individual and joint preference for contract type varies with output price probabilities. Secondly, it allows us to measure the relative power of agents, i.e., how buyers and sellers influence the joint decisions towards their individually preferred contract and which characteristics influence the relative power of agents.

We find that the preference for an output-shared contract is relatively high in the joint decision than the individual decisions. When the decision is made jointly, the choice of an output-shared contract is more likely when the buyer is more risk-averse than the seller, which suggests evidence of a risk-sharing motive in the choice an output-shared contract. Using the matched agents' individual preferences for the contract, we construct the level of disagreement between sellers and buyers for each choice situation to infer the relative power of agents to influence the joint decision towards their individually preferred contracts. Using binary probit analysis, we find that sellers have greater power to influence the joint decision in their favour when the level of disagreement increases between buyers and sellers. Interpersonal relationships between buyers and sellers, such as kinship ties, longer years of contracts the agents' had and buyers being more educated than sellers augment the buyers' relative power to determine the joint decision.

The rest of the paper is structured as follows. Section 2 provides a brief review of agrarian contract choice. In Section 3, we describe groundwater contract characteristics in general, as well as those particular to the study location. Section 4 elaborates on the experimental design and implementation procedure. Section 5 outlines the results and Section 6 ends the paper with concluding remarks.

2. Agrarian contract choice

Most commonly encountered agrarian contractual agreements are output-shared contracts (SC) and fixed-price (FC) contracts (Otsuka et al., 1992). The mode of payment differs between these contracts. In the output-shared contract, a share of total crop output is

paid as the price for water. In the fixed-price contract, a fixed amount per unit area per season is paid for water. In the standard classical contract choice theory, output-shared contracts are seen as sub-optimal due to inefficiency in terms of under-provision of inputs because the sharecroppers receive only a part of their marginal product of input (labour). This is the so-called Marshallian inefficiency (Otsuka and Hayami, 1988). An output-shared contract in the land-rental contracts was compared to a principal-agent problem, where tenants (sharecroppers) have an incentive to under-provide inputs, which are difficult for the landlord to observe, in order to maximise the utility with respect to the inputs applied (Cheung, 1969, Stiglitz, 1974). The landlord has to incur a cost of monitoring output-sharecropping tenants to enforce the terms and conditions of the contract (Holmström, 1979). Due to the additional cost of monitoring, it has been predicted that, in the long run, output-shared contracts would become less prevalent. However, studies have evidenced an increase in the choice of output-shared contracts in agrarian contracts, which is puzzling given the predictions of classical theory (Fujita, 2004, Manjunatha et al., 2011). In the literature, a number of explanations have been given for the existence of output-shared contracts, such as transaction costs burden, agents' liquidity constraints, and risk-sharing incentives.

The transaction cost theory argues that the output-shared contract is as efficient as other contracts if the cost incurred by agents to monitor and enforce the terms and conditions of the contract is zero (Cheung, 1969). Datta et al. (1986) and Murrell (1983) argue that each contract carries certain transaction costs. For example, the landlord has to monitor the tenant in both output-shared and fixed-price contracts. In output-shared contracts, monitoring is required to reduce the tenant's shirking on labour and other inputs, while, in the fixed-price contract, monitoring is required to reduce land quality mismanagement and soil fertility exhaustion, which are difficult to observe by the landlord. The choice of the contract depends on the relative transaction costs between the contracts.

The liquidity constraint theory argues that agents' liquidity constraints play a major role in the choice of contract, as the time of contractual payment differs between an output-shared and a fixed contract. Ackerberg et al. (2002) suggest that agents' matching in these contracts are endogenously determined based on their liquidity and resource constraints and that agents' matching determines the type of the contract. They find that tenants who are less wealthy are more likely to have output-shared contracts with wealthy landlords in the Italian land-rental market. Examining the relationship between contract choice and working capital investment

in crop production, Laffont and Matoussi (1995) and Tikabo and Holden (2003) found that an increase in the working capital of the tenant increases the likelihood of a fixed-price contract while an increase in the working capital of the landlord increases the likelihood of an output-shared contract. The transaction cost and liquidity constraint arguments either explain one agent's viewpoint or do not consider the combined effects of agents' preferences on the contract decisions.

Finally, the risk-sharing theory argues that an output-shared contract provides an incentive for agents to share the risk of production. The conceptual model of Stiglitz (1974) and David (1977) shows that the choice of contract depends on the risk preferences of both the agents. Their model predicted that the choice of a fixed-price contract is in equilibrium when landlords are risk-neutral and tenants are risk-averse. The choice of the output-shared contract is an equilibrium contract if both landlord and tenant are risk-averse; it allows them to share risk where a more risk-averse agent is willing to accept a lower share of output in exchange for sharing the risk. The risk-sharing argument was widely accepted as a positive reason for the existence of an output-shared contract in the contract choice literature (Otsuka and Hayami, 1988). These arguments spurred many empirical inquiries to test the predictions. Allen and Lueck (1999) and Aggarwal (2007) used yield variance as a proxy measure for the riskiness of a crop and found weak evidence in support of risk-sharing arguments for the existence of output-shared contracts. On the other hand, Ackerberg et al. (2002) found that high-risk crops such as grapevines are more likely than cereal crops to be under output-shared contracts. Using risk preferences of tenants and landlords in Ethiopian land markets, Bezabih (2009) found that risk-averse landlords are more likely to prefer output-shared contracts, while tenants' risk preferences do not matter for contract choice, which seems to be counter-intuitive to the prediction of the risk-sharing arguments. Empirical evidence concerning the risk-sharing argument is mixed.

There are a few studies that have focused on groundwater contracts. Kajisa and Sakurai (2005) found that output-shared and fixed-price contracts are equally efficient in Indian groundwater markets. They argue that, unlike land-rental contracts, buyers and sellers in the groundwater contracts are neighbouring farmers due to the topographical constraint of water delivery, which enables them to observe and interact closely with each other, resulting in negligible monitoring costs. In exploring the efficiency of contracts, the conclusions drawn from their study are limited due to the endogenous matching of agents in the contract. Aggarwal (2004) argued that, since water can be economically delivered only within a certain

area, the number of agents available for the contract is restricted within that topographical area. Therefore, endogenous matching of agents is less likely be an issue in the case of groundwater contracts. The author used different crop riskiness measures to investigate the risk-sharing incentive in groundwater contract choice and found no evidence to support the risk-sharing theory.

A review of groundwater contracts in India has shown that the price of water per hour of pumping ranges from USD 0.1 to USD 0.60, which is about 2 to 3 times higher than the pumping cost of water (Saleth, 1998).[4] Certain evidence suggests that the price charged is exorbitant and exploitative, and there are claims that the sellers act as 'water lords' (Shah, 1993, Jacoby et al., 2004). On the other hand, Fujita and Hossain (1995) argue that the price charged is not exorbitant; rather, it is reasonable if one considers the long-term interest rate on tubewell investments. There is clear evidence that the water price paid is higher under an output-shared contract than a fixed-price contract (Kajisa and Sakurai, 2005). It has been argued that an additional increase in the price of water under output-shared contracts than other contracts is a risk premium paid to the seller for sharing the risk.

Most empirical studies have explored the factors that affect the choice of contract after the decision to enter into a contract, with an implicit assumption that the agents have identical bargaining power in the contract decision. However, it is important to understand the relative bargaining power of sellers and buyers in these contracts, which informs us about how competitive the contracts are. To understand agents' relative bargaining power, it is important to understand the trade-offs that each agent faces when deciding on the contract and what are the contract preferences of individual agents before they jointly decide on the contract type.

3. Groundwater contracts in India

Property rights for underground water are linked to land rights in India. Though usufructuary rights to groundwater exist, there are no tradable water rights or organised markets set up for groundwater trading. These implicit rights in groundwater enable trade with those who are unable to invest in a tubewell. Informal groundwater sharing is an alternative instrument when an organised market does not exist, particularly if water is to be

[4] Saleth (1998) reviewed the price information from different studies and found several interesting patterns around different parts of India. The hourly water rate in Gujarat is far higher (USD 0.4 to USD 1.30) than in peninsular hard-rock regions such as Andra Pradesh and Tamil Nadu (USD 0.10 to USD 0.60) and in Indo-Gangetic regions such as Uttar Pradesh and West Bengal (USD 0.11 to USD 0.14). The difference in the price reflects the scarcity value of water and differences in the electricity tariff structure in different states.

allocated at the local level (Easter et al., 1999). Informal groundwater contracts are bilateral contractual agreements between farmers, where groundwater is traded between farmers to cultivate crops. A seller is a party who owns an active tubewell and extracts groundwater for personal cultivation as well as selling water to a neighbouring buyer. A buyer is a party who does not own an active tubewell and buys water from a seller. These are localised, unregulated and verbal contracts; in other words, no third party is involved between sellers and buyers to mediate and enforce the terms and conditions of the contracts.

3.1. Characteristics of groundwater contracts in the study area

We carried out a survey on groundwater contracts in April-May 2015 in the state of Karnataka, India. Three districts, namely Kolar, Chikkaballapura, and Tumkur, were selected based on the intensity of groundwater contracts observed in the previous studies in the state (Somanathan and Ravindranath, 2006, Manjunatha et al., 2011).[5] In total, 29 villages were selected from this district. All villagers with groundwater contracts in the village at the time of the survey were covered. The survey collected detailed information about the water contract agreements, production aspects of the contracted plot and characteristics of buyers and sellers.

The characteristics of groundwater contracts observed in the study area are reported in Table 1. We observed 199 groundwater contracts in the survey. Output-shared contracts cover about 87 percent of total contracts observed, followed by fixed-price contracts (9 percent), land-linked contracts (3 percent) and hourly contracts (1 percent). Manjunatha et al. (2011) and Fujita (2004) have observed a similar pattern, where output-shared contracts dominate other types of contracts in India and Bangladesh, respectively. In our study, under the output-shared contract, one-third of the total output produced is paid as the water price. The share of output does not vary within or between villages and districts.[6] The share of the output was paid after the harvest of the crop and in most cases (91 percent) it is paid in terms of the value of total output. In the case of a fixed-price contract, the fixed amount was decided per season or per year per unit area by seller and buyer, varying depending on the crop. In most cases (89

[5] The selected districts also come under the critically exploited groundwater zone. No other source of irrigation is available except groundwater. Therefore, water demand for agriculture is high. Drilling a new tubewell is a risk due to a deep and confined aquifer. Sharing groundwater allows reallocation of water for the best alternative use.

[6] Kajisa and Sakurai (2003) found variations in the output share from one-fourth to one-third in the state of Madhya Pradesh. However, the price of water varies by one third to two thirds in different parts of India (Saleth, 1998)

percent), the pre-decided fixed amount was paid in two or three instalments before the harvest. In the case of the hourly contract, INR 40 (USD 0.6) per hour of water delivered was paid, but this varies depending on demand for water in the village[7].

Table 1: Groundwater contract characteristics in Karnataka

Particulars of contracts	Output-Shared contract	Fixed-price contract	Hourly payment contract	Land-linked water contract	All
No. of contracts	173	18	2	6	199
Terms of payment	One-third of output value	Fixed amount	40[a] (14.12)	1.2[b] (0.66)	-
Time of payment	After the crop harvest	Instalments before the harvest	After every irrigation	-NA-	-
Crops observed	Chrysanthemum, Maize and Mulberry	Tomato, Mulberry and Maize	Tomato and Onion	Mulberry, Tomato and Maize	-
Price of water per season per acre					
Mulberry	10364 (4154)	6701 (2258)	-NA-	-NA-	-
Maize	4397 (1387)	2800 (754)	-NA-	-NA-	-
Tomato	12789 (9314)	10611 (5759)	-NA-	-NA-	-
Years of contract	3.18 (3.36)	2.14 (2.05)	2.67 (3.30)	3.50 (3.41)	3.09 (3.26)
Area contracted (Acre)	0.58 (0.40)	1.28 (0.71)	0.50 (0.00)	0.79 (0.46)	0.64 (0.48)
Kin relationship between seller and buyer	0.43 (0.50)	0.67 (0.49)	0.00 (0.00)	0.67 (0.52)	0.46 (0.50)

Note: Standard deviations in parentheses. 'a' is payment made, in Rupees per hour of water delivered; 'b' is acres of land lent to the seller in exchange for water for an acre
NA: Not attended

In the case of a contract for an hourly price of water, the buyer pays after every irrigation. In the case of a land-linked contract, no cash or crop output was exchanged between buyer and seller; instead, on average, 1.2 acres of the buyer's land was lent to the seller in exchange for water for an acre of land.[8] We encountered nearly 20 different types of crops grown under groundwater contracts. The most common crops are mulberry (the host

[7] We calculate the water rate per hour of pumping in all types of contracts by considering the total water pumped and water payment made by buyers. We found water price per hour of pumping ranges from USD 0.4 to USD 2. Comparing our hourly water rates to the reported rates of Saleth (1998), which are about USD 0.10 to USD 0.6 in hard rock areas (which includes Karnataka), we see an increase in the price of water per hour.
[8] Implicitly, the land rent acts as the price of water.

plant of the silkworm), maize, tomato, chrysanthemum and China aster. Most of the crops appear in all types of contracts, except chrysanthemum and China aster (cut flowers), which are grown mostly under output-shared contracts. We present the water price paid by buyer per crop season per acre of water delivered for the selected crops. The average amount paid under output-shared contracts is higher than under fixed-price contracts in the case of mulberry, tomato and maize.[9] Land-linked and hourly contracts are ad-hoc contracts which are rarely observed. From now, on we focus on output-shared and fixed-price contracts.

Among the groundwater contract types, the output-shared contract dominates all other types of contracts, which is in contrast to the predictions of the classical theory of contract choice. Output-shared contracts are very common in agrarian contracts (Sadoulet et al., 1997, Pender and Fafchamps, 2006, Fujita, 2004). With an output-shared contract, the agents can share the risk because the water price is paid in terms of the value of total output, which allows the buyer to share the production risk as well as the output price risk with the seller.[10] The crops grown under these contracts are mostly vegetables and flowers, which are risky to produce, in part because the prices of these crops fluctuate more in Indian markets. Therefore, the total risk is high in producing as well as getting a good price for these crops. Consequently, buyers may find the output-shared contracts as a good option given the set of contract choices. Regarding the price of water, the average price paid under output-shared contracts is generally higher than under fixed-price contracts, which increases the unit value of water under output-shared contracts. Therefore, the seller has an incentive to choose an output-shared contract in preference to other contracts. However, it is not clear whose preferences (the buyer's and/or the seller's) preferences are driving the choice of an output-shared contract.

In the survey, we asked both sellers and buyers to state a reason for choosing the particular contract in that season. The survey revealed that 56 percent of buyers under output-shared contracts chose this type of contract because the seller opted for it, 28 percent stated concern over timely irrigation and 12 percent wanted to share the risk and profit with the seller. Similarly, 84 percent of buyers under fixed-price contracts revealed that they preferred

[9] The crops that we observed both under output-shared and fixed-price contracts are selected for the comparison. The water cost is a substantial share of the total input costs in these contracts. The water cost is about 0.5, 0.4 and 0.23 percent of total input cost in output-shared contract and about 0.3, 0.22 and 0.25 percent of total input cost in fixed-price contracts for mulberry, tomato and maize, respectively.

[10] Allen and Lueck (1992) claimed that risk-sharing in output-shared contracts is efficient further if the value of total output is shared, rather than a share of the total output, thereby, the market risk will be shared between agents.

this type of contract because they obtained more profit. On the other hand, 50 percent of sellers under output-shared contracts preferred this type of contract as it generated more profit, 26 percent chose it because the buyer opted for it and 21 percent wanted to share profit and loss with the buyer. Among sellers who had contracts other than output-shared contracts, 52 percent reported that the choice was driven by the buyer's preference, while 28 percent wanted to avoid the risk in the output-shared contract. Agents' stated reasons for their choices indicate that the choice of the output-shared contract is largely due to sellers' preference rather than buyers' preference.

At this point, we do not know whether the preference for output-shared contracts is due to risk-sharing motives or due to differences in the bargaining power of buyers and sellers. In order to understand the choice of contract, we need to understand the individual preferences of buyers and sellers and how their preferences culminate in the final decision about the contract at a given level of risk. Each agent has a preference for a contract which maximises his or her utility given the ability to withstand the risk. If the matched agents have similar contract preferences individually, it is easy for them to decide on the contract jointly. If the agents' individual contract preferences are different, the matched agents have to negotiate the contract type. Each agent has some power to influence the outcome in his or her favour. Based on the assumption of the classical theory of contract choice, we hypothesise that i) sellers and buyers have equal bargaining power in the contract decision. Given the similar (dissimilar) risk preferences, the matched agents might have a divergent (convergent) preference for a contract which leads to a particular choice of contract. For example, if both seller and buyer are risk-averse, the seller would prefer a risk-free contract (other than output-shared), while the buyer would prefer an output-shared contract, allowing the risk to be shared. The case is the reverse if both of them are risk-loving. If the seller is risk-loving and the buyer is risk-averse, both would prefer a contract which shares the risk (output-shared contract).

4. Experiment

4.1. Experiment location

The sellers and buyers who participated in our survey were contacted again and a lab-in-the-field experiment was carried out during the month of December 2015.[11] In total, 199 buyers and 100 sellers participated in the experiment. The experiment involved different steps and was carried out at different intervals (detailed in Section 4.3).

Table 2 presents the socio-economic characteristics of sellers and buyers. Almost all respondents are males and married. In terms of education and family size, both groups appear to be similar, with an average education of five years and with five family members. On average, sellers are older and own more land than buyers, and a Mann-Whitney test suggests that the difference is statistically significant ($p<0.0000$). This indicates a substantial resource gap between sellers and buyers in terms of land ownership. Sellers have a contract with at least two buyers in a season, on average, while buyers mostly buy water from a single seller during a season. Sellers have at least one additional buyer who is potentially ready to enter into a contract, while buyers have almost no other potential seller who is ready to deliver water around their deliverable area. The average length of contracts observed is about three years and the average contracted area is 0.64 acres (≈0.26 hectares). In 46 percent of the contracts, sellers and buyers share kinship ties (Table 1).

Table 2: Socio-economic characteristics of sellers and buyers in groundwater sharing contracts

Variables	Seller				Buyer				Mann-Whitney test (p-value)
	Mean	Std. Dev	Min	Max	Mean	Std Dev	Min	Max	
Gender	0.97	0.17	0	1	0.98	0.14	0	1	0.611
Age	50.74	8.07	28	74	48.26	8.43	24	70	0.014
Education	5.43	4.55	0	16	5.58	4.01	0	15	0.779
Marital status	0.99	0.1	0	1	1	0	1	1	0.317
Family size	5.25	2.61	2	20	5.05	1.37	2	10	0.472
Land owned (acre)	3.31	2.16	1	10	2.13	1.4	0.1	9	0.000
No. of buyers (sellers) per sellers (buyers)	1.89	1.09	1	5	1	0	1	1	0.000
Potential additional buyers/sellers	1.01	1.24	0	4	0.1	0.37	0	3	0.000
No. of observations	101				199				

[11] Before this experiment, all subjects participated in a trust experiment. Both the experiments were finished within the day in each village. We had 199 buyers and 101 sellers in the previous survey. One seller was not available at the time of the experiment.

4.2. Experimental design

We used the multiple price list method developed by Holt and Laury (2002), which was modified to fit the groundwater contract setting. The subjects faced a series of decisions in choosing between an output-shared and a fixed-price contract. In order to frame the choices, we used the observed groundwater contract characteristics from our earlier survey. As a first step, a major crop in each district was selected.[12] The selected crops were mulberry, maize, and chrysanthemum in Kolar, Chikkaballapura, and Tumkur districts, respectively. Secondly, the payoff in the experiment was derived by considering the average yield in the locality and by choosing high and low output prices in the market, which were taken from the survey. Here we explain the case of the mulberry crop. The subjects were asked to assume that they are planning to have a new groundwater contract for an area of 0.25 acres. In a normal production year, 50 kg of cocoons can be produced per crop season per unit area, but the price of cocoons is uncertain. To simplify, we assume that the price of the cocoons by the time of harvest could be either low or high, i.e., INR 100 to INR 400 per kg; however, farmers are not sure about the price probability. Total earnings from the contract would be INR 5000 or INR 20000, depending on whether they got the low or the high price. Terms of payments were assumed as one-third of the total value of output in the case of an output-shared contract and INR 4000 per season per unit area in the case of a fixed-price contract. An output-shared contract would yield profit of INR 3333 or INR 13333 for the buyer, and INR 1667 or INR 6667 for the seller. The fixed-price contract would yield INR 1000 or INR 16000 for the buyer, and INR 4000 for the seller. The earning details for other crops can be seen in the appendix.

Table 3 presents the paired choices faced by buyers and sellers for the mulberry crop. We used 11 choice situations. In each choice situation, the subjects were asked to choose between an output-shared and a fixed-price contract. The earnings are constant across the choices situation for a given contract, while the probability of earnings changes for each choice situation. The probability of a high price is 100 percent to start with and decreases 10 percentage points as we move down the decision rows. So, in the first row, the probability of a high output price is 100 percent. The buyer and seller are certain to earn INR 13333 and

[12] The crops grown are different in all three districts. The production and marketing aspects differ by crop. Thus, subjects would not know the production and market aspects of the crop grown in another district. Use of a single crop was not feasible in terms of presenting a convincing scenario to the subjects, nor was assuming normal yield, because yield varies depending on the fertility of the region.

INR 6667, respectively, if they choose an output-shared contract, and they earn INR 16000 and INR 4000, respectively, if they choose a fixed-price contract. In the subsequent decision rows, the probability of high earnings decreases for each decision row as we move down the decision rows and it reaches probability zero on the final row (certainty of low earning). The last column shows the difference in the expected earnings between output-shared and fixed-price contracts (not shown to subjects). In the first six rows, the expected earnings from the fixed-price contract are higher for the buyer. In the seller's case, the expected earnings from output-shared contracts are higher in the first six rows.

There are two notable features of our experimental design. First, if sellers and buyers are risk-neutral and have the aim of maximising their respective earnings from the contract, each side's preference for a contract type is contradictory to the other. That is, in the first six rows, earnings are higher in the fixed-price contract for the buyer, while they are higher in the output-shared contract for the seller. Second, buyers face market risk in both types of contracts, while sellers face market risk only in output-shared contracts, i.e., not in fixed-price contracts. The buyer faces a choice between two lottery situations, while the seller faces a choice between a lottery and a certain payment.

Table 3: Decisions faced by buyers and sellers for mulberry crop

Row	Buyer decision		Seller decision		Diff. expected earnings (SC-FC)	
	Output-shared contract (SC)	**Fixed-price contract (FC)**	**Output-shared contract (SC)**	**Fixed-price contract (FC)**	**Buyer**	**Seller**
1	Certainty of earning INR **13333**	Certainty of earning INR **16000**	Certainty of earning INR **6667**	Certainty of earning INR **4000**	-2667	2667
2	10% chance of earning INR **3333** OR 90% chance of earning INR **13333**	10% chance of earning INR **1000** OR 90% chance of earning INR **16000**	10% chance of earning INR **1667** OR 90% chance of earning INR **6667**	Certainty of earning INR **4000**	-2167	2167
3	20% chance of earning INR **3333** OR 80% chance of earning INR **13333**	20% chance of earning INR **1000** OR 80% chance of earning INR **16000**	20% chance of earning INR **1667** OR 80% chance of earning INR **6667**	Certainty of earning INR **4000**	-1667	1667
4	30% chance of earning INR **3333** OR 70% chance of earning INR **13333**	30% chance of earning INR **1000** OR 70% chance of earning INR **16000**	30% chance of earning INR **1667** OR 70% chance of earning INR **6667**	Certainty of earning INR **4000**	-1167	1167
5	40% chance of earning INR **3333** OR 60% chance of earning INR **13333**	40% chance of earning INR **1000** OR 60% chance of earning INR **16000**	40% chance of earning INR **1667** OR 60% chance of earning INR **6667**	Certainty of earning INR **4000**	-667	667
6	50% chance of earning INR **3333** OR 50% chance of earning INR **13333**	50% chance of earning INR **1000** OR 50% chance of earning INR **16000**	50% chance of earning INR **1667** OR 50% chance of earning INR **6667**	Certainty of earning INR **4000**	-167	167
7	60% chance of earning INR **3333** OR 40 chance of earning INR **13333**	60% chance of earning INR **1000** OR 40% chance of earning INR **16000**	60% chance of earning INR **1667** OR 40% chance of earning INR **6667**	Certainty of earning INR **4000**	333	-333
8	70% chance of earning INR **3333** OR 30% chance of earning INR **13333**	70% chance of earning INR **1000** OR 30% chance of earning INR **16000**	70% chance of earning INR **1667** OR 30% chance of earning INR **6667**	Certainty of earning INR **4000**	833	-833
9	80% chance of earning INR **3333** OR 20% chance earn INR **13333**	80% chance of earning INR **1000** OR 20% chance of earning INR **16000**	80% chance of earning INR **1667** OR 20% chance of earning INR **6667**	Certainty of earning INR **4000**	1333	-1333
10	90% chance of earning INR **3333** OR 10% chance of earning INR **13333**	90% chance of earning INR **1000** OR 10% chance of earning INR **16000**	90% chance of earning INR **1667** OR 10% chance of earning INR **6667**	Certainty of earning INR **4000**	1833	-1833
11	Certainty of earning INR **3333**	Certainty of earning INR **1000**	Certainty of earning INR **1667**	Certainty of earning INR **4000**	2333	-2333

4.3. Implementation

The experiment was carried out in a sequence of steps. Subjects completed each step with the help of instructions and proceeded to the next step once the previous step was completed. In step 1, the buyers and sellers were contacted separately at their homes. We explained the purpose of contacting them. Once they agreed to participate, we read out the instructions and demonstrated in front of the subjects. Subjects were asked to make two series of decisions, one now and another one later in the evening on the same day. Table 3 was shown to the subjects as part of the first series of decisions (without the difference in expected earnings). The instructor presented the task to the buyer and seller subjects using their respective decision series. At the end of step 1, the subjects were asked to come to a common place in the village in the evening in order to finish the second series of decisions.[13] Step 2 was carried out in the evening, and the actual sellers and buyers from the contract were matched to make decisions jointly. Steps 1 and 2 are similar, except that both seller's and buyer's earnings were presented (see Appendix Table A2). That means that the seller and buyer had to jointly agree on the contract for each decision situation. In both steps, the subjects were allowed to switch between contracts only once.

In the introduction to step 1, the subjects were informed about the second series of the decisions; however, no clue was given about their joint decision. A decision in one of these two series was randomly selected to pay out to three sellers and buyers in each district.[14] It was stressed that the selected subjects were to be contacted at the end of the experiment in each district, which usually took about 6 to 8 days to pay the earnings individually.[15] Paying the subjects individually discourages partners from making internal agreements to choose the contract in a particular way and induces them to maximise their own earnings.

Great care was taken to ensure the subjects' understanding of the output price probabilities and payoff structure of the experiment. In both step 1 and step 2, the choices were explained orally and were demonstrated. The probabilities of high and low output price

[13] They were to collect the participation fee of INR 100, as well as their earnings from the first phase of the experiment (trust experiment). Therefore, they had an incentive to attend the second stage in the evening.

[14] Since the task was adapted to the observed contract characteristics (yield, high and low price, fixed amount), the stakes were high. Therefore, it was not possible to pay all the subjects. To incentivise the subjects for the task, we reduced the number of payments by randomly selecting three sellers and three buyers in each district. The selected candidates were contacted after finishing the experiment in the district.

[15] In order to build up trust with the lag in payment, we gave our experimenter contact information, including personal mobile number. In addition, we were not strangers, as we had conducted a survey before with the same subjects, which had built rapport with them.

were illustrated using green and red slips of paper. Depending on the distribution of high and low output price probabilities, we placed a number of green and red slips into a bag and told the participants to pick a slip from the bag. Drawing a green slip would yield them high-price earnings, while a red slip would yield low-price earnings. For example, in Row 2 of Table 3, we placed nine green slips and one red slip to represent a 90 percent probability of high-price earnings and a 10 percent probability of low-price earnings. In addition, we used an example session, where subjects had to place a correct number of green and red slips into a bag for the given probabilities of high and low-price earnings before they made decisions in step 1. Furthermore, participants were instructed to put the right number of green and red slips into the bag before they took each decision.

At the end of the experiment in each district, three buyers and sellers were randomly selected. The selected subjects were personally contacted and paid later to ensure privacy. In order to select a decision, first a decision series was selected using a coin toss procedure, where *'head'* represents step 1 (individual) series of choices and *'tail'* represents step 2 (joint) series of choices. Then subjects drew a card from a deck of eleven numbered cards to determine which decision in the selected series would be paid for real. For the selected decision, the subject drew a slip from a bag consisting of a number of green and red slips, which corresponded to the distribution of high and low output prices for the selected decision.

The order in which the subject faced the decisions was the same for all the subjects. Following the real-world contract setting, agents first think about their preferred contract, knowing their own ability in farming, and then approach the appropriate partner to make a decision about the contract. Therefore, the subjects made an individual decision first, followed by the joint decision.

5. Model

The buyer's and seller's preference for a contract type were elicited given the two alternative contracts, rather than eliciting their preference for a particular contract. An individual i receives utility $U_{ic}(x)$ from choosing contract c, which is a function of a set of contract attributes x. Following the random utility framework developed by McFadden (1973), utility is modelled as a function of a deterministic and a random component. The deterministic component V_{ic} is a function of contract attributes and the random component ε is stochastic in nature. Thus, the utility of an individual i choosing a contract c is represented

as $U_{ic} = V_{ic} + \varepsilon_{ic}$, where $V_{ic} = f(x)$ is the deterministic component and ε_{ic} is the random component.

An individual i chooses an output-shared contract (sc) in the choice situation j given the alternative of a fixed-price contract (fc) if the utility from the output-shared contract (sc) is greater than or equal to the utility from choosing the fixed-price contract, i.e., $U_{isc} \geq U_{ifc}$

The probability of choosing an output-shared contract by i under choice situation j is:

$$P_{ij}(sc) = Prob\left[V(x_{ijsc}) + \varepsilon_{ijsc}) > V(x_{ijfc}) + \varepsilon_{ijfc})\right] \quad (1)$$

We have one attribute from the contract, which is `*earnings*´. Assuming the utility is linearly associated with earnings, the probabilistic model can be written as,

$$P_{ij}(sc) = Prob\left[V(Earning_{jsc} - Earning_{jfc}) + (\varepsilon_{ijsc} - \varepsilon_{ijfc}) > 0\right] \quad (2)$$

The econometric specification becomes

$$P_{ij}(sc) = \alpha + \beta_i \Delta Earning_j + \eta_{ij} \quad (3)$$

where α is an alternative specific constant (ASC) that represents preference for output-shared or fixed-price contract, irrespective of the earnings between contracts. $\Delta Earning_j = Earning_{jsc} - Earning_{jfc}$, $\eta_{ij} = \varepsilon_{ijsc} - \varepsilon_{ijfc}$, and β is the parameter to be estimated. The parameter β represents how the difference in earnings between contracts is associated with the choice of contract.

Given the individual preferences of buyers and sellers and their joint contract preferences, we can make two types of comparisons. First, comparing the joint decision to the individual decisions of sellers and buyers (joint vs. seller and buyer) allows us to understand whose preference the joint decision corresponds to. By doing so, we encounter four potential joint outcomes, where i) the joint decision is identical to the seller's individual decision, ii) the joint decision is identical to the buyer's individual decision, iii) the joint decision is identical to both the buyer's and seller's individual decisions and iv) the joint decision is different from both the buyer's and seller's individual decisions.[16] These joint outcomes are

[16] The fourth category is called 'choice shifts' in decision theory. Choice shift is a feature of group decision-making, where the group decision processes affect the individual members' decision-making. In that case, individuals make different choices within the group than the choices they make individually (Eliaz et al., 1971). Out of total decisions the matched pairs have made, 47, 28, 15, and 10 percent of the decisions belong to category i), category ii), category iii) and category iv), respectively.

mutually exclusive for a matched pair i given the choice situation j. Second, comparing the individual decisions of sellers and buyers (sellers vs. buyers) for each choice situation allows us to understand how individual agents' preferences are aligned. Given the choice situation, if the seller's choice is identical to the choice of the buyer, then the matched pair i is said to be in *'agreement'* with each other's preferences. If the seller's choice is different from the choice of the buyer, then the matched pair i is said to be in *'disagreement'* with each other's preferences. If the matched pairs are in agreement in their individual preferences, that is, the seller's preference for the contract is identical to the preference of the buyer, the joint decision will be identical to both agents' preferences (joint outcome category iii). If the matched pairs are in disagreement with each other's individual preferences, that is, the seller's preference is not identical to the preference of the buyer, the joint decision will be identical to either the seller's or buyer's preference (joint outcome category i or ii). That is, they have to negotiate the joint decision, each trying to influence the joint decision in his favour. Depending on the relative bargaining power of sellers and buyers, the joint decision is identical to either the seller's preference or the buyer's preference.

In order to understand the relative bargaining power of sellers and buyers, we need to understand how the individual preference disagreement determines the joint outcome that represents either the seller's or buyer's preferred decision. If the joint decision is identical to the seller's preference, we can say that the seller has more power to influence the joint decision in his favour, and vice versa if the joint decision is identical to the buyer's preference. For a matched pair i in a given choice situation j, we specify the model as follows:

$$y_{ij} = \alpha + \beta_1\, disagreement_{ij} + \beta_2 Rx_i + \beta_3\, C_i + \varepsilon_{ij} \qquad (4)$$

where y_{ij} represents whose decision the joint decision corresponds to in a choice situation j for pair i. It takes the value *one* if the joint decision is identical to the buyer's individual decision and *zero* if the joint decision is identical to the seller´s decision.[17] The variable $disagreement_{ij}$ represents the degree of disagreement in individual preferences between a buyer and seller in pair i in choice situation j. Rx_{ij} represents observed characteristics of the buyer in in relation to seller, i.e., characteristics that describe the extent to which agents differ in their characteristics and C_i represents observed contract characteristics for pair i. ε_{ij} is a

[17] We also estimate a Multinomial Logit model considering all four categories of joint decisions corresponding to individual preferences. The estimated model is presented in appendix Table A1.

random error term of pair i in a choice situation j. $\beta's$ are a set of parameters to be estimated. Parameter β_1 represents the relative bargaining power of buyers in deciding the joint contract. If β_1 is positive, the buyer has relatively more power in the joint decision, while, if β_1 is negative, the seller has more power.

The degree of disagreement indicates the preference divergence between buyers and sellers for a given choice situation. We construct the degree of disagreement using the predicted probability of contract choice by buyers and sellers for each choice situation, from Equation 3, and we take the absolute difference between predicted probabilities of buyers and sellers. The measure of the degree of disagreement ranges from 0 to 1. It is 0 if the buyer and seller have a similar preference for a contract and 1 if the buyer and seller have a contrary preference for a contract. Any value between zero and one indicates the extent of disagreement. Figure 2 in the appendix shows the degree of disagreement between buyers and sellers over the choice situations. The degree of disagreement decreases as the low and high price risks become closer to each other. We estimate Equation (3) and (4) using a Random Parameter Binary Probit (RPBP) model, where the model assumes the estimated parameter to varies across the population with a specific distribution (Revelt and Train, 1998). The parameters of earnings (Equation 3) and disagreement (Equation 4) are specified as normally distributed and assumed to be heterogeneous across the matched pairs. The intercept and parameters of relative socio-economic characteristics and contract characteristics are assumed to be fixed. We resort to the simulated maximum likelihood method to approximate the choice probabilities, which allow us to estimate the individual specific predicted probabilities for each choice situation (Train, 2003).

6. Results

Table 4 reports the proportion of output-shared contracts chosen by buyers, sellers and jointly for each decision row. We have 177 matched pairs, who have made individual as well as joint decisions.[18] With a very small risk of a low output price, the proportion of sellers that prefer an output-shared contract is very high. With an increased risk of a low output price, the proportion of output-shared contracts decreases among the sellers. In contrast, the proportion of buyers who prefer an output-shared contract is low when the risk of a low price is small. For sellers, there is a gradual shift from output-shared to fixed-price contracts as the

[18] Nine out of 177 pairs have switched twice between contracts in the joint decision. Adding these joint choices did not change our main results. Therefore, we include them in our main analysis.

probability of a low price increases. However, for buyers, there is a large shift towards output-shared contracts once the probability of a low price is above 50 percent. In the joint decision, we observed 57 percent of the decisions shifting from output-shared to fixed-price contracts and a 23 percent shift from fixed-price to output-shared contracts as the risk of low output price increases. For the remaining decisions, 18 and 2 percent of the joint decisions were for output-shared and fixed-price contracts throughout the choice situations, respectively. The preference for an output-shared contract is high when low output price risk is very small, and it decreases with an increased risk of a low output price. As can be noticed, the contract choice pattern in the joint decision is more similar to the choice pattern of sellers than that of buyers. The Pearson chi-square test revealed that there exist significant distributional differences in the choice of contract between sellers, buyers and the joint decisions.[19]

Table 4: Proportion of output-shared contract choices in buyer's, seller's, and joint decision

Decision row	Relative frequency of output-shared contract choices		
	Buyer	**Seller**	**Joint**
1	0.00	1.00	0.74
2	0.10	0.93	0.74
3	0.18	0.88	0.73
4	0.28	0.84	0.66
5	0.38	0.69	0.63
6	0.68	0.56	0.58
7	0.84	0.42	0.54
8	0.93	0.27	0.49
9	0.95	0.16	0.43
10	0.98	0.09	0.40
11	1.00	0.00	0.41
No. of observations	177	91	177
Average no. of safe choices	6.32 (2.10)	5.15 (2.52)	-

Standard deviation in parentheses

Risk preferences of buyers and sellers are measured by accounting for the number of safe choices made in the individual decisions.[20] The buyer faces a choice between two contracts that carry risk; the safe option in such a case is the choice of the contract that yields less variable earnings between high and low output prices. Given the choice sets in Table 3,

[19] Using a chi-square test, we compared each decision situation between buyers vs. sellers, joint vs. sellers and joint vs. buyers. In total, 33 chi-square tests indicated that there exists a statistical difference in the choice of contract between these groups.

[20] Safe choices are a number of safe alternatives chosen after shifting from a risky alternative without ever shifting back.

variability in earnings under an output-shared contract is relatively low than a fixed-price contract. A risk-neutral buyer would choose an output-shared contract at least five times. If a buyer were to choose an output-shared contract more than five times, he would be considered risk-averse. If a buyer were to choose an output-shared contract fewer than five times, he would be considered a risk-lover. The seller faces a choice between a risky contract and a safe contract; the fixed-price contract is the safe contract, which does not carry any risk. A risk-neutral seller would choose a fixed-price contract at least five times given the choice situations. If the seller were to choose a fixed-price contract more than five times, he would be considered risk-averse. If a seller were to choose a fixed-price contract fewer than five times, he would be considered a risk-lover. The last row in Table 4 shows the number of safe choices made by sellers and buyers. An average of 6 and 5 safe choices are made by buyers and sellers, respectively. The difference in the number of safe choices between buyers and sellers is statistically significant at the 1 percent level (t-test), which indicates that the buyers are relatively more risk-averse than sellers.

Next, we analyse the determinants of the individual decisions. We use a random parameter binary probit model to estimate Equation (3), where the dependent variable is equal to one if the output-shared contract is chosen. All models are estimated using 500 Halton draws. The estimated coefficients are presented in Table 5. In Columns 1 and 3, we report the results from a model with the difference in expected earnings between output-shared and fixed-price contract and crop dummies as explanatory variables. The difference in expected earnings between contracts could take positive or negative values. A positive difference means that the expected earnings from an output-shared contract are higher than from a fixed-price contract, and the contrary is true for the negative difference. We allow for different effects of positive and negative differences in earnings between contracts. In Columns 2 and 4, we include socio-economic characteristics of buyers and sellers.

In the buyer's decisions, the alternative specific constant (ASC) is positive and significant, which indicates that the buyers have intrinsic preferences for an output-shared contract. When the expected earnings from the output-shared contract are higher than from the fixed-price contract, an increase in the level of difference in the earnings between contracts increases the likelihood of choosing the output-shared contract, and vice versa when the expected earnings from the fixed-price contract are higher than those from the output-shared contract. The coefficients of the crop dummies reveal that output-shared contracts are

less likely for mulberry and maize crops than for chrysanthemum. The earnings difference between high and low output prices under fixed-price contracts is wider for chrysanthemum, while it is relatively low in the cases of mulberry and maize. Among the socio-economic variables, buyers with more education and more land are less likely to choose output-shared contracts, which suggests that they are less likely to face liquidity constraints, and thus more likely choose fixed-price contracts. If a buyer had an output-shared contract in the previous season, he is more likely to choose an output-shared contract.

In the seller's decision, the ASC is negative and not statistically significant, which suggests that the sellers do not have any particular preference for contract type. When the expected earnings from the output-shared contract are higher than from the fixed-price contract, an increase in the difference in earnings between contracts increases the likelihood of choosing the output-shared contract, and vice versa when the earning from the fixed-price contract is more than from the output-shared contract. With respect to crop dummies, sellers are less likely to choose output-shared contracts for mulberry and maize crops than for chrysanthemum crops; a significant difference exists between maize and chrysanthemum. Sellers have on average two buyers, which means that they could have the same or different contracts with different buyers. Sellers' contracts in the previous season were classified into three categories: i. output-shared contract with all the buyers, ii. contracts other than an output-shared contract with all the buyers and iii. different contracts with different buyers. Considering a seller who had different contracts with different buyers as a base case, we find that the sellers who had contracts other than an output-shared contract with all buyers are less likely to choose output-shared contracts than are the base group. This implies a path-dependent choice of contract. The estimated standard deviations on the difference in earnings between the contracts are significant in both the sellers' and buyers' case, which suggests that we capture the unobserved heterogeneity in buyers' and sellers' choices with respect to earnings in the contract.

Table 5: Results of random parameter binary probit model for the buyer's and seller's preference for output-shared contracts

Variables	Buyer		Seller	
	(1)	**(2)**	**(3)**	**(4)**
Alternative specific constant	2.293*** (0.105)	2.083*** (0.192)	-0.086 (0.120)	-0.187 (0.189)
Difference in earnings (SC – FC) if SC> FC	6.330*** (0.653)	6.630*** (0.620)	2.347*** 0.236	2.368*** (0.237)
Difference in earnings (SC – FC) if SC< FC	-1.070*** (0.066)	-1.179 *** (0.068)	-0.812*** (0.138)	-0.845*** (0.142)
Crop: Mulberry	-2.607*** (0.105)	-1.959*** (0.130)	-0.194* (0.110)	-0.102 (0.149)
Crop: Maize[a]	-2.510*** (0.112)	-2.672*** (0.123)	-0.696*** (0.116)	-0.767*** (0.122)
Socio-economic characteristics				
Education (years)		-0.106*** (0.011)		0.030*** (0.009)
Land holdings (acres)		-0.130*** (0.031)		0.034 (0.022)
Previous contract: SC		1.234*** (0.143)		-0.144 (0.136)
Previous contract: Other than SC[b]				-0.640*** (0.164)
Standard deviation of the random variables				
Difference in earnings (SC – FC) if SC> FC	3.387*** (0.322)	3.506*** (0.315)	1.514*** (0.150)	1.554*** (0.155)
Difference in earnings (SC – FC) if SC< FC	0.605 *** (0.046)	0.663*** (0.048)	0.553*** (0.089)	0.576*** (0.092)
Pseudo R-squared	0.296	0.311	0.23	0.23
No. of observation	1947		1001	
No. of buyers/sellers	177		91	

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*
a- Base is chrysanthemum flower crop, b – Base is when the seller has both sc and other than sc with buyers

In order to understand the choice dynamics in the joint decision with respect to risk preferences of sellers and buyers, we plot the proportion of output-shared contract choice depending on the relationship of risk preferences between buyers and sellers for each choice situation.[21] Figure 1 shows that, when buyers are more risk-averse than sellers the proportion of output-shared contract choice is high compared to when they have same risk preferences and when buyers are less risk-averse than sellers. There is no difference in the proportion of output-shared contract choice in the latter two cases. Note that, for the first three decision rows, the proportion of output-shared contracts is very high irrespective of the risk preferences of agents. In the first three decision rows, the probabilities of high price-earnings are high; therefore, the choice of output-shared contract benefits sellers more than buyers. This finding suggests that the joint choice of the contract is influenced more by sellers than buyers.

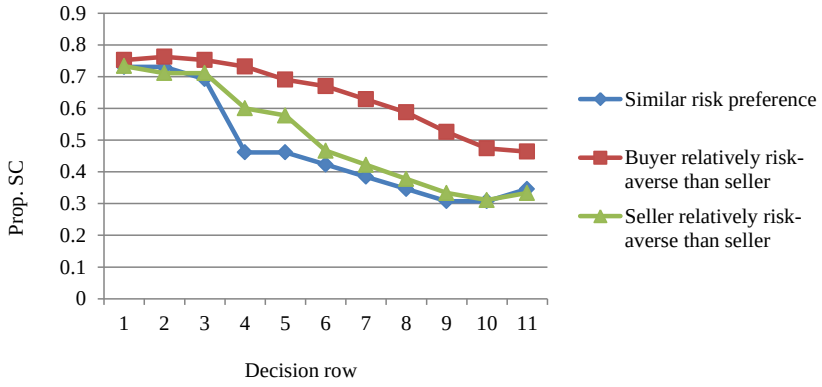

Figure 1: Proportion of output-shared contract choice according to the risk preferences of buyers and sellers

The marginal effects of estimated Equation (4) are presented in Table 7. The coefficient of the degree of disagreement is negative and significant at the 10 percent level. The model results imply that a 10-percentage point increase in the level of disagreement between the seller's and buyer's individual preferences reduces the likelihood that the buyer's choice corresponds to the joint decision by 2 percentage points. In other words, the results indicate that sellers have relatively more power to influence the joint decision. A kinship tie between

[21] Our risk-aversion measure is the number of safe choices by sellers and buyers in the individual decisions. Among the matched pairs, 58 percent of buyers are relatively more risk-averse than sellers, 27 percent of buyers are relatively less risk-averse than sellers and 15 percent of buyers are equally risk-averse as sellers.

sellers and buyers has a significant impact on the joint decision outcomes. When a buyer and a seller share kinship ties, the probability that the buyer's choice is equal to the joint decision increases by 16 percentage points than non-kin pairs. This suggests that kinship increases the relative power of buyers in joint decisions. With respect to crop dummies, the joint decisions are less likely to correspond to the buyer's choice for mulberry and maize crops than for chrysanthemum. Because chrysanthemum is a high-stakes flower crop which requires more investment and faces more output price variations than do mulberry and maize, the buyer puts more effort into driving the joint decision toward his preferred contract in order to avoid loss. [22]

Table 7: Estimates of conditional model for buyers' bargaining power

Dep variable: Joint choice= Buyer's choice	**(1)**	**(2)**
		Disagreement>0.5
Disagreement b/w buyer and seller | $Prob^b(sc) - Prob^s(sc)$ |	-0.240***	-0.337***
	(0.000)	(0.000)
Kinship ties	0.164***	0.153***
	(0.000)	(0.000)
Years of contract	0.001	0.017***
	(0.864)	(0.001)
Previous contract: SC	-0.028	-0.171***
	(0.489)	(0.001)
No. of potential sellers	0.022	0.034
	(0.674)	(0.570)
Buyer owns more land than seller	0.042	-0.074**
	(0.121)	(0.016)
Buyer more education than seller	0.024	0.074**
	(0.334)	(0.011)
Buyer older than seller	-0.027	-0.058*
	(0.297)	(0.050)
Crop: Mulberry	-0.119***	-0.019
	(0.001)	(0.600)
Crop: Maize	-0.125***	-0.236***
	(0.000)	(0.000)
No. of observations	1445	1255
No. of pairs	177	177
McFadden Pseudo R-squared	0.19	0.23

*p- values in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

[22] Average number of safe options chosen by buyers is 5.08, 5.79 and 7.16 and by sellers 5.12, 6.17 and 4.62 for mulberry, maize and flower crops, respectively. The median difference showed that the difference in the number of safe choices made by buyers and sellers is significantly different (Prob > |z| = 0.00) in the case of flowers, while the difference is not significant in the case of mulberry and maize crops.

It is interesting to see the magnitude of the relative bargaining power of buyers when the matched pairs are at an equal level of disagreement regarding each other's individual preferences, and what characteristics of agents increase the bargaining power of buyers. In Column 2, we estimate the model by restricting the degree of disagreement to more than 0.5 units. The results confirm the relatively greater power of sellers in the bargaining process when there is an equal level of disagreement with each other's preferences. Kinship ties, an increase in the length of contract with the seller and having more education than the seller increase the likelihood of the buyer's preference corresponding to the joint decision. This confirms that the interpersonal relationship between sellers and buyers through kinship ties and long-term contracts increases the buyer's relative bargaining power. We also notice that the relative power of the buyer decreases when the buyer and seller had an output-shared contract in the previous season and when the buyer has more land than the seller. In the latter case, the buyer has to accept the seller's preferred contract because the buyer is in need of water to irrigate a large area.

7. Conclusions

In developing countries, many agricultural input markets are still informal in nature, due to poor formal institutions that otherwise would facilitate transactions. It is believed that these informal markets work pretty well as long as the number of buyers and sellers is high, which increases the competition in the market (Easter et al., 1999). However, there is large concern about market power development in groundwater markets, due to increasing water scarcity and topographical constraints on water delivery. In this study, we examined the relative bargaining power of buyers and sellers in informal groundwater contracts in India. We carried out a lab-in-the-field experiment using matched pairs of sellers and buyers who had groundwater contracts at the time of the study. In the experiment, sellers and buyers made a series of decisions, choosing between an output-shared and a fixed-price contract with a varied probability of output price. The agents made decisions first individually and then jointly.

Our survey on groundwater contracts in the study area indicates that 87 percent of the observed groundwater contracts are of the output-shared type. From the experiment, we find a high preference towards output-shared contracts in the joint decisions than the individual choices of sellers and buyers, which is consistent with the high proportion of output-shared

contracts observed in the study area. Further, in the joint decision, the preference for output-shared contracts increases when buyers are more risk-averse than sellers. That is, the choice of an output-shared contract allows the risk-averse buyer to share the risk with a seller who is relatively less risk-averse. We also observed that 60 percent of the buyers are relatively more risk-averse than the sellers, which suggest a reason for the strong preference for the output-shared contract.

We find that sellers have more bargaining power to influence the joint decision in their favour when individual preferences are in disagreement. Our findings suggest that sellers have market power in groundwater contracts. Different studies have measured market power in different ways that are difficult to compare directly with our findings. Janakarajan (1993) and Shah and Ballabh (1997) found evidence that the price charged for water is higher than the cost of extraction in groundwater contracts, which they depicted as the characteristics of a monopoly market. In contrast, Kolvalli and Ciconine (1989) argued that sellers do not exercise the full power of their monopoly position due to interlinkages in the input markets such as labour and capital markets. Furthermore, they argue that reputational concerns in the close community in villages might induce sellers to charge a reasonable price.

We identified some characteristics of buyers that augment their relative bargaining power in the contract choice. We find that when buyer and seller have had a long history of a contractual relationship and when they share kinship ties, both factors increase the buyer's relative power to influence of the final outcome in the joint decision-making. Evolution of a strong interpersonal relationship between buyers and sellers through a long history of contracts together and altruistic concerns towards kin buyers might be the underlying factors that allow buyers to exert their preferences in a joint decision. This finding is consistent with that of Jacoby et al. (2004), who found price discrimination in groundwater contracts in Pakistan, where they found sellers charged a lower price for tenants-cum-buyers compared to non-tenant buyers. Similar evidence was found in Tamil Nadu by Janakarajan (1993) and Narayanamoorthy (1991), where sellers provided hidden price concessions and priority services to large, regular and on-time payment buyers.

Our findings have two important implications. First, they give a clear picture about sellers' exploitative behaviour in these contracts. It is not surprising to find that sellers have more influence in the choice of contracts given their usufructuary right to extract groundwater

and the scarcity of water in India. Because these contracts are unregulated, the poor and marginal farmers who depend on these contracts for food production are exploited, which is a great concern in rural areas. This raises the question of the equity implications of these contracts. Second, present trends of decreasing rates of aquifer levels in India further increase the water scarcity (World Bank, 2010). This might further widen the bargaining power gap between buyers and sellers. Shah (1993) has expressed concerns about the success of legal or organisational public policy intended to regulate these contracts unless the system of property rights in groundwater is reformed drastically, based on an understanding of the local institutional settings. The present study provides information about the relative bargaining position of agents in these contracts, which can be considered in different policy interventions that are needed to bring the present form of groundwater contracts towards a competitive market with the sustainable extraction of water.

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Appendix

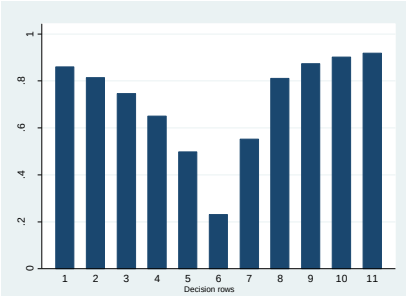

Figure 2: Degree of disagreement between buyer's and seller's preferences

Table A1: Marginal effects of multinomial probit model with 4 categories of choices

Variables	(1) Joint=Seller	(2) Joint=Buyer	(3) Joint=Seller=Buyer	(4) Choice shift case
Disagreement b/w buyer and seller | $Prob^b(sc) - Prob^s(sc)$ |	0.476***	0.152***	-0.385***	-0.242***
	(0.046)	(0.047)	(0.031)	(0.026)
Kinship ties	-0.131***	0.138***	0.004	-0.011
	(0.035)	(0.036)	(0.024)	(0.019)
Years of contract	-0.011**	0.007	0.008**	-0.003
	(0.006)	(0.005)	(0.003)	(0.003)
Previous contract: SC	0.071	-0.083	-0.029	0.041
	(0.065)	(0.055)	(0.048)	(0.034)
No. of potential sellers	-0.020	0.071*	0.046	-0.096**
	(0.055)	(0.040)	(0.033)	(0.049)
Buyer owns more land than seller	-0.015	-0.010	0.039	-0.014
	(0.041)	(0.039)	(0.027)	(0.023)
Buyer more education than seller	-0.040	0.029	0.010	0.002
	(0.039)	(0.037)	(0.026)	(0.019)
Buyer older than seller	0.057	-0.033	0.007	-0.032
	(0.042)	(0.037)	(0.028)	(0.021)
Crop: Mulberry	0.094	-0.093*	-0.001	-0.001
	(0.059)	(0.050)	(0.043)	(0.030)
Crop: Maize	0.190***	-0.109***	-0.066***	-0.015
	(0.042)	(0.041)	(0.024)	(0.022)
No. of observations	1,947	1,947	1,947	1,947
No. of pairs	177	177	177	177

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table A2: Joint decision faced by sellers and buyers for mulberry crop

Decision row	Earnings in SC			Your choice		Earnings in FC
				SC	FC	
1	Certainty that seller earns INR **6667** and buyer earns INR **13333**					Certainty that seller earns INR **4000** and buyer earns INR **16000**
2	With 10% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 90% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 10% chance or INR **16000** with 90% chance
3	With 20% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 80% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 20% chance or INR **16000** with 80% chance
4	With 30% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 70% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 30% chance or INR **16000** with 70% chance
5	With 40% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 60% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 40% chance or INR **16000** with 60% chance
6	With 50% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 50% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 50% chance or INR **16000** with 50% chance
7	With 60% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 40% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 60% chance or INR **16000** with 40% chance
8	With 70% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 30% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 70% chance or INR **16000** with 30% chance
9	With 80% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 20% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 80% chance or INR **16000** with 20% chance
10	With 90% chance seller earns INR **1667** and buyer earns INR **3333**	OR	With 10% chance seller earns INR **6667** and buyer earns INR **13333**			Seller earns INR **4000** and buyer earns INR **1000** with 90% chance or INR **16000** with 10% chance
11	Certainty that seller earns INR **1667** and buyer earns INR **3333**					Certainty that seller earns INR **4000** and buyer earns INR **1000**

Table A3: Expected earnings in SC and FC for sellers and buyers for mulberry crop

Decision row	Expected earnings in SC		Expected earnings in FC		Diff (SC-FC)		Risk-aversion parameter	
	Seller	**Buyer**	**Seller**	**Buyer**	**Seller**	**Buyer**	**Seller**	**Buyer**
1	6667	13333	4000	16000	2667	-2667	> 3.25	> 1.15
2	6167	12333	4000	14500	2167	-2167	3.25	1.15
3	5667	11333	4000	13000	1667	-1667	2.18	0.76
4	5167	10333	4000	11500	1167	-1167	1.44	0.49
5	4667	9333	4000	10000	667	-667	0.81	0.27
6	4167	8333	4000	8500	167	-167	0.20	0.07
7	3667	7333	4000	7000	-333	333	-0.42	-0.14
8	3167	6333	4000	5500	-833	833	-1.13	-0.37
9	2667	5333	4000	4000	-1333	1333	-2.04	-0.65
10	2167	4333	4000	2500	-1833	1833	-3.47	-1.08
11	1667	3333	4000	1000	-2333	2333	> -3.47	> -1.08

Table A4: Joint decisions faced by sellers and buyers for maize crop

Decision row	Earnings in SC			Your choice		Earnings in FC
				SC	FC	
1	Certainty that seller earns INR **3000** and buyer earns INR **6000**					Certainty that seller earns INR **2000** and buyer earns INR **7000**
2	With 10% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 90% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 10% chance or INR **7000** with 90% chance
3	With 20% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 80% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 20% chance or INR **7000** with 80% chance
4	With 30% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 70% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 30% chance or INR **7000** with 70% chance
5	With 40% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 60% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 40% chance or INR **7000** with 60% chance
6	With 50% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 50% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 50% chance or INR **7000** with 50% chance
7	With 60% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 40% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600**with 60% chance or INR **7000** with 40% chance
8	With 70% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 30% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 70% chance or INR **7000** with 30% chance
9	With 80% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 20% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 80% chance or INR **7000** with 20% chance
10	With 90% chance seller earns INR **1200** and buyer earns INR **2400**	OR	With 10% chance seller earns INR **3000** and buyer earns INR **6000**			Seller earns INR **2000** and buyer earns INR **1600** with 90% chance or INR **7000** with 10% chance
11	Certainty that seller earns INR **1200** and buyer earns INR **2400**					Certainty that seller earns INR **2000** and buyer earns INR **1600**

Table A5: Expected earnings in SC and FC for sellers and buyers for maize crop

Decision row	Expected earnings in SC		Expected earnings in FC		Diff (SC-FC)		Risk-aversion parameter	
	Seller	Buyer	Seller	Buyer	Seller	Buyer	Seller	Buyer
1	3000	6000	2000	7000	1000	-1000	> 5.15	> 2.02
2	2820	5640	2000	6460	820	-820	5.15	2.02
3	2640	5280	2000	5920	640	-640	3.47	1.35
4	2460	4920	2000	5380	460	-460	2.33	0.90
5	2280	4560	2000	4840	280	-280	1.38	0.53
6	2100	4200	2000	4300	100	-100	0.49	0.19
7	1920	3840	2000	3760	-80	80	-0.41	-0.15
8	1740	3480	2000	3220	-260	260	-1.40	-0.53
9	1560	3120	2000	2680	-440	440	-2.64	-0.99
10	1380	2760	2000	2140	-620	620	-4.54	-1.68
11	1200	2400	2000	1600	-800	800	> -4.54	> -1.68

Table A 6: Joint decisions faced by sellers and buyers for chrysanthemum crop

Decision row	Earnings in SC			Your choice		Earnings in FC
1	Certainty that seller earns INR **19000** and buyer earns INR **38000**			SC	FC	Certainty that seller earns INR **10000** and buyer earns INR **47000**
2	With 10% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 90% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 10% chance or INR **47000** with 90% chance
3	With 20% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 80% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 20% chance or INR **47000** with 80% chance
4	With 30% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 70% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 30% chance or INR **47000**with 70% chance
5	With 40% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 60% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 40% chance or INR **47000** with 60% chance
6	With 50% chance seller earns INR **3400** and, buyer earns INR **6800**	OR	With 50% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 50% chance or INR **47000** with 50% chance
7	With 60% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 40% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 60% chance or INR **47000** with 40% chance
8	With 70% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 30% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 70% chance or INR **47000** with 30% chance
9	With 80% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 20% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 80% chance or INR **47000** with 20% chance
10	With 90% chance seller earns INR **3400** and buyer earns INR **6800**	OR	With 10% chance seller earns INR **19000** and buyer earns INR **38000**			Seller earns INR **10000** and buyer earns INR **200** with 90% chance or INR **47000** with 10% chance
11	Certainty that seller earns INR **3400** and buyer earns INR **6800**					Certainty that seller earns INR **10000** and buyer earns INR **200**

Table A7: Expected earnings in SC and FC for sellers and buyers for chrysanthemum crop

Decision row	Expected earnings in SC		Expected earnings in FC		Diff (SC-FC)		Risk-aversion parameter	
	Seller	Buyer	Seller	Buyer	Seller	Buyer	Seller	Buyer
1	19000	38000	10000	47000	9000	-9000	> 2.83	> 0.83
2	17440	34880	10000	42320	7440	-7440	2.83	0.83
3	15880	31760	10000	37640	5880	-5880	1.97	0.58
4	14320	28640	10000	32960	4320	-4320	1.38	0.40
5	12760	25520	10000	28280	2760	-2760	0.87	0.25
6	11200	22400	10000	23600	1200	-1200	0.38	0.11
7	9640	19280	10000	18920	-360	360	-0.12	-0.04
8	8080	16160	10000	14240	-1920	1920	-0.69	-0.20
9	6520	13040	10000	9560	-3480	3480	-1.41	-0.41
10	4960	9920	10000	4880	-5040	5040	-2.56	-0.74
11	3400	6800	10000	200	-6600	6600	> -2.56	> -0.74

Chapter II

Contract Choice and Risk Preferences: Evidence from Informal Groundwater Contract Choices in Rural India

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Abstract

Exploring the different contract systems in an agrarian market is important to understand their efficiency and equity aspects. This study analyses factors that can affect the choice of groundwater contracts in rural India. A primary survey and a lab-in-the-field experiment were carried out to obtain matched information about buyers and sellers of groundwater and to elicit their risk preferences. We find that the risk preferences of both sellers and buyers influence the choice of contract, which suggests a risk-sharing motive in the choice decision. A situation with a buyer who is more educated and older than the seller is associated with a lower probability that the contract is an output-shared contract, which implies the agents' relative influence on the contract decision. The results are particularly relevant for groundwater contracts where the endogenous matching of agents is less likely be an issue.

JEL Codes: C83, C93, D86, Q13, Q25

Keywords: Output-shared contract, Fixed-price contract, Endogenous matching, Omitted variable bias

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1. Introduction

India is the largest user of groundwater in the world and groundwater is a valuable resource in rural India. Groundwater is the source of irrigation for about 60 percent of India's total irrigated area and 85 percent of the drinking water supply (World Bank, 2010). The dependency on groundwater has led to unsustainable extraction and decreasing aquifer levels, which in turn has serious implications for farmers' livelihood and food security.[24] The scarcity of groundwater has stimulated informal trading of water at local levels, where formal markets do not exist to facilitate such trades. Informal groundwater trading is important in areas that depend heavily on groundwater for irrigation. These contracts are bilateral agreements between individuals. A farmer who has access to groundwater beneath his or her land can install a tubewell and extract water. In the event that there is surplus water, the farmer can sell (seller) the surplus to a farmer who is in need of water (buyer). These contracts are common in South Asia and in some parts of China. In India, these contracts cover over 15 percent of the total irrigated area (Saleth, 1998).

The agents who trade groundwater can have different types of contractual agreements. The most common in groundwater markets are output-shared, in which the contractual parties decide on the share of the total output to pay for water delivered, and fixed-price contracts, in which the parties decide on a fixed amount to pay per season of water delivered (Kajisa and Sakurai, 2005). These groundwater contracts increase access to water for small and marginal farmers who are unable to install tubewells, and they increases the irrigated area and food production in the country (Meinzen-Dick, 1996, Mukherji, 2004, Shah, 1993). However, the effects of these contracts on efficiency and equality in income distribution have been questioned (Easter and Hearne, 1995, Jacoby et al., 2004)

Output-shared contracts are often described as sub-optimal due to the potential incentive of undersupply of labour and other inputs, which results in lower productivity than other types of contract (Otsuka and Hayami, 1988). In general, the water price paid under output-shared contracts is higher than other contracts (Kajisa and Sakurai, 2005, Shah and Ballabh, 1997), which leads to different equity implications for the agents involved in these contracts. Interestingly, output-shared contracts are the most common agrarian contracts (Fujita, 2004). The perceived inefficiency and high water price in output-shared contracts raises the question

[24] If the present extraction trend continues, 60 percent of India's aquifers will be in critical condition by 2030 (World Bank, 2010).

of what makes agents choose an output-shared contract. In this paper, we analyse the factors that affect the choice between fixed-price and output-shared contracts in the context of informal groundwater contracts in rural India.

The classical theories of contract choice model the choice of contract as a function of transaction costs (Datta et al., 1986, Murrell, 1983), financial constraints (Laffont and Matoussi, 1995, Ackerberg et al., 2002, Tikabo et al., 2007) and risk-sharing incentives (David, 1977, Holmström, 1979, Stiglitz, 1974). In the empirical literature, a number of proxy variables have been used to test these theories. In particular, testing the risk-sharing theory, Allen and Lueck (1999) and Aggarwal (2007) used a crop riskiness measure and found no support for a risk-sharing argument.[25] On the other hand, Bezabih (2009) considered both landlords' and tenants' risk preferences for land rental contract choice and found that the risk preference of the landlord affected the choice of contract. The empirical evidence for risk-sharing is mixed. The empirical studies mostly estimate a reduced form choice equation with two important assumptions. First, it is assumed that the agents are randomly matched, that is, the agents' characteristics are independent of each other. However, Ackerberg et al. (2002) showed that a rich landlord who owns a vineyard had an output-shared contract with poor tenants, which suggests that landlords and tenants are endogenously matched based on their characteristics. Ignoring this matching and testing the hypothesis based on observed socio-economic characteristics leads to biased inferences. Second, these studies do not explicitly model or measure the agents' relative influence through bargaining power. Agents' relative ability to influence the contract choice could differ, depending, among other things, on agents' characteristics in relation to their contractual partner.[26] We believe both agents' matching and their relative influence on the contract choice are important in empirical estimation. Matching has been extensively discussed and there are several ways to deal with it. Agents' relative ability to influence decision-making has not been covered much in the literature. However, ignoring agents' relative ability in influencing the contract decision leads to omitted variable bias in the empirical estimation.

[25] For the liquidity constraint theory, working capital, household assets and land ownership of the landlord as well as the tenants were used as proxy measures (Ackerberg et al., 2002 and Tikabo et al., 2003). In the case of risk-sharing, the coefficient of the variation in the crop yield was used as a measure of risk. However, the choice of crop is more complex and has been influenced by many factors such as market access, infrastructure location and climate-specific characteristics. Therefore, the crop riskiness measure is a weak proxy which leads to omitted variable bias.

[26] Stiglitz (1974) proposed that the choice of contract depends on the risk preferences of both agents. The model predicts that the equilibrium choice of contract depends on the relative risk preference of agents. However, the model assumes that agents have equal ability in deciding about the contract.

This study contributes to the contract choice literature by analysing the choice determinants of the output-shared contract while dealing with the endogenous matching of agents and controlling for agents' relative ability in influencing the contract decision.

The study was carried out in a number of villages in the state of Karnataka, India. Our main focus is to investigate the role of risk preferences and risk-sharing in the choice of contract in groundwater markets. We carry out a lab-in-the-field experiment to elicit risk preferences of sellers and buyers of groundwater. Overcoming the endogenous matching of agents is often difficult due to limited data on the characteristics of the contracts that are not chosen and the agents who have not entered into a contract (i.e., additional potential agents). However, endogenous matching of agents is less of a problem for groundwater contracts compared to land rental contracts since water can only be delivered within a certain radius, which limits the number of sellers and buyers within a delivery area (Aggarwal, 2007). In our study area, we observed very few agents who are potentially available to enter into a contract, which confirms that the agents' matching based on their characteristics is negligible. With respect to agents' relative ability to influence the contract decision, the researcher cannot observe such characteristics directly. However, we believe that the ability to influence the contract terms depends on the agents' inherent characteristics as well as the agents' characteristics in relation to their contractual partners. For example, a buyer who is richer than a seller might have more power than the seller to decide on the type of contract. Similarly, a buyer who is less risk-averse than a seller might have more influence on the contract choice. In order to overcome the omitted variable bias due to agents' relative influence on the choice of contract, we control for socio-economic characteristics of buyers in relation to those of sellers and for risk preferences of buyers in relation to those of sellers. We estimate a reduced form choice equation using sellers' and buyers' socio-economic characteristics, their risk preferences, and characteristics of buyers in relation to those of sellers as explanatory variables.

The rest of the paper is organised as follows. In Section 2, we describe the study location and particulars of groundwater contract characteristics. Section 3 elaborates on experimental design in eliciting risk preferences of sellers and buyers. Section 4 outlines our estimation strategies. The results are presented in Section 5. Section 6 ends the paper with concluding remarks.

2. Study area and groundwater contracts

We carried out a survey on groundwater sharing in India in April – May 2015. Three districts were selected from Karnataka state, namely Kolar, Chikkaballapura, and Tumkur. based on the intensity of groundwater contracts observed in the previous studies in the state (Somanathan and Ravindranath, 2006, Manjunatha et al., 2011). The districts are located in central and eastern dry agro-climatic zones. These areas do not have any source of irrigation for crop production except groundwater. There is extensive dependency on groundwater for intensive production. Sharing of groundwater has become increasingly common in the area due to its scarcity. These groundwater contracts are informal arrangements between farmers to trade groundwater for the cultivation of crops. The survey was carried out in 29 villages in these districts. All groundwater contracts that were in effect in each village at the time of the survey were recorded. We approached both sellers and buyers of water to gather their socio-economic characteristics and contract particulars.

Table 1: Socio-economic characteristics of sellers and buyers in groundwater contracts

Variables	Seller				Buyer				Mann-Whitney test (p-value)
	Mean	Std. Dev	Min	Max	Mean	Std Dev	Min	Max	
Gender	0.97	0.17	0	1	0.98	0.14	0	1	0.611
Age	50.74	8.07	28	74	48.26	8.43	24	70	0.014
Education (years)	5.43	4.55	0	16	5.58	4.01	0	15	0.779
Family size	5.25	2.61	2	20	5.05	1.37	2	10	0.472
Family labour force	3.52	1.35	0	9	2.89	1.17	0	7	0.000
Land holdings (acre)	3.31	2.16	1	10	2.13	1.40	0.1	9	0.000
No. of buyers (or) sellers	1.89	1.09	1	5	1.00	0.00	1	1	0.000
No. of additional potential buyers (or) sellers	1.01	1.24	0	4	0.10	0.37	0	3	0.000
No. of safe choices made	5.24	2.52	1	10	6.28	2.12	1	10	0.000
No. of observations	101				199				

The socio-economic characteristics of sellers and buyers are presented in Table 1. We have information about 199 buyers and 101 sellers. Both buyers and sellers are typically men, with an average age of 50 years, and an average education of 5 years. Sellers own more land and have more family labour to carry out the farm activities than buyers. Sellers on average have a contract with at least two buyers, while buyers mostly buy from one seller during a season. Sellers have at least one additional potential buyer, while buyers have almost no additional potential sellers around their deliverable area.

Table 2 presents the details of the contract that we observed in the study area. We found 199 groundwater contracts at the time of the survey; 87 percent of contracts are output-shared contracts, followed by fixed-price contracts (9 percent), land-linked-water contracts (3 percent) and hourly-payment contracts (1 percent). In an output-shared contract, the price of water in our survey area is one-third of the total output. The price of water is paid after the harvest of the crop and is usually paid as a share of total value of the output produced (revenue). The share of the output value does not vary either within or between villages. Under a fixed-price contract, a fixed amount per unit area per season or year is agreed upon between buyer and seller, which is usually paid in instalments before the harvest.[27] In an hourly-payment contract, price per hour of water is paid when the water is delivered. On average, INR 40 (USD 0.6) per hour was paid in the survey area. In the land-linked water contracts, no share of output or cash was paid. The buyers exchanged part of their land with the seller for water. On average, 1.2 acres of a buyer's land was lent to the seller in exchange for the supply of water to an acre of the buyer's land. The latter two types of contracts are ad-hoc in nature and are less often encountered. Therefore, from now on we focus on output-shared and fixed-price contracts.

The output-shared contract is the dominant type of groundwater contract. Manjunatha et al. (2011) and Fujita (2004) also found that the output-shared contract is the most common type in India (Karnataka state) and Bangladesh, respectively. In output-shared and fixed-price contract, on average, the contract agents have had 3 and 2.5 years of contract, respectively. The land area contracted for water delivery in fixed-price contracts (1.28 acre) is higher than in an output-shared contracts (0.58 acre).[28] Kinship ties between buyers and sellers are more common in fixed-price contracts (67 percent) than an output-shared contract (43 percent); however, the difference is not statistically significant at conventional levels. We encountered

[27] The number of instalments depends on what arrangements the sellers and buyers have made. We observed between two and three instalments.
[28] The Mann-Whitney test (p=0.0000) suggests that the difference is statistically significant.

nearly 20 different types of crops grown under these contracts. The crops grown under these contracts are mostly flowers and vegetables, for which there are substantial price fluctuations in the Indian market; therefore, they are risky to produce. The most common crops are mulberry (the host plant for silk worms), maize, tomato, chrysanthemum and China aster. These appear in all types of contracts, except for chrysanthemum and China aster (cut flowers), which are grown mainly under an output-shared contracts.

Table 2: Groundwater contract characteristics in Karnataka

Particulars of contracts	Output-shared contract	Fixed-price contract	Hourly payment contract	Land-linked water contract	All
No. of contracts	173	18	2	6	199
Terms of payment	One-third of value of output	Fixed amount	40[a] (14.12)	1.2[b] (0.66)	-
Time of payment	After the crop harvest	2-3 instalments before the harvest	After every irrigation	- NA -	-
Crops grown	Chrysanthemum, Maize, China aster and Mulberry	Tomato, Mulberry, Maize and Groundnut	Tomato and Onion	Mulberry, Tomato, Maize, Finger millet and Coriander	-
Years of contract	3.18 (3.36)	2.55 (2.42)	2.67 (3.30)	3.50 (3.41)	3.13 (3.27)
Area contracted (Acre)	0.58 (0.40)	1.28 (0.71)	0.50 (0.00)	0.79 (0.46)	0.64 (0.48)
Kin relationship between seller and buyer	0.43 (0.50)	0.67 (0.49)	0.00 (0.00)	0.67 (0.52)	0.46 (0.50)

Standard deviation in parentheses
'a' is payment made in Rupees per hour of water delivered
'b' is the acres of land lent to the seller in exchange for water for an acre
NA: Not attended as there is no common measure to calculate an average, because it depends on the crop type.

The water price paid depends on the type of crop. For a few crops, we have observations for both output-shared and fixed-price contracts. Table 3 presents water price paid per season per acre for mulberry, maize and tomato. The amount paid per acre is the highest for tomato, followed by mulberry and maize. The amount paid for water is higher in output-shared contracts for all the crops; however, the difference in payment is small for tomato and maize crops. The standard deviation is quite large in the case of an output-shared contract, which indicates the high risk (production and price risk) the seller faces with this

contract.[29] In the case of fixed-price contracts, the price per season is fixed. That price varies depending on the tubewell characteristics and the interpersonal relationship between seller and buyer. Given the high risk involved for water price in the output-shared contract, it is surprising to see that it is the contract most often chosen.

Table 3: Water use, water price and profitability in output-shared and fixed-price contracts

Particulars	Mulberry		Tomato		Maize	
	Output-Shared contract	Fixed-price contract	Output-Shared contract	Fixed-price contract	Output-Shared contract	Fixed-price contract
No. of obs.	11	4	6	8	31	2
Water price paid per acre per season (INR)	10400 (4200)	6000 (3000)	13000 (9300)	11000 (5800)	4400 (1400)	3900 (800)
Water used per acre per season (in gallons)	221000 (103000)	186000 (52000)	494000 (265000)	462000 (152000)	751000 (421000)	743000 (385000)
Price per hr of pumping (INR)	134 (40)	84 (37)	84 (42)	83 (80)	23 (7)	28 (7)
Yield per acre (kgs)	143 (36)	213 (25)	7400 (1740)	9200 (2900)	1000 (240)	1600 (71)
Output Price per kg (INR)	239 (51)	299 (7)	6 (3)	12 (11)	13 (2)	12 (2)
Total cost per acre (INR)	19900 (9100)	19800 (16200)	31100 (7800)	50400 (26600)	18800 (6000)	15800 (3200)
Net profit per acre (INR)						
Mean	4300 (12000)	37800 (10000)	2500 (24200)	42000 (60700)	-9400 (5800)	-3300 (5400)
Median	2400	37300	-5200	49500	-8500	-3300

1 gallon = 3.7 litres
Standard deviation in parentheses

Based on the incentives that the agents face in these contracts, there are two main arguments that have been discussed in the agrarian contract choice literature. Firstly, Eswaran and Kotwal (1985) argued that the choice of contract resembles the double-sided-incentive model in land-rental contracts, where each contract gives different incentives to landlords and tenants. The choice of contract depends on the relative incentives the agent faces between contracts. In groundwater contracts, Aggarwal (2007) argued that timely irrigation is an

[29] We have very few observations for fixed-price contracts as a basis for statistical comparison with output-shared contracts.

important aspect in the choice of contract. The buyer would choose an output-shared contract in order to ensure the timely delivery of water. In this case, the buyer thinks that the seller's income from selling water depends directly on the yield of output-shared contract plot, which creates an incentive for the seller to provide timely irrigation to the buyer's plot. On the other hand, the seller has an incentive to choose a fixed-price contract if the monitoring of labour and other input supplies is costly. The second group of arguments consider the insurance incentive against the risk. The risk-sharing model (Cheung, 1969, Stiglitz, 1974) implies that the choice of contract depends on the risk preferences of agents. An output-shared contract provides an incentive for agents to share the risk, while in the fixed-price contract the buyer alone bears all the risk. Therefore, the optimal choice of contract is a function of the risk preferences of both agents. Given the crop type, if the buyer is risk-neutral and the seller is risk-averse, the fixed-price contract is an equilibrium contract; if both buyer and seller are risk-averse, an output-shared contract is the optimal choice, where the buyer pays the water price plus a risk premium to compensate the seller for risk-sharing (Stiglitz, 1974).

In groundwater contracts, the water can be delivered economically within a certain radius, implying that sellers and buyers are mostly neighbouring farmers with plots close to each other. Hence, it is easy for agents to monitor each other's plots, the buyer's efforts and the timeliness of the seller's water delivery. As we can see from Table 3, there is not much difference between water use (in gallons) in output-shared and fixed-price contracts. Therefore, the underlying explanations on monitoring and timely water delivery are less likely to motivate the choice of output-shared contract. Interestingly, even though water use is the same in these contracts, the profitability of buyers under output-shared contracts is significantly lower than under fixed-price contracts.[30] This raises concerns about the income distribution between sellers and buyers of these contracts. However, a great deviation in the profitability of buyers between these contracts is more likely ascribable to the difference in the output produced and price received in the market at the time of harvest. Due to uncertainty in the output price and production, we believe that the contract choice is more likely motivated by the risk-sharing incentive. In order to explore the risk-sharing incentive, we need to understand the risk preferences of sellers and buyers.

[30] We could not perform a statistical test due to the very small number of fixed-price contracts.

3. Risk preferences of sellers and buyers

We used the multiple price list method developed by Holt and Laury (2002), which was modified to fit the groundwater contract setting. The subjects faced a series of decisions in choosing between an output-shared and a fixed-price contract. In order to incentivise the choices, we used the observed characteristics of groundwater contracts from the survey. A major crop in each district was selected.[31] The selected crops were mulberry, maize and chrysanthemum in Kolar, Chikkaballapura, and Tumkur districts, respectively. The payoff in the experiment was derived by considering the average yield in the locality, and the high and low output price in the market, which was taken from the survey. Here, we explain the case of the mulberry crop. The subjects were asked to assume that they are planning to have a new groundwater contract for an area of 0.25 acres. In a normal year, 50 kg of cocoons can be produced per crop season per unit area. The price of the cocoons by the time of harvest could either be low, INR 100, or high, INR 400, per kg; however, they are not certain about the price probability. The gross earnings for the buyer would be either INR 5000 or INR 20000 depending on whether the price after harvest is low or high. The price of water was one-third of the total value of output in an output-shared contract and INR 4000 per season per unit area in the case of a fixed-price contract. Therefore, the output-shared contract would yield a profit of INR 3333 or INR 13333 for the buyer, and a profit of INR 1667 or INR 6667 for the seller. The fixed-price contract would yield INR 1000 or INR 16000 for the buyer and INR 4000 for the seller. The earnings details for other crops are found in the Appendix.

Table 4 presents the paired choices faced by buyers and sellers for the mulberry crop. We used 11 choice situations. In each choice situation, the subjects are asked to choose between an output-shared and a fixed-price contract. In each contract, the earnings are constant across the choice situations, while the probabilities of low and high prices are systematically varied across the choice situation. The probability of a high price is 100 percent to start with and then decreases 10 percentage points for each row as we move down the rows. For example, in the first row, the output price probability is 100 percent. Therefore, the buyer is certain to earn INR 13333 and the seller is certain to earn INR 6667 if they choose an output-shared contract. If they choose a fixed-price contract, they earn INR 16000

[31] The crops grown are different in the three districts. The production and marketing aspects differ with crop type. Thus, subjects would not know the production and market aspects of the crop grown in another district. Use of a single crop was not realistic for the subjects, nor was assuming normal yield, since it varies depending on the fertility of the region.

and INR 4000, respectively. In the last decision row, there is zero probability of a high price and certainty of a low price. The last column shows the difference in the expected earnings between an output-shared and a fixed-price contract (not shown to subjects). In the first six rows, the expected earnings from the fixed-price contract are higher for the buyers. In the seller's case, the expected earnings from output-shared contracts are higher in the first six rows.

Great care was taken to ensure the subjects' understanding of the price probabilities and payoff structure of the experiment. The choices were explained orally and were demonstrated. The probabilities of high and low earnings were illustrated using green and red slips of paper. Depending on the distribution of high and low earning probabilities, we placed a number of green and red slips into a bag and told the participants to pick a slip from the bag. Drawing a green slip would yield them high-price earnings, while a red slip would yield low-price earnings. For example, in Row 2 of Table 3, we placed nine green slips and one red slip to represent 90 percent probability of high-price earnings and 10 percent probability of low price earnings. In addition, we used an example session, where subjects had to place a correct number of green and red slips into a bag for the given probabilities of high and low-price earnings before they took decisions. Furthermore, participants were instructed to put the right number of green and red slips into the bag before they took each decision. At the end of the experiment in each district, three buyers and three sellers were randomly selected for pay-out of a randomly selected decision. The selected subjects were contacted in person and paid later to ensure privacy.

Risk preferences of buyers and sellers are measured by accounting for the number of safe choices made.[32] The buyer faces a choice between two contracts that carry risk; the safe option in such a case is the choice of the contract that yields less variable earnings between high and low output prices. Given the choice sets in Table 4, variability in earnings under an output-shared contract is relatively low than a fixed-price contract. A risk-neutral buyer would choose an output-shared contract at least five times. If a buyer chooses an output-shared contract more than five times, he would be considered risk-averse. If a buyer chooses output-shared contract fewer than five times, he would be considered a risk-lover. The seller also faces a choice between a risky and a safe contract; the fixed-price contract is the safe contract, which does not carry any risk. A risk-neutral seller would choose a fixed-price contract at

[32] The safe choices are the number of safe alternatives chosen after shifting from a risky alternative without ever shifting back.

least five times given the choice situations. If the seller chooses a fixed-price contract more than five times, he would be considered risk-averse. If a seller chooses a fixed-price contract fewer than five times, he would be considered a risk-lover. Table 1 shows that on average buyers and sellers made 6.28 and 5.24 safe choices, respectively. This indicates that buyers are risk-averse and sellers are risk-neutral in the study area.

Table 4: Decisions faced by the buyers and sellers for mulberry crop

Row	Buyer decision		Seller decision		Diff. expected earnings (SC-FC)	
	Output-shared contract (SC)	**Fixed-price contract (FC)**	**Output-shared contract (SC)**	**Fixed-price contract (FC)**	**Buyer**	**Seller**
1	Certainty of earning INR **13333**	Certainty of earning INR **16000**	Certainty of earning INR **6667**	Certainty of earning INR **4000**	-2667	2667
2	10% chance of earning INR **3333** OR 90% chance of earning INR **13333**	10% chance of earning INR **1000** OR 90% chance of earning INR **16000**	10% chance of earning INR **1667** OR 90% chance of earning INR **6667**	Certainty of earning INR **4000**	-2167	2167
3	20% chance of earning INR **3333** OR 80% chance of earning INR **13333**	20% chance of earning INR **1000** OR 80% chance of earning INR **16000**	20% chance of earning INR **1667** OR 80% chance of earning INR **6667**	Certainty of earning INR **4000**	-1667	1667
4	30% chance of earning INR **3333** OR 70% chance of earning INR **13333**	30% chance of earning INR **1000** OR 70% chance of earning INR **16000**	30% chance of earning INR **1667** OR 70% chance of earning INR **6667**	Certainty of earning INR **4000**	-1167	1167
5	40% chance of earning INR **3333** OR 60% chance of earning INR **13333**	40% chance of earning INR **1000** OR 60% chance of earning INR **16000**	40% chance of earning INR **1667** OR 60% chance of earning INR **6667**	Certainty of earning INR **4000**	-667	667
6	50% chance of earning INR **3333** OR 50% chance of earning INR **13333**	50% chance of earning INR **1000** OR 50% chance of earning INR **16000**	50% chance of earning INR **1667** OR 50% chance of earning INR **6667**	Certainty of earning INR **4000**	-167	167
7	60% chance of earning INR **3333** OR 40% chance of earning INR **13333**	60% chance of earning INR **1000** OR 40% chance of earning INR **16000**	60% chance of earning INR **1667** OR 40% chance of earning INR **6667**	Certainty of earning INR **4000**	333	-333
8	70% chance of earning INR **3333** OR 30% chance of earning INR **13333**	70% chance of earning INR **1000** OR 30% chance of earning INR **16000**	70% chance of earning INR **1667** OR 30% chance of earning INR **6667**	Certainty of earning INR **4000**	833	-833
9	80% chance of earning INR **3333** OR 20% chance earn INR **13333**	80% chance of earning INR **1000** OR 20% chance of earning INR **16000**	80% chance of earning INR **1667** OR 20% chance of earning INR **6667**	Certainty of earning INR **4000**	1333	-1333
10	90% chance of earning INR **3333** OR 10% chance of earning INR **13333**	90% chance of earning INR **1000** OR 10% chance of earning INR **16000**	90% chance of earning INR **1667** OR 10% chance of earning INR **6667**	Certainty of earning INR **4000**	1833	-1833
11	Certainty of earning INR **3333**	Certainty of earning INR **1000**	Certainty of earning INR **1667**	Certainty of earning INR **4000**	2333	-2333

4. Empirical Model

In order to identify the determinants of contract choice in groundwater contracts, we construct a choice equation as follows:

$$Y_i = \beta^s X_i^s + \beta^b X_i^b + \beta^c X_i^c + \varepsilon \quad (1)$$

where Y_i indicates whether the matched pair i had an output-shared contract or a fixed-price contract at the time of the survey. Y_i equals 1 if pair i had an output-shared contract and zero if they had a fixed-price contract. X^s, X^b and X^c are buyers, sellers and crop-specific characteristics, respectively. β^s, β^b and β^c are corresponding parameter vectors, and ε is an error term assumed to be distributed independently and identically with mean zero and variance σ^2. A potential problem with the specification in (1) is that the error ε might be correlated with sellers' and buyers' characteristics because the agents' matching is endogenous (Ackerberg et al., 2002). For example, a landlord is more likely to prefer an output-shared contract with a hard-working tenant. A risk-averse tenant is more likely to have an output-shared contract with a risk-neutral landlord. Both observed and unobserved (by researchers) characteristics can influence the matching.[33] Thus, estimated coefficients from Equation (1) will be biased due to endogenous matching of sellers and buyers ($E[x_i\varepsilon] \neq 0$). However, Aggarwal (2007) argued that the endogenous matching problem is less serious with groundwater contracts because water can only be delivered economically within a certain distance. As a result, there are only a limited number of potential buyers and sellers. In our study area, buyers have nearly no other potential seller around the deliverable area, while the sellers have on average one additional potential buyer (Table 1). Given the few additional potential agents in the study area, we conclude that the endogenous matching issue is less serious in our case.

The risk preferences of agents are clearly important in influencing both the contract choice and the matching, and these are often unobserved by researchers (Ackerberg et al.,

[33] As an alternative, one can estimate a system of structural equations, using the characteristics of potential sellers and buyers. The information about the potential agents is often limited in survey data. One suggestion is to use instrumental variables that affect the agents' matching but do not directly affect the contract choice. Another possibility is to use a fixed effect estimation to control for unobserved characteristics of agents. Ackerberg et al. (2002) used regional dummies and their interactions with tenants' characteristics as instrumental variables to address endogenous matching of landlords and tenants. Although regional dummies and interactions help capture the matching of agents, this approach does not ensure the exclusion restriction. That is, regional specific effects might drive the agents in the region to choose a certain type of contract. Aggarwal (2007) has used fixed effect estimation to control for unobserved endogenous matching of sellers and buyer, since the pairs are observed twice due to multiple contracts.

2002, Bezabih, 2009). We do have information about the number of safe choices made by sellers and buyers in the experiment, which represents their risk preferences, and we include this information as explanatory variables.[34] An important potential omitted variable bias in the choice equation is the agents' ability to influence the contract decision. Harding et al. (2003) suggest that, if agents' individual characteristics that affect their bargaining power also determine their preference for a contract, then the coefficients of agents' characteristics do not fully capture the effect of agents' bargaining power. To overcome such complexity, they argue that agents' relative bargaining ability is captured to the extent by which buyers' and sellers' differ in their characteristics, such as differences in social status and education. It is, of course, possible that the relative ability to influence the contract choice decision is directly related to an agent's characteristics in relation to his or her matched partner. For example, if a buyer is less risk-averse than a seller, or if a buyer is richer than a seller, the buyer might have more power to influence the contract decision in his or her favour. In addition to sellers' and buyers' characteristics, we include a number of buyers' characteristics in relation to sellers' characteristics that represent their ability to influence the contract choice decision. We consider the difference in age, education, landholding and risk preference between buyers and sellers. Table 5 presents the description of buyers' characteristics in relation to their matched sellers. As can be noted, buyers are relatively more risk-averse and own less land than sellers.

Further, we control for contract characteristics, such as the number of years the matched agents have had a contract, kinship ties between agents, and the availability of potential sellers in the locality, all of which can influence the choice of contract. We classified the crops grown under these contracts into three categories, namely high, medium and low-risk crops (see Table 5). The classification was done based on the coefficient of variation in the output price observed in our samples (Appendix Table A3).[35]

5. Results

We estimate Equation (1) with a binary probit model with different specification of buyers' and sellers' characteristics. The marginal effects are presented in Table 6. In Model 1, socio-economic characteristics of matched buyers and sellers are used to explain the contract

[34] The number of safe choices is a discrete count. An increase in the number of safe choices by an agent represents an increase in the agent's risk aversion.
[35] The detailed classification of crops is presented in the appendix.

choice.[36] We find that an output-shared contract is more likely if the landholdings of buyers and sellers are larger. We find that the influence of the buyer's risk preferences on contract choices is statistically significant. The likelihood of an output-shared contract increases with the number of safe choices of buyers, i.e., the more risk-averse the buyer is, the greater the likelihood of an output-sharing contract. Output-shared contracts are less likely when the land area contracted under a groundwater contract is larger. The district-specific effects suggest that output-shared contracts are more common in Chikkaballapura and Tumkur than the Kolar district, presumably because these districts grow more maize and flowers, which are riskier to produce.

Table 5: Buyers' socio-economic characteristics in relation to their sellers

Relative characteristics	Description	Mean
Buyer elder	Buyer older than seller (1 = if buyer is older than seller; 0 = otherwise)	0.41 (0.49)
Buyer educated	Buyer more educated than seller (1 = if buyer is more educated than seller; 0 = otherwise)	0.43 (0.50)
Buyer owns more land	Buyer has more landholding than seller (1 = if buyer has more land than seller; 0 = otherwise)	0.28 (0.45)
Buyer more risk-averse	Buyer is more risk-averse than seller (1 = If number of safe choices by buyer is more than seller; 0 = otherwise)	0.58 (0.49)
Price risk crop dummy		
Low	1 = If CV of price is less than 0.19; 0 = otherwise	0.18 (0.38)
Medium	1 = if CV is between 0.19 and 0.40; 0 = otherwise	0.54 (0.50)
High	1 = if CV is more than 0.40; 0 = otherwise	0.28 (0.42)

CV: Coefficient of variation
Standard deviation is in parentheses
.

As we explained in Section 4, there is a potential omitted variable bias concerning the agent's ability to influence the choice of contract. We therefore include the buyers' characteristics in relation to their sellers' characteristics in Model 2. Now, only the seller's landholding is statistically significant. Because the landholding of an agent is a proxy for wealth, our result suggests that sellers with more land prefer output-shared contracts because they are not liquidity-constrained. In Model 2, the risk preferences of both buyers and sellers

[36] We have pair-level information for 181 contracts. Considering only output-shared and fixed-price contracts for analysis, we are left with 174 matched pairs of sellers and buyers.

are statistically significant determinants of the contract choice. More specifically, a more risk-averse buyer (one who made a higher number of safe choices) is more likely to choose an output-shared contract. This is logical, since an output-shared contract means that the buyer can share the risk with the seller. On the other hand, more risk-averse sellers are less likely to choose output-shared contracts, which again is consistent, since the risk is smaller with a fixed-price contract. Interestingly, we find that the choice of an output-shared contract is less likely when the buyer and seller share kinship ties. This suggests that the contract choice is not only motivated by one's own material self-interest. When the buyer and seller have had a long history of a contractual relationship, an output-shared contract is less likely, which suggests that a long-term contractual relationship between agents leads to a choice of contract that is more profitable to the buyer.[37] Again, an output-shared contract is less likely when the contracted land area is large. A large area under contract requires more investment of working capital to grow crops; buyers who are able to make such an investment have the ability to bear risk and therefore choose a fixed-price contract. Furthermore, our results indicate that, for crops with a high price risk, an output-shared contract is less likely. Many of the buyers' socio-economic characteristics in relation to those of sellers are statistically significant. When the buyer has more education and is older than the seller, the output-shared contract is less prevalent. Both education and age are likely to be correlated with bargaining power. The relationship between buyer and seller risk preferences does not have a statistically significant impact on the contract choice. The correlation between agents' own risk preferences and their risk preferences in relation to each other might be a reason for the insignificant results.[38] However, estimating without either of them leads to omitted variable bias.

[37] There is a potential problem with endogeneity when including the number of years of a contractual relationship between agents, which might bias the results. As a robustness check, we estimate Equation (1) with and without the variable for years of contract. We did not find any difference in the model estimates.

[38] The estimated coefficients are still unbiased; however, multicollinearity increases the variance of the estimate, which decreases the precision (Wooldridge, 2010).

Table 6: Determinants of choice of output-shared contract

VARIABLES	Model 1	Model 2
Buyer age	-0.001	0.004
	(0.002)	(0.003)
Buyer education	-0.002	0.002
	(0.005)	(0.004)
Buyer land	0.022**	-0.0004
	(0.011)	(0.011)
Seller age	0.002	-0.005
	(0.003)	(0.004)
Seller education	0.003	-0.004
	(0.004)	(0.005)
Seller land	0.021**	0.030***
	(0.010)	(0.012)
Buyer's no. of safe choices	0.017***	0.027**
	(0.006)	(0.013)
Seller's no. of safe choices	-0.008	-0.015*
	(0.006)	(0.008)
Kinship ties	-0.031	-0.029*
	(0.023)	(0.016)
Years of contract	0.0003	-0.006*
	(0.005)	(0.003)
Potential sellers	0.064	0.057
	(0.045)	(0.045)
Contracted area	-0.092***	-0.092***
	(0.025)	(0.021)
District: Chikkaballapura	0.249***	0.272***
	(0.079)	(0.057)
District: Tumkur	0.234***	0.264***
	(0.083)	(0.059)
Crop dummy: Medium price risk	0.009	0.001
	(0.033)	(0.022)
Crop dummy: High price risk	-0.060	-0.110***
	(0.054)	(0.038)
Buyer more risk-averse		-0.022
		(0.048)
Buyer owns more land		0.076*
		(0.044)
Buyer more educated		-0.082**
		(0.034)
Buyer older		-0.153***
		(0.053)
N0. Of observations	174	174

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

6. Summary and Conclusions

In this study, we explored factors that affect the choice of contract in informal groundwater contracts. Given the scarcity of water and the nature of groundwater markets, we found that each buyer had very few potential sellers and each seller had very few potential buyers. This supports the argument of Aggarwal (2007) that the endogenous matching of agents is less of a problem in groundwater contracts due to few potential agents. We find that both sellers' and buyers' risk preferences affect the choice of contract. Our results indicate that risk-averse sellers are less likely to prefer output-shared contracts and risk-averse buyers are more likely to prefer output-shared contracts. By comparison, Bezabih (2009) used experimentally elicited risk preferences of landlords and tenants in the land-rental market and found that only the landlord's risk preference affects the choice of contract. The author found that an increase in the risk-aversion of landlords increases the likelihood of output-shared contracts being chosen. This is in contrast with our study; we find that the more risk-averse sellers are, the more likely they are to prefer a contract which doesn't carry risk i.e., a fixed contract. Further, the risk preference profiles of sellers and buyers suggest that buyers are mores risk-averse than sellers. Therefore, the study concludes that the strong preference for output-shared contracts in groundwater contracts is motivated by the agents' risk-sharing incentive.

We found a weaker preference for an output-shared contract when sellers and buyers shared kinship ties. In this line, Sadoulet et al. (1997), who found that, in land rental contracts, kin landlords help and are expected to help more frequently in case of emergency than non-kin landlords. Our results indicate that a fixed-price contract is more likely to be chosen with kin buyers. Perhaps the mechanism explained by Sadoulet et al. (1997) might drive such choices, as kin agents have a relationship beyond the contract.

Not accounting for the agent's relative ability in influencing decision-making leads to a biased conclusion about the contract choice. We used buyers' socio-economic characteristics in relation to their seller, and buyers' risk preferences in relation to their seller as proxy measures to represent the agents' ability relative to one another. Buyers' socioeconomic characteristics in relation to their seller suggest that, when buyers are older and more educated than sellers, it is less likely that output-shared contracts are chosen. This indicates that these factors are related to the agents' potential to influence the joint decision. The theoretical model of Stiglitz (1974) suggests that an output-shared contract is optimal in agrarian

contracts, as it provides an incentive to share risk between agents. Stiglitz's conceptual model considered that the choice of contract is a function of relative risk preferences of agents and predicted that the choice of an output-shared contract is optimal when both sellers and buyers are risk-averse. We did not find statistically significant effects on contract choice of relative risk preferences of buyers in relation to their sellers. The results are particularly relevant to groundwater contracts, where the endogenous matching of agents is less of a problem.

The results of our study have a number of implications. A majority of water buyers are marginal farmers and are more risk-averse than sellers; thus, buyers prefer an output-shared contract such that they can share the risk with sellers, although it gives them lower profits than a fixed contract. Although an output-shared contract acts as a risk-sharing mechanism for buyers, it affects the distribution of income resulting from groundwater sharing. The risk and uncertainty are results of both production risk and output price volatilities. Crop insurance might be a risk-coping strategy to overcome the production risk. To overcome price volatilities, Fafchamps (1992) recommends integration of local markets into state or national level markets so that the local supply would not affect prices. These efforts could cushion risk-averse buyers in agrarian markets, allowing them to make better choices and improving the equity effects of local informal trading.

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Appendix

Table A1: Decisions faced by the buyers and sellers for maize crop

Row	Buyer decision						Seller decision				Diff. expected earnings (SC-FC)	
	Output-Shared contract (SC)			Fixed-price contract (FC)			Output-Shared contract (SC)			Fixed-price contract (FC)	Buyer	Seller
1	Certainty of earning INR **6000**			Certainty of earning INR **7000**			Certainty of earning INR **3000**			Certainty of earning INR **2000**	-1000	1000
2	10% chance of earning INR **2400**	OR	90% chance of earning INR **6000**	10% chance of earning INR **1600**	OR	90% chance of earning INR **7000**	10% chance of earning INR **1200**	OR	90% chance of earning INR **3000**	Certainty of earning INR **2000**	-820	820
3	20% chance of earning INR **2400**	OR	80% chance of earning INR **6000**	20% chance of earning INR **1600**	OR	80% chance of earning INR **7000**	20% chance of earning INR **1200**	OR	80% chance of earning INR **3000**	Certainty of earning INR **2000**	-640	640
4	30% chance of earning INR **2400**	OR	70% chance of earning INR **6000**	30% chance of earning INR **1600**	OR	70% chance of earning INR **7000**	30% chance of earning INR **1200**	OR	70% chance of earning INR **3000**	Certainty of earning INR **2000**	-460	460
5	40% chance of earning INR **2400**	OR	60% chance of earning INR **6000**	40% chance of earning INR **1600**	OR	60% chance of earning INR **7000**	40% chance of earning INR **1200**	OR	60% chance of earning INR **3000**	Certainty of earning INR **2000**	-280	280
6	50% chance of earning INR **2400**	OR	50% chance of earning INR **6000**	50% chance of earning INR **1600**	OR	50% chance of earning INR **7000**	50% chance of earning INR **1200**	OR	50% chance of earning INR **3000**	Certainty of earning INR **2000**	-100	100
7	60% chance of earning INR **2400**	OR	40% chance of earning INR **6000**	60% chance of earning INR **1600**	OR	40% chance of earning INR **7000**	60% chance of earning INR **1200**	OR	40% chance of earning INR **3000**	Certainty of earning INR **2000**	80	-80
8	70% chance of earning INR **2400**	OR	30% chance of earning INR **6000**	70% chance of earning INR **1600**	OR	30% chance of earning INR **7000**	70% chance of earning INR **1200**	OR	30% chance of earning INR **3000**	Certainty of earning INR **2000**	260	-260
9	80% chance of earning INR **2400**	OR	20% chance earn INR **6000**	80% chance of earning INR **1600**	OR	20% chance of earning INR **7000**	80% chance of earning INR **1200**	OR	20% chance of earning INR **3000**	Certainty of earning INR **2000**	440	-440
10	90% chance of earning INR **2400**	OR	10% chance of earning INR **6000**	90% chance of earning INR **1600**	OR	10% chance of earning INR **7000**	90% chance of earning INR **1200**	OR	10% chance of earning INR **3000**	Certainty of earning INR **2000**	620	-620
11	Certainty of earning INR **2400**			Certainty of earning INR **1600**			Certainty of earning INR **1200**			Certainty of earning INR **2000**	800	-800

Table A2: Decisions faced by the buyers and sellers for chrysanthemum crop

Row	Buyer decision						Seller decision				Diff. expected earnings (SC-FC)	
	Output-Shared contract (SC)			Fixed-price contract (FC)			Output-Shared contract (SC)			Fixed-price contract (FC)	Buyer	Seller
1	Certainty of earning INR **38000**			Certainty of earning INR **47000**			Certainty of earning INR **19000**			Certainty of earning INR **10000**	-9000	9000
2	10% chance of earning INR **6800**	OR	90% chance of earning INR **38000**	10% chance of earning INR **200**	OR	90% chance of earning INR **47000**	10% chance of earning INR **3400**	OR	90% chance of earning INR **19000**	Certainty of earning INR **10000**	-7440	7440
3	20% chance of earning INR **6800**	OR	80% chance of earning INR **38000**	20% chance of earning INR **200**	OR	80% chance of earning INR **47000**	20% chance of earning INR **3400**	OR	80% chance of earning INR **19000**	Certainty of earning INR **10000**	-5880	5880
4	30% chance of earning INR **6800**	OR	70% chance of earning INR **38000**	30% chance of earning INR **200**	OR	70% chance of earning INR **47000**	30% chance of earning INR **3400**	OR	70% chance of earning INR **19000**	Certainty of earning INR **10000**	-4320	4320
5	40% chance of earning INR **6800**	OR	60% chance of earning INR **38000**	40% chance of earning INR **200**	OR	60% chance of earning INR **47000**	40% chance of earning INR **3400**	OR	60% chance of earning INR **19000**	Certainty of earning INR **10000**	-2760	2760
6	50% chance of earning INR **6800**	OR	50% chance of earning INR **38000**	50% chance of earning INR **200**	OR	50% chance of earning INR **47000**	50% chance of earning INR **3400**	OR	50% chance of earning INR **19000**	Certainty of earning INR **10000**	-1200	1200
7	60% chance of earning INR **6800**	OR	40% chance of earning INR **38000**	60% chance of earning INR **200**	OR	40% chance of earning INR **47000**	60% chance of earning INR **3400**	OR	40% chance of earning INR **19000**	Certainty of earning INR **10000**	360	-360
8	70% chance of earning INR **6800**	OR	30% chance of earning INR **38000**	70% chance of earning INR **200**	OR	30% chance of earning INR **47000**	70% chance of earning INR **3400**	OR	30% chance of earning INR **19000**	Certainty of earning INR **10000**	1920	-1920
9	80% chance of earning INR **6800**	OR	20% chance earn INR **38000**	80% chance of earning INR **200**	OR	20% chance of earning INR **47000**	80% chance of earning INR **3400**	OR	20% chance of earning INR **19000**	Certainty of earning INR **10000**	3480	-3480
10	90% chance of earning INR **6800**	OR	10% chance of earning INR **38000**	90% chance of earning INR **200**	OR	10% chance of earning INR **47000**	90% chance of earning INR **3400**	OR	10% chance of earning INR **19000**	Certainty of earning INR **10000**	5040	-5040
11	Certainty of earning INR **6800**			Certainty of earning INR **200**			Certainty of earning INR **3400**			Certainty of earning INR **10000**	6600	-6600

Table A3: Crop classification based on output price risk

Crop name	Mean	Std. dev	Coefficient of variation	Price risk class
Mulberry	253.94	47.74	0.19	Low
Tomato	10.44	9.39	0.90	High
Maize	13.28	1.71	0.13	Low
Chrysanthemum	43.67	17.06	0.39	Medium
China aster	43.00	21.28	0.49	High
Finger millet	20.55	2.21	0.11	Low
Beans	23.00	6.98	0.30	Medium
Climbing bean	23.00	10.82	0.47	High
Field bean	22.67	6.43	0.28	Medium
Carrot	15.00	1.41	0.09	Low
Cauliflower	2.58	0.99	0.39	Medium
Chili	20.00	-	-	Low
Coriander	21.00	1.41	0.07	Low
Cucumber	6.00	4.00	0.67	High
Groundnut	37.50	3.54	0.09	Low
Paddy	14.00	0.82	0.06	Low
Potato	17.00	4.24	0.25	Medium
Pumpkin	8.00	2.83	0.35	Medium
Sunflower	28.33	2.89	0.10	Low
Sweetcorn	8.00	-	-	Low
Sweet potato	7.00	1.73	0.25	Medium
Onion	10.00	-	-	Low

'-' *not included due to a single observation*

Chapter III

Trust and Kinship: Experimental Evidence from Rural India

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Abstract

The empirical evidence on the role of kinship in trust and cooperation is mixed. In this study, we investigate the role of kinship when it comes to altruism and trust. We conduct a field experiment, using a dictator and trust game, in India with households involved in informal groundwater sharing. We find that a kin partner is trusted more than non-kin. Altruistic motives play a major role in explaining the differential trust towards kin and non-kin. We find only a small difference between trustworthiness of kin and non-kin receivers. However, we observed a change in the trustworthiness of kin receivers based on how close they are within their kin network. Interestingly, the expectation about non-kin trustworthiness is low, while in reality there is no difference in trustworthiness between kin and non-kin.

JEL Codes: C90, C93, D03, D64

Keywords: Trust, Altruism, Kinship

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1. Introduction

Trust as a form of social capital is an essential element in all kinds of activities, ranging from interpersonal relationships, work environment, and business relationships to economic growth and development (Berg et al., 1995, Beugelsdijk et al., 2004, Dean, 2005, Bouma et al., 2008). In a world with low trust, transaction, supervision, enforcement, and psychological costs would be very high and thus bad for the functioning of society and economic efficiency (Alger et al., 2010, 2012, Di Falco and Bulte, 2011, Di Falco and Bulte, 2013).

Fukuyama (1995b) argued that people are more likely to trust and be trustworthy with people with whom they are familiar and with whom they interact frequently. A number of studies have shown a decrease in the level of trust with social distance (Barr, 2003, Buchan and Croson, 2004, Cadsby et al., 2008, Etang et al., 2011). It is important and relevant from a policy point of view to understand the role of social distance in trust and trustworthiness. For example, if individuals only trust those with whom they have close interactions, such as their own clans, own community members, and members of their own villages, this restricts their trade and business, with limited scope for expansion.[40]

At the village level in most developing countries, frequent interaction happens within social networks, which mostly consist of kin, friends, and neighbours. Kinship plays a special role among social networks due to its genetic link and norms such as obligatory sharing and family interaction, particularly in developing countries. Banerjee and Duflo (2007) report that 50 percent of households that live on less than USD 2 per day in urban areas in developing countries have a small business, with family members as employees with no specified salary. These informal business and trades are self-enforced agreements, which means that there is a high risk that agents could breach the agreement. In place of informal agreements, kinship acts as a tool to enforce agreements based on trust among individuals involved in such agreements. The evidence from the studies which have investigated the effect of kinship on trust is mixed. One group of studies argues that kinship ties increase the moral obligations among the members, where one considers a loss to one's kin as a loss to oneself; therefore, kinship ties help in alleviating the market imperfection and act as a catalyst in the development process. In informal land rental contracts, Sadoulet et al. (1997) found that the

[40] The interactions not only help in building trust, but also stimulate informal resources exchange and collective action among individuals who trust each other. In most developing countries, where formal institutions are weak, people create their own informal rules for establishment of institutions where people can cooperate, trade and exchange resources. Examples include land rental markets and water markets.

agents' efforts under the contract were not necessarily determined by the contract agreement when the contracting agents share kinship ties. Kin are expected to help in various ways in the case of production shocks, where kinship ties act as informal insurance. Obligatory sharing norms among kin help overcome credit and insurance market imperfections in developing countries and act as instruments in consumption smoothing (Rosenzweig, 1988). Kin solidarity helps the members of a small business reinforce trust, protect property rights and reduce transaction costs in rural China (Peng, 2004).

On the other hand, another group of studies argues that the obligatory sharing norms among kin invite free-riding among members (Di Falco and Bulte, 2011). Kassie and Holden (2007) argue that, due to obligatory sharing norms among kin, kin landlords in land rental contracts cannot exercise their contractual rights to break a contract with kin tenants when they provide lower efforts. They showed evidence of lower production in a contract where kin are involved. Di Falco and Bulte (2011) explored consumption and accumulation decisions of households in Africa. They observed increased spending on non-sharable durables and reduced savings in liquid assets when the number of dependent kin in the network increased.[41] The evidence on the dark side of kinship leads to the conclusion that kinship is a hindrance to the development process.

Given the two distinct effects of kinship, it is not clear whether individuals trust kin groups more or less than non-kin groups when selecting a partner to a contract or for the exchange of resources. The present study aims to study the following questions. i) Does there exist differential trust towards kin than non-kin groups? If it exists, which direction would the difference take? ii) Can we observe two distinct effects of kinship based on observable characteristics of kin relationships?

Many psychological studies have used kinship in assessing different behaviours, such as altruism (Madsen et al., 2007, Rachlin and Jones, 2008) and nepotism (Allen-Arave et al., 2008). The study by Vollan (2011) poses a similar question, where economic experiments were used to study how trust and trustworthiness differ with kinship, friendship and an unrelated person in the village. We contribute to this scarce literature by considering a relatively broad class of kin and non-kin in the village to elicit trust and trustworthy behaviour. We also construct a measure of social closeness among a kin network to explain

[41] Likewise, Jakiela and Ozier (2015) also found reduced investment on higher return portfolios to keep income hidden when kin attend the experiment.

the distinct effects of kinship that were found by the aforementioned studies. In addition, we investigate the extent to which trust is altruistically motivated, and whether a potential difference in trust between kin and non-kin can be explained by altruism.

A lab-in-the-field experiment was conducted in selected villages of Karnataka state in India. Because trust plays a crucial role in the success of informal contractual arrangements, we considered villagers who have been involved in informal groundwater sharing contracts as the sender in our experiment. We used an investment game (Berg et al., 1995) to elicit trust and trustworthiness and a standard dictator game (Kahneman et al., 1986) to elicit altruism. We use a within-subject design, where each sender plays against a kin and a non-kin group of receivers. We find that kin are trusted more than non-kin; the difference is statistically significant. We also find high altruistic concern towards the kin group, which can explain a large fraction of the variation in the observed trust difference towards kin and non-kin. The difference in the trustworthiness of kin and non-kin receivers is small. However, kin receivers' trustworthiness depends on how close they are within their kin network. Senders believe that kin receivers are more trustworthy, but, in the experiment, there is no difference in trustworthiness.

The rest of the paper is structured as follows. Section 2 provides a brief review of the literature on different measures of social distance and elicitation of trust and altruistic behaviour. In Section 3, the experimental design and the field implementation are described. In Section 4, the experimental results are reported and in Section 5 a summary and discussion of experimental findings are presented.

2. Social Distance and Kinship

Social distance is a measure of closeness and affinity between individuals or groups in society. In a laboratory setting, social distance has been measured either between individuals or between groups depending on the objective of the study. Glaeser et al. (2000) measured the social connection between sender and receiver, using an investment game developed by Berg et al. (1995), by considering the number of friends they have in common. They found that when the sender and receiver are socially close, i.e., have more friends in common, both trust and trustworthiness increased. On the other hand, Ahmed (2007) showed how small differences in the subjects' matching can build group affinity in laboratory experiments. In the experiment, the subject was either paired with a subject within the experimental session (in-

group matching) or with a subject in another experimental session (out-group matching). Ahmed (2007) found that matching within the session caused more in-group association, in that subjects exhibited more cooperative behaviour towards their in-group partners. It was also suggested that such acts are due to an in-group preference among the members of the group, rather than negative feelings towards out-group members.

Trust and other-regarding preferences have also been investigated across countries, where cross-border distance was used as a measure of social distance. Studies have involved playing an investment game using French and German subjects (Willinger et al., 2003), US and Chinese subjects (Buchan and Croson, 2004), Austrian and Japanese subjects (Netzer and Sutter, 2009) and US, Russian, and South African subjects (Ashraf et al., 2006) and found certain differences in subjects' behaviour. The observed differences are attributed to the culture-specific differences between countries. In addition to the differences in trust between countries, Ashraf et al. (2006) also found a stronger trust difference between communities of different races within the country, which was explained as the behaviour acquired through a long history of discrimination against particular groups; see also Alesina and La Ferrara (2002). Ethnicity and religious-based social distance create broader segments within a nation. Fershtman and Gneezy (2001) measured social distance using ethnic groups in Israel. They played investment, dictator and ultimatum games between two ethnic groups and found that Eastern Jews are mistrusted compared to Ashkenazic Jews, which was attributed to ethnic stereotypes in the country. However, in the ultimatum game, when the stereotyped ethnic group has a strategy to punish distrust, the trend of mistrust disappears. Johansson-Stenman et al. (2009) used religion as a measure of social distance and measured trust between Muslim and Hindu subjects in rural Bangladesh. They found no difference in trust between Muslim and Hindu subjects.

A few studies have measured social distance by considering existing social relationships at the community/village level. Comparing trust in traditional and resettled communities of Zimbabwe, Barr (2003) found higher trust in the traditional villages than in the resettled villages, which was attributed to the kinship/long-standing relatedness in traditional communities. By contrast, in resettled communities, neighbours are mostly unrelated, which builds relatively lower trust. In the process of identifying the borders of trust, Etang et al. (2011) found that fellow villagers are trusted more than people from outside the village; however, trustworthiness does not differ within and between villages. This evidence supports

the assumption that frequent interaction among individuals provides an opportunity for better understanding and thus such individuals are more likely to trust each other (Fukuyama, 1995a). The above-mentioned studies elicited trust among socially interacting groups in villages, which gives an idea of how trust is constrained in the local settings and social networks.

In order to understand the dynamics of trust within the social network, the social networks have been classified into different groups, such as kin, friends, neighbours and unrelated persons, such that the interpersonal relationships within the social network are used to explain the behaviour of individuals. Among the classified social networks, kinship has a special nature due to its genetic link and the existence of its own norms in the group. The well-known kin selection theory developed by Hamilton (1964) states that any individual/organism cooperates and works to promote the survival and success of its kin or clans, even at the cost of its own welfare, which is referred to as 'kin altruism'. Kin altruism is altruistic behaviour where actions are driven by kin selection. Altruism is beneficial to an individual if $Br - C > 0$, where 'B' is the inclusive fitness benefit[42], 'C' is the cost to the actor, and 'r' refers to the degree of relatedness between actor and receiver. Given the cost and benefits of sharing a good, the inclusive gain increases with an increase in the degree of relatedness (r) among the individuals. An economic model of kin altruism and sharing norms was conceptualised by Alger et al. (2010, 2012), where they predict how sharing norms among kin influences the efforts of individuals, given the varied levels of altruism among kin. With a high level of altruism, they predicted that the effect of empathetic feelings towards kin outweighs the cost of free-riding by kin. Therefore, high altruistic concerns among kin push siblings to exercise optimal effort to help each other in order to achieve maximum welfare.[43] Many psychological studies have confirmed the stable existence of altruism towards kin (Madsen et al., 2007, Stewart-Williams, 2007, Rachlin and Jones, 2008, Osiński, 2009). An inquiry into how genetic and social distance determine altruistic behaviour found that altruism is strongly contingent on both genetic distance and social closeness (Rachlin and Jones, 2008).

[42] In Biological terms, inclusive fitness is the survival and reproductive success of the individual organism. In broader terms, it is related to the benefit (direct and indirect) an individual could get from helping an individual which carries the related gene to survive and be successful.

[43] They also argue that a moderate or low level of altruism among siblings in a risky environment reduces the effort, since the free-riding outweighs the empathetic effect.

An economic experiment was conducted by Vollan (2011) which studied how individuals trust kin, friends and unrelated persons in villages of Namibia and South Africa. He found evidence that kin and friends were trusted equally, while unrelated persons were trusted less. However, kin are expected to reciprocate less than others, while the expectations for reciprocity from friends are higher than kin, which provides evidence for 'kin altruism'. Adding to this, Binzel and Fehr (2013) argue that the frequent interaction among friends helps friends trust each other, compared to an unrelated person in their social networks. On the other hand, non-experimental evidence on the effect of kinship is mixed. A group of studies has found evidence that kin solidarity and kin trust play an important role in protecting property rights, reducing transaction costs and acting as informal insurance by sharing risk when institutions are too weak to establish such governance (Peng, 2004, Rosenzweig, 1988). Sadoulet et al. (1997) argued that the existence of compulsory sharing norms among kin increases the moral obligation and, therefore, the actions of individuals are not constrained by the terms and conditions of the agreement. On the other hand, a group of studies has found evidence to support the dark side of kinship (Di Falco and Bulte, 2011, Jakiela and Ozier, 2015). Di Falco and Bulte (2013) suggest that compulsory sharing among kin invites free-riding and weakens incentives to adopt actions that can reduce exposure to weather shocks in Africa. In an experimental study, Jakiela and Ozier (2015) also found reduced investment on higher return portfolios to keep income hidden when kin attend the experiment. The studies' evidence on the dark side of kinship suggests that kinship is a hindrance to the developmental process.

In India, informal business plays a major role in contributing to the national economy. The formal sector contributes around 12-14 percent to the national income, while that of the informal sector is more than 30 percent. 92 percent of the Indian workforce is in the informal sector (Kalyani, 2016). Most workers in these businesses are family workers (i.e., kinship-based), usually with no explicit written contracts of employment, and usually their employment is not subject to labour legislation, social security regulations or collective bargaining agreements (Sastry, 2004). It has been shown that family-based informal businesses are far less productive (40 percent less) than non-family based informal businesses (Raj and Sen, 2016). However, (Rosenzweig, 1988) argued that kin-based informal agreements in India act as a risk mitigation strategy and help in consumption smoothing where no formal insurance markets exist.

Given this backdrop of literature, we do not have a definite prediction about the direction of the effect of kinship on trust and trustworthiness. It is the aim of this paper to study the effect of kinship on trust and trustworthiness. Considering the argument of kin solidarity (Peng, 2004) and sharing norms among kin (Sadoulet et al., 1994), we believe that, in close communities such as villages in developing countries, kin are given more emphasis in decision-making. Therefore, our Hypothesis i) is that individuals are more likely to trust and be trustworthy to their kin than non-kin. The existence of obligatory sharing norms among kin might lead to evasive and free-riding behaviour from members of the kin group (Di Falco and Bulte, 2011). However, the distortionary behaviour among kin depends on certain characteristics of the kin group in the community, such as how much kin care for each other and closeness within the kin group. Therefore, Hypothesis ii) is that socially close kin exhibit more trust and trustworthiness towards their kin compared to those who are not close to their kin. The obligatory sharing norms among kin lead to frequent interaction among them, which helps them learn about each other's behaviour; therefore, they have a better understanding about the trustworthiness of kin. The frequent interaction is less likely among non-kin, which leaves them with less information about the trustworthiness of the non-kin group. Therefore, Hypothesis (iii) is that expectations about the trustworthiness of kin are better calibrated than are expectations regarding non-kin.

3. Experimental Design and Implementation

We use the investment game developed by Berg et al. (1995) to elicit trust and trustworthiness (from now on referred as the 'trust experiment'), where both senders and receivers are given the same endowment. The sender can send all, some or none from the endowment. The amount sent by the sender is tripled by the experimenter, and then given to the receiver. The receiver can then return all, some or none of the amount received. The proportion sent by the sender is a measure of trust, and the proportion returned by the receiver is a measure of trustworthiness.

A standard dictator game was used to elicit altruistic concerns (Kahneman et al., 1986). Each sender was given an endowment and asked to decide how to split this between himself or herself and the receiver. The sender could send all, some or none from his or her endowment. The receiver does not make an active choice, but simply receives what is sent. The proportion sent to the receiver is a measure of the altruistic concern for the sender.

3.1. Subjects

The experiment was carried out in selected villages of the Karnataka state, India.[44] The selected villages have contracts to share groundwater to cultivate crops. Groundwater contracts are informal water-sharing agreements between farmers, where a tubewell owner (seller) extracts groundwater for personal use as well as for sale to a neighbouring farmer who does not have a tubewell (buyer). In these contracts, the seller is responsible for providing water input while the buyer takes care of the remaining inputs. The buyers and sellers can make different contractual arrangements.[45] Terms and conditions of agreements are verbal in nature and no third party is involved in the agreement, either to monitor or to enforce the terms and conditions of the contract. Therefore, groundwater contracts are a good example of a non-enforceable contract. Trust among the agents of the contract is important for selection of type of contract as well as for the success of the contract. That is, if a number of buyers are potentially available, the seller selects one or several buyers whom he trusts. Understanding the level of trust of contract agents among their social network is important since it gives an idea about whom they select to share water with. Therefore, parties of groundwater contracts (both seller and buyers) are given the role of the sender. Receiver subjects are randomly selected from a stratified sample of kin and non-kin groups of senders in the village (discussed in detail in the next section).[46]

The socio-economic characteristics of senders and receivers are reported in Table 1. More than 95 percent of the household heads are male, married and belong to the Hindu religion, in both the receivers and senders groups. On average in both the groups, subjects are 50 years old, with an average education of five years, and belong to a family with five members. Both senders and receivers are small farmers with an average land holding of 2.5 acres. We run a Kruskal-Wallis test on socio-economic characteristics of senders and receivers and find no statistical difference between them. This suggests that the differences between groups in relation to their socio-economic variables are not associated with the treatment effect.

[44] Karnataka is an Indian state, located in Southern India. Villages were selected from three districts of the state, namely Chikkaballapura, Kolar, and Tumkur.

[45] There are four main types of contractual arrangements: output-shared contract (a pre-decided share of the output is paid as the price of water to the seller), fixed-price contract (a fixed amount of money is paid per year or season as the price of water), land-linked water contract (a predefined land area is given by the buyer to the seller in order obtain water from him) and hourly water contract (a predefined amount will be paid by the buyer per hour of water delivered). These kinds of informal markets are commonly seen in India and other South Asian countries (see Saleth, 1998, and Shah, 1993)

[46] Villages selected in our experiment consist of 220 to 600 households per village

Table 1: Socio-economic characteristics of Senders and Receivers

Variables	Sender		Receiver		p-value Kruskal-Wallis test
	Mean	Std. Dev.	Mean	Std. Dev.	
Gender (1=Male, 0=Female)	0.98	0.14	0.95	0.21	0.060
Age (years)	49.04	8.30	50.33	9.40	0.117
Education (years)	5.55	4.18	5.75	4.34	0.555
Marital status	1.00	-	1.00	-	-
Family size	5.12	1.88	4.97	1.35	0.710
Land (acre)	2.53	1.78	2.36	1.64	0.267
Religion (1- Hindu, 0-Muslim)	1.00	0.06	1.00	0.04	0.619
No. of kin households	8.30	2.24	7.86	2.13	0.000
No. close households	9.98	0.40	10.00	0.04	0.233
No. kin houses in close household group	1.22	1.36	1.16	1.19	0.650
No. of observations	299		299		-

3.2. Implementation

The experiment was conducted in the subjects' homes. Instructions were read out loud. Conducting the experiment in private not only helped us avoid interruptions but also kept identities and decisions confidential.

Anonymity between subjects is very important in the trust game in order to elicit unbiased behaviour (Hoffman et al., 1996). Failure to ensure anonymity would mean that a subject's decisions might be affected by unobserved previous experiences with a particular person or fear of expected post-experimental punishment, which would bias the true trust difference between groups. Our aim is to elicit trust towards kin and non-kin, which requires us to give clear information about the kinship of the partner. Maintaining anonymity while providing clear information about the matched partner is challenging. Therefore, first, we have to identify the kin and non-kin group of the subject in the village. Once we identify the groups, we can follow the randomised matching of a partner from the identified groups; thereby, the subjects know whether the matched partner is kin or non-kin, but do not know exactly who the person is. The randomised matching of agents from the identified groups not only allows us to give clear information on the matched partner but helps us maintain individual anonymity.

3.2.1. Senders' Decisions

First, we approached senders and explained the purpose of contacting them (see the full instructions in the appendix). They were informed that, to compensate for their time, a participation fee of INR 100 (~USD 1.4) would be paid at the end of the experiment.[47] They were assured that the information provided by them would be confidential. In order to identify kin and non-kin groups, we used the village household list, which consists of household information, such as house number, name of the household head and details about family members. Subjects were asked to identify households that are linked to them within three generations. Clear information was given about the type of relationships that exist within three generations. Truncating the generation link to three was mainly motivated by the psychological literature, where most studies considered kin/relatives as parents, siblings, cousins, aunts, uncles, nieces, nephews, children and grandchildren (Madsen et al., 2007, Stewart-Williams, 2007, Rachlin and Jones, 2008, Osiński, 2009).[48] Interpreting this kin relationship in terms of generations, this covers about three generations' links. Using three generations' links to identify subjects' kin groups includes close as well as distant kin. We used a village household list that had household details as well as photographs of all the members of the household over 18 years old, which made it possible for subjects who are unable to read to identify their kin group. Since the identified kin and non-kin groups in the village are established based on genetic links, we do not know how kin are viewed in a social (closeness) context. In order to obtain some information on how kinship and social closeness are related, we also asked subjects to rank the 10 households in the village that are closest to them. Household number one would be the closest, in descending order to household number 10. We defined closeness as how they feel about being close, which could be emotional, reciprocal, or friendly. However, it was emphasised that close ones could be their kin, non-kin, friends and neighbours in the village. Considerable efforts were made to explain that they did not have to exclude the households that they had already identified as kin.[49]

Once finished with the identification of the kin and closest households, we moved to the experiments. We used a within-sample design, where each sender is matched with a kin and a

[47] The participation fee is equivalent to two hours' wage for manual labour in India

[48] Studies used relatedness factor (r) as a discontinuous variable i.e., r = 0.75 for parents or siblings, r = 0.5 for grandparents, aunts, uncles, nieces or nephews and r = 0.25 for cousins (Madsen et al., 2007, Osiński, 2009).

[49] In the pilot survey, we found that some of the subjects left out kin households when identifying close households because they thought they had already identified households when they marked those households as 'kin'.

non-kin receiver to make decisions in the trust and dictator experiments. Subjects were informed that they would be matched with two persons in the village. One of them would be randomly selected from the identified kin group and the other would be randomly selected from the remaining households other than those marked as kin on the village list. The senders were involved in four decisions: one each with the matched persons in each game. At the end of the experiment, two randomly selected decisions were realised. We gave an assurance that their identity would not be revealed anywhere, not even to the matched partner.

Unlike Berg et al. (1995), an endowment was given to senders only in the trust game, by following the designs of Glaeser et al. (2000) and Johansson-Stenman et al. (2009). For each decision in which they were involved, subjects were endowed with INR 200 (about USD 3.3). The decision situation in each game was explained with a few examples in order to make subjects think about all possible payoffs. Subjects were asked to make decisions on '*how much he/she would like to send to the matched kin partner'.* Similarly, they were asked to make decisions for the matched *'non-kin'* partner. For all the decisions, subjects were requested to make their decisions as a multiple of INR 20. The expected amount to be received from kin and non-kin partners was also recorded for the trust game.[50] We varied the order in which the subject faced the decisions for trust and dictator games as well as the order of the decisions made towards kin and non-kin partners, to control for order effects.[51] We also elicited the risk preferences of senders. The details of the elicitation procedure can be found in Yashodha (2017).[52] At the end, the subjects were thanked for their cooperation, and requested not to discuss anything about the decision situations and the decisions made until we came back. We promised to come back the same evening for payment.

3.2.2. Receivers' Decisions

The randomly matched kin and non-kin receivers were approached on the same day. We followed the same procedure as we used for the sender in identifying receiver's groups of kin, non-kin and close households in the village. Kin receivers were informed that they had been matched with a randomly selected kin member from their identified kin group in the village

[50] The endowment is approximately equal to the one-day wage rate in the region. The senders' expected reciprocity was not incentivised

[51] There are four orders of decision the subject could face: a) played the trust game first and faced a kin decision first, b) played the trust game first and faced a non-kin decision first, c) played the dictator game first and faced a kin decision first and d) played the dictator game first and faced a non-kin decision first.

[52] Schechter (2007) has found that the risk preference of a subject has a significant association with trust. Therefore, we elicit the risk preferences of the subjects to test this evidence.

list and non-kin receivers were informed that they had been matched with a random person from the list other than their identified kin group.[53] They were informed that they were to play the role of receivers in both the trust and dictator game. In total, receivers were involved in two decisions in which they had to make one decision along with their matched partner (receiver in trust experiment) and in the other decision, they did not make any decision themselves (receiver in dictator experiment). One of these two decisions was randomly selected at the end to be paid out. We used the same rules and examples about the game as we used for senders. We used the strategy method to elicit the amount returned in the trust game (Brandts and Charness, 2000). For each possible amount that the matched partner could send (where the tripled amount corresponded to the amount originally sent), the receivers were asked '*how much they would like to return to the matched partner*'. They had to mark the amount that they would like to return as a multiple of 20.

After finishing all the decisions made by the receiver, we used a coin toss procedure to select the decision for payment. If the trust game decision was selected for payment, the receivers were informed about the money sent by their partner. Receivers were paid after deducting the amount that they had decided to return by looking at the contingency table. If the dictator game decision was selected, receivers were informed about the amount shared by their partner and were paid accordingly.

In the evening, sender subjects were contacted and informed about the decisions selected for payment. We calculated their payoff by considering their partners' decisions for the corresponding selected decisions and paid them along with the participation fee. At the end of the experiment, the subjects were requested not to discuss the experiment and the money earned in the game with anyone in the village.

3.3. Hurdles in the design

Our experimental design differs in a number of aspects from existing studies eliciting trust and trustworthiness. We elicited a full list of the participants' kin group for three generations, which gives us a broad range of kin networks to match, unlike Vollan (2011),

[53] We used the kin list identified by the sender to select a kin receiver. After approaching kin receivers, they also identified their kin group. We made sure that the kin sender was in the kin group identified by the kin receiver. We avoided the selection of a sender as a receiver for another sender to reduce the entropy effect. We also avoided double selection of the same household for the receiver role.

where subjects were matched to randomly selected kin who participated in the same experiment, which restricted the kin group network.

Communication within the village about the experiment might have informed the subjects about the experiment beforehand. To avoid this, we finished the experiment quickly, mostly within a day in each village. Since the experiment was conducted in subjects' homes, we believe that the information was not likely to spread. In addition, subjects were instructed not to discuss the experiments with anyone. Since matched kin and non-kin subjects were from the same village, subjects could potentially figure out the identity of the matched partners by following the enumerator's movement in the village, to influence the matched partner decisions. In order to avoid this, different enumerators instructed the senders and the matched receivers.

During the experiment, the subjects were informed whether the matched partner belonged to kin or non-kin groups. This makes kinship salient in creating the group. This might exert some demand effect on subjects' behaviour. However, in order to minimise such effects, we changed the order in which the decisions were faced and we communicated neutrally about both the groups while instructing subjects.

The composition of non-kin samples is a matter of concern in a caste-based hierarchical society like India. Marriage within the caste is common, and therefore a kin group is relatively homogenous in terms of caste. The composition of the non-kin group, in contrast, depends more on the caste composition of the village. Thus, any observed difference could also be due to caste-based discrimination, rather than kinship. Therefore, we check the caste composition of villages to see whether the non-kin group is heterogeneous in terms of caste. The majority of the villages in our sample are dominated by one type of caste, which reduces the heterogeneity in non-kin samples in terms of caste (see Appendix Table A2).

4. Results

4.1. Mean comparisons

On average, senders and receivers earned INR 364 (USD 5.4) and INR 75 (USD 1.1) respectively, along with the participation fee of INR 100 (USD 1.4). Table 2 presents the proportion sent, returned and expected in the trust and dictator experiments. Let us begin with the trust experiment. The average share of the endowment sent is 31 percent (≈INR 60). This

is lower than what is typically found in the literature (Camerer, 2003, Johnson and Mislin, 2011), where the average proportion sent is often around 50 percent. The proportion sent is considerably higher if the receiver is kin (38 percent) than non-kin (24 percent), and the difference is statistically significant (p-value<= 0.001). Interestingly, 17 percent of the subjects sent nothing and this share was higher for a non-kin partner (22 percent) than for a kin partner (13 percent). We also perform a between-subject comparison by exploiting the varied order of decisions faced by subjects, which also supports the results found in Table 2.[54]

Table 2: Mean proportion sent, returned, and expected from kin and non-kin partners in Trust and Dictator experiment

	Total	**Kin**	**Non-kin**	**P-value [a] (kin – non-kin)**
Proportion sent in trust game	0.31 (0.24)	0.38 (0.25)	0.24 (0.20)	0.0004
Proportion sent in dictator game	0.25 (0.22)	0.31 (0.22)	0.18 (0.19)	0.0001
Proportion expected to return	0.37 (0.19)	0.42 (0.18)	0.31 (0.19)	0.0000
Proportion of sample sent zero in trust game	0.17	0.13	0.22	-
Proportion of sample sent zero in dictator game	0.23	0.16	0.31	-
Proportion of sample expects zero return	0.11	0.04	0.19	-

Parentheses represent standard deviations, [a] Wilcoxon signed-rank test

Sending more to kin could be motivated by an expectation of a stronger reciprocal action by kin receivers. On average, 42 and 31 percent of the tripled amount was expected from kin and non-kin partners, respectively; this difference is also statistically significant at the 1 percent level (p-value <0.001; Wilcoxon signed-rank test). Higher expectations about a kin partner's reciprocity might be spurred by frequent interaction and obligatory sharing norms among the kin group.

Another important reason why the proportion sent to the kin receiver is higher could be altruism. If we look at the behaviour in the dictator game, this is indeed what is suggested. On average, 25 percent (≈50 INR) of the endowment in the dictator experiment was sent to the

[54] The order of decisions faced by subjects was varied, which allows us to explore between-sample comparisons. Comparing the proportion sent by subjects who faced the kin decision first to the proportion sent by subjects who faced the non-kin decision first (shaded cells in Table A1 in Appendix), we found the proportion sent to kin is significantly higher than the proportion sent to a non-kin partner.

receiver, which is consistent with the other results in the literature (Camerer, 2003, Cox, 2004). The average proportion sent to a kin partner (31 percent) was considerably higher than what was sent to a non-kin partner (18 percent); again, the difference is statistically significant (p-value < 0.0001). The share of subjects who sent nothing is higher with a non-kin partner (31 percent) than with a kin partner (16 percent).

Table 3: Proportion returned by kin and non-kin receivers contingent on amount sent

Contingent amount	Mean proportion returned		P-values[b]
	Kin	Non-kin	
20/60	0.44	0.45	0.565
40/120	0.40	0.37	0.219
60/180	0.39	0.36	0.025
80/240	0.40	0.36	0.018
100/300	0.39	0.37	0.184
120/360	0.40	0.38	0.333
140/420	0.41	0.38	0.117
160/480	0.42	0.39	0.081
180/540	0.42	0.40	0.217
200/600	0.44	0.41	0.131

[b] *Kruskall-Wallis equality-of-populations rank test and Bonferroni critical value is 0.005*

The average contingent proportion returned by kin and non-kin receivers is 41 and 39 percent, respectively, which is higher than what was found by Ashraf et al. (2006), and consistent with the findings of Johansson-Stenman et al. (2009) and Etang et al. (2011).[55] Note that we used the strategy method for the amount returned. Table 3 presents the comparison of the returned ratio between kin and non-kin receivers for each contingent amount. The proportion returned by kin is marginally higher than the amount returned by non-kin receivers for all the contingent amounts. However, the difference is statistically significant in only 3 out of 10 contingent amounts.[56] Our test of comparison between kin and non-kin receivers could suffer from multiple comparison problems since the subjects make multiple decisions on the contingent amount received. We carry out multiple comparison tests to reduce the overall chance of false rejection. We follow the Bonferroni adjustment criterion to assert the critical level; it suggests that the critical level for a percentage significant level is

[55] The difference in the average proportion returned is not statistically significant. Later studies used a direct revelation approach.

[56] Except for the contingent amount 20/60, in all the contingent situations, kin receivers returned more than non-kin. We can see that the proportion returned is higher when a sender sent 20 INR (receiver received 60 INR). This could be due to restricting the decision to multiples of 20, as subjects have to start from INR 20 in that case, which covers about 1/3rd of the proportion received.

simply 0.005.[57] If the p-value is less than 0.005, the hypothesis of no difference in the proportion returned by kin and non-kin receivers is rejected. From Table 3, we do not see any p-values that are less than 0.005, which suggests that there is no difference in the proportion returned by kin and non-kin receivers.

4.2. Kinship and Closeness

On average, both sender and receiver subjects identified 8 kin households, ranging from a minimum of 4 to a maximum of 15 households (Table 1).[58] The subjects identified 10 close households in their social network, which could be kin or non-kin. This allows us to know the number of kin households in their close group. We observed at least one kin in their identified close households list in both sender and receiver groups. Thus, kinship does appear in the social closeness context of individuals, but perhaps less often than what one would expect. Similar findings are reported by Rachlin and Jones (2008), where they found that kin appear very frequently in the subjects' social network and are given higher ranks for closeness.

4.3. Econometric analysis

Now, we estimate the proportion sent in the trust game as a function of whether the matched partner is kin, conditional on the proportion sent in the dictator game – an indicator of altruistic motive and proportion expected to return – as an indicator of expected reciprocity. The results are presented in Table 4. An unconditional estimation in Column 1 shows that kin partners receive more than non-kin partners. The estimate implies that the proportion sent to a kin partner is 14 percentage points more than a non-kin partner. We next control for senders' altruistic motives and find that the magnitude of difference in the proportion sent to kin and non-kin partners decreases by 4 percentage points. Introducing senders' expected reciprocity motives and risk preferences does not change the size of the difference in the proportion sent to kin and non-kin partners. Both expected reciprocity and altruistic motives exhibit a positive association with the proportion sent, which is in line with previous studies (Cox, 2004,

[57] The Bonferroni adjustment verifies the true critical level (α) using a conventional α critical level, divided by the number of multiple tests n; that is, $\alpha = \alpha/n$. In our case, there are 10 multiple comparisons to make for each pair. The adjusted critical level is 0.005 (0.05/10).

[58] Senders identified significantly more kin households than did receivers. All of the subjects in the sender group identified 10 close households and ranked them, except three subjects, who could not identify more than four close households.

Schechter, 2007, Ashraf et al., 2006). We did not find any statistically significant effect of subjects' risk preferences on proportion sent.

We find statistically significant order effects: senders send more when they face the non-kin decision first and send less when they face the dictator decision first. Given the general tendency of sending more to kin, in the former case, facing the kin decision after the non-kin decision increases the total proportion sent by the subject.[59] In the latter case, facing a trust decision (which has the incentive of reciprocity from the receiver) after the dictator decision (which has no reciprocal actions by the receiver) reduced the proportion sent in the trust game. Among the agents of groundwater contracts, sellers of water send more than buyers of water. We also found that senders having a higher number of kin in their close group do not significantly differ in the proportion sent. The interaction between kinship and number of kin in the close group of households was also tested, but the interaction coefficient was not significant.[60] We also found regional differences in the proportion sent, which reflects the general trust behaviour in the specific region.[61] Among the demographic variables, age and education were found to have a negative effect on the proportion sent. Considering land owned, which is a proxy for the subject's wealth, an increase in landholdings increases the proportion sent. Further, we control for subjects' belief about wealth status, and help given and received from the kin group in the village.[62] Conditional on all relevant controls, the difference in the proportion sent to kin and non-kin partners is consistent and statistically significant. The result implies that the proportion sent to kin partners is 4 percentage points higher than the proportion sent to non-kin partners, which confirms our Hypothesis i) that individuals trust their kin more than they trust the non-kin group. We do not find any significant evidence regarding the relationship between the number of kin in the close group of households and the level of kin trust. Therefore, we do not accept Hypothesis ii) that

[59] From Appendix Table A1, we can confirm that the average proportion sent is high when the sender faces the non-kin decision first followed by the kin decision. After the decision was made for the non-kin partner, subjects were asked to make a decision for the kin partner, which made kinship salient in the experiment. This might encourage the subject to behave in a certain way; therefore, the effect we see might be due to an experimental demand effect.

[60] Estimates were very sensitive to the addition of interaction terms. With such specifications, neither the interaction term nor the kinship variable was significant in explaining the proportion sent.

[61] Accordingly, subjects from the Chikkaballapura and Tumkur districts sent significantly less than did subjects from the Kolar district.

[62] We controlled for how often subjects received help from kin and gave help to kin in the village, using a five-point Likert-scale (from 1= more often to 5= did not receive at all). The results suggest that less help received from kin decreases the amount sent. Similarly, subjects stated their subjective comparison of their individual wealth to the wealth of their kin network in the village and the position/place they gave to their kin in everyday life, which did not have an effect on the proportion sent.

socially close kin exhibit more trust towards their kin compared to those who are not close to their kin.

Table 4: Determinants of trust behaviour

Variables	Proportion sent trust experiment				Proportion sent dictator experiment
	(1)	(2)	(3)	(5)	(6)
Kin partner (1-kin receiver, 0-otherwise)	0.137*** (0.019)	0.035*** (0.013)	0.109*** (0.018)	0.044*** (0.014)	0.091*** (0.022)
Proportion sent in dictator game		0.809*** (0.037)		0.589*** (0.044)	
Proportion expected to return			0.129** (0.053)	0.082** (0.039)	
Risk preferences			-0.012 (0.008)	0.001 (0.006)	
Agent type (1-Seller, 0-buyer)				0.032* (0.017)	-0.042** (0.020)
No. kin in the close group of households				0.009 (0.006)	0.003 (0.008)
Kin*No. kin in the close group of households					0.029** (0.012)
Order 1: Faced non-kin decision first				0.034** (0.014)	0.011 (0.016)
Order 2: Faced dictator decision first				-0.042*** (0.014)	-0.018 (0.016)
Gender				0.023 (0.050)	0.027 (0.048)
Age				-0.003*** (0.001)	-0.002** (0.001)
Education				-0.005** (0.002)	0.005** (0.002)
Family size				-0.004 (0.004)	0.002 (0.004)
Land (acres)				0.009** (0.004)	0.012* (0.006)
Wealth comparison to kin (1-more, 2-equal, and 3-less)				0.013 (0.010)	-0.028** (0.013)
Position given kin in daily life (1-more imp, 5-not imp)				0.011 (0.011)	0.005 (0.013)
Help received from kin (1-more often, 5-not at all)				-0.021** (0.008)	0.014 (0.009)
Help is given to kin (1-more often, 5-not at all)				0.004 (0.010)	0.009 (0.011)
Constant	0.241*** (0.012)	0.092*** (0.011)	0.273*** (0.021)	0.347*** (0.088)	0.259*** (0.097)
Regional effects	NO	NO	NO	YES	YES
No. observations	598	598	492	492	598
R-squared	0.081	0.562	0.103	0.508	0.221

**** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses*

Next, we look at the behaviour in the dictator game. Column 6 reports the determinants of the proportion sent in the dictator experiment. The proportion shared with a kin partner is on average 9 percentage points higher than the proportion shared with a non-kin partner. Interacting the number of kin in the close group of households with the kin dummy shows that the proportion shared with a kin partner increases as the number of kin in the close group of households increases. Estimated at the mean, the proportion shared with kin in the dictator experiment is 12 percentage points higher than the proportion shared with non-kin partners. This suggests that there is substantial altruistic concern towards kin compared to non-kin partners.[63]

Next, we analyse the determinants of trustworthy behaviour of receivers. The results are reported in Table 5. Conditional on the contingent amount received, we find that kin return a higher proportion than non-kin receivers, and the difference is significant at the 10 percent level. Interacting a kin dummy with the number of kin in the close group of households changes the sign of the kin dummy from positive to negative. The interaction term is positive and statistically significant, indicating that kin return more if there are more kin in the close group of households. As a robustness check, we also estimate the model including demographic variables and other stated information about kin in the village. The size of the primary coefficient does not change much when including these additional variables.

The results show a twofold effect of kinship. Kin receivers send back less than non-kin when they have no kin in the close group; however, kin receivers send back more than non-kin receivers if they have at least one kin in their close group. Evaluating at the mean, kin receivers return 2 percentage points more than non-kin receivers. The result confirms that kin exploit the relationship or develop evasive behaviour when they feel kin are distant to them. However, kin increase reciprocal and earnest behaviour when they feel socially close to kin. The results confirm our Hypothesis i) that trustworthiness differs between kin and non-kin receivers. However, the magnitude of the difference is economically less of a concern. Our Hypothesis ii) is also confirmed in the case of trustworthiness where the trustworthiness of the kin receivers varies according to the extent of social closeness with the kin group.

[63] We checked for problem of multicollinearity and found VIF less than 3. Addition of an interaction term did not affect the coefficients of other variables.

Table 5: Determinants of Trustworthiness

Variables	Proportion returned		
	(1)	(2)	(3)
Kin	0.026*	-0.055***	-0.056***
	(0.015)	(0.018)	(0.019)
Kin × No. kin in close group of households		0.068***	0.068***
		(0.009)	(0.009)
Gender			0.002
			(0.037)
Age			-0.003***
			(0.001)
Education			-0.003
(years)			(0.002)
Marital status			-0.166***
(1-married, 0-otherwise)			(0.026)
Family size			0.005
			(0.006)
Land			0.004
(Acre)			(0.004)
Wealth comparison with kin			-0.015
(1- more, 2-equal, 3-less)			(0.011)
Position given kin			-0.021*
(1-more imp, 5-not imp)			(0.012)
Help received from kin			0.006
(1-more often, 5-not at all)			(0.009)
Help is given to kin			-0.002
(1-more often, 5-not at all)			(0.010)
Constant	0.431***	0.431***	0.826***
	(0.014)	(0.014)	(0.090)
Fixed effect of amount received	YES	YES	YES
Regional effect	NO	NO	YES
No. of observations	5,980	5,980	5,980
R-squared	0.014	0.092	0.119

**** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses,*
Standard errors are estimated by clustering the observations at the individual level.

We also investigate whether kin and non-kin receivers' behaviour aligns with senders' expectation about their trustworthiness. Table 6 reports senders' expectations from kin and non-kin receivers and the corresponding actual proportion returned by receivers. We use a t-test, where we compare the mean expected return to the actual proportion returned by kin and non-kin receivers for each proportion sent by senders. Senders' expectations are higher compared to the actual proportion returned by kin receivers; however, we find a significant difference in one out of 9 cases, when senders sent 80 percent of the endowment.[64] In the case of non-kin receivers, senders' expectations are lower than what was actually returned. In three out of six cases, we found that the expected returns are significantly lower than the actual

[64] We used the entire receiver samples for this analysis, since we used the strategy method to elicit the proportion returned. These results are based on small sample properties.

proportion returned by the receiver. This result confirms Hypothesis iii), that the senders are less likely to make incorrect predictions about their kin group's trustworthy behaviour. However, the predictions about the trustworthiness of non-kin partners are in fact incorrect in half of the cases. However, non-kin receivers return more than predicted by senders. The existence of frequent interactions and exchange relationships within the kin network might help senders form well-calibrated expectations about the trustworthiness of their kin, while these mechanisms are absent in the case of non-kin groups, which leads to incorrect beliefs about the non-kin partners.

Table 6: Mismatch in Expectations and Actual Reciprocity

Proportion sent	Proportion expected to be returned				Proportion returned		
	Obs	Kin	Obs	Non-kin	Obs	Kin	Non-kin
0.1	28	0.37 (0.26)	56	0.23 (0.20)	299	0.44 (0.27)	0.45*** (0.27)
0.2	23	0.46 (0.23)	34	0.32 (0.25)	299	0.40 (0.23)	0.37 (0.22)
0.3	49	0.41 (0.18)	61	0.37 (0.17)	299	0.39 (0.20)	0.35 (0.20)
0.4	14	0.42 (0.12)	10	0.38 (0.15)	299	0.40 (0.20)	0.36 (0.20)
0.5	110	0.42 (0.16)	67	0.32 (0.13)	299	0.39 (0.19)	0.37** (0.19)
0.6	7	0.40 (0.13)	0	-NA-	299	0.40 (0.19)	0.38 (0.20)
0.7	8	0.42 (0.17)	0	-NA-	299	0.41 (0.19)	0.38 (0.19)
0.8	2	0.75 (0.29)	0	-NA-	299	0.42** (0.19)	0.39 (0.19)
0.9	0	0	0	-NA-	299	0.42 (0.19)	0.40 (0.20)
1	19	0.49 (0.15)	4	0.21 (0.16)	299	0.44 (0.19)	0.41** (0.20)

*Standard deviations in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

5. Conclusions

In this study, we aimed to test the differences in the trust and trustworthy behaviour of individuals towards kin and non-kin groups. We carried out a lab-in-the-field experiment in selected villages in Karnataka, India. We used a trust experiment to elicit trust and trustworthy behaviour and dictator experiments to elicit altruistic behaviour. We used a within-subject design, where each sender is matched to a kin and to a non-kin receiver to make decisions. Our study confirms the findings of Cox (2004), where trust is found to be

motivated by the expected reciprocity of and altruistic concerns for the receivers. Unlike Schechter (2007), we did not find any association between subjects' risk preference and trust behaviour. Exploring the kin relationship between subjects, we find a higher level of trust towards the kin group than towards non-kin, which was demonstrated by the higher proportion sent to kin than non-kin partners in the trust game.

Our findings support the result of Vollan (2011), where the level of trust is higher towards family members and friends than towards unrelated persons in South African and Namibian villages. Based on the expected reciprocity, Vollan (2011) claims that the subject's actions are apparently motivated by altruism rather than by the calculated expectation of reciprocity when kin are involved. That is, they found subjects expect a friend to return more (reciprocity) than a family member, which was described as an altruism. In our study, we exclusively account for a measure of altruism and expected reciprocity to explain the difference in trust behaviour towards kin and non-kin. We found high expected reciprocity and altruism towards kin groups, which suggests that both altruism and reciprocity motives explain the difference in trust towards these groups. Among the motives, high altruism explains much of the variation in trust differences between kin and non-kin. This brings us to the evolutionary concept of 'kin selection', where individuals favour their kin at their own cost due to the inclusive fitness benefit from helping kin (Hamilton, 1964).

In the case of receivers, the difference in kin and non-kin receivers' trustworthiness is very small. However, the behaviour of kin receivers changes according to their closeness to their kin group. Kin receivers show higher trustworthiness than non-kin when they have kin in their close group of households in the village, whereas they exhibit lower trustworthiness than non-kin receivers when they do not have kin in their close group of households. We explain this as follows: when kin are socially close to each other, actions are not only motivated by reciprocity but also by moral obligation, where receivers consider a loss suffered by a kin member as a loss of their own. On the other hand, when kin receivers are socially distant within their kin network, moral obligations may fail to motivate their actions. Thus, they may not care about a loss endured by their kin when deciding their actions.

Our finding confirms the evidence of both strands of literature, which argued the positive and negative effects of kinship. Sadoulet et al. (1997) and Peng (2004) argued that the action of kin members does not depend on the terms and conditions of an agreement, and that kinship acts as an informal risk-sharing network, and protects property rights in small-

scale innovation. On the other hand, Di Falco and Bulte (2011) and Jakiela and Ozier (2015) claim that obligatory sharing norms among kin invite free-riding behaviour and distortionary spending, which are a hindrance to the development process. By considering the degree of closeness within the kin network, our study provides support for both the positive and negative effects of kinship on the trustworthy behaviour of kin. However, we do not find this to be evidence for trust behaviour. In disentangling the distinct effects of kinship by considering the social closeness in the kin network, this study has put forward a new perspective on looking into the effects of kinship.

Senders' actions differ when the partner is kin, while receivers' actions do not differ much depending on whether the partner is kin or non-kin. A study by Cadsby et al. (2008) found that reciprocal behaviour is not sensitive to social distance. Barr (2003) and Etang et al. (2011) also found similar patterns of results, where senders' behaviour is affected by the matched partner belonging to a certain group, while the behaviour of the receiver did not change. Barr (2003) explained the findings based on the structure of the game, where the sender (1st player), before making a decision, had to think forward about another player's action. On the other hand, the receiver (2nd player) was not in a position to think forward; rather, the receiver could only act in response to the actions of the sender. Under such an incentive structure, in addition to altruism and reciprocal expectation motives, the sender might prefer to send more to kin as an investment in maintaining a reputation in the kin network. The reputational investments are not relevant for the receiver since they respond to the action of senders, which does not affect their reciprocity.

Unlike Vollan (2011), we find that senders have higher expectations of trustworthiness from kin than from non-kin receivers. Comparing expected trustworthiness of senders and actual trustworthiness of receivers, we find that senders are less likely to be incorrect about kin trustworthiness than non-kin trustworthiness. The trustworthiness of non-kin receivers is underestimated, although, in fact, there is no difference between kin and non-kin receivers' trustworthiness. This difference might be coming from the difference in the social interactions with kin and non-kin individuals. Customary and frequent interactions with kin allows senders to have reliable information about their behaviour, which enables them to make better predictions about kin's trustworthiness. The contrary is true with respect to non-kin. As a result of senders' misconceptions about non-kin trustworthiness, individuals might not interact as often as they might if they had more trust in each other. This might restrict

informal trade and sharing of resources. Thus, false beliefs about the trustworthiness of non-kin might reduce the overall welfare of agents in informal markets.

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Appendix

Table A1: Between-sample comparison of proportion sent in trust game

	First decision faced is…	Proportion sent		Average prop. sent	Mean difference of first decision (Kin – Non-kin)	T-test (p-vales)
		Kin	Non-kin			
Played trust game first	Kin	0.37 (0.26)	0.25 (0.21)	0.31 (0.24)	0.09	0.0177
	Non-Kin	0.45 (0.26)	0.28 (0.21)	0.37 (0.24)		
Played trust game second	Kin	0.33 (0.23)	0.21 (0.19)	0.27 (0.21)	0.11	0.0029
	Non-Kin	0.35 (0.25)	0.22 (0.20)	0.29 (0.23)		

Parentheses represent standard deviations

Table A2: Caste composition of scheduled castes and scheduled tribes in the sample villages

District	Village no.	Village name	No. of hh	Total persons	SC	ST	Proportion of SC/STs
Gowribidanuru	1	Kothur	624	2508	971	149	0.447
	2	Mallenahalli	131	667	426	60	0.729
	3	Thokalahalli	287	813	126	126	0.310
	4	Hulikunte	108	660	192	69	0.395
	5	Krishnarajapura	95	545	293	231	0.961
	6	Chimakalahalli	183	345	38	0	0.110
Tumkur	7	Ajjihalli	90	363	101	2	0.284
	8	Kallumane thota	157	637	2	81	0.130
	9	Tharati	416	1713	121	23	0.084
	10	Masanipalya	142	-	-	-	-
	11	Chikkapalanahalli	88	378	0	7	0.019
	12	Doddapalanahalli	439	1877	257	245	0.267
	13	Seegepalya	178	-	-	-	-
	14	Kambadalalli	57	237	0	105	0.443
	15	DN palya/channapatana	260	1087	21	232	0.233
	16	yelerampura	367	1459	31	118	0.102
	17	Kambadahalli	110	441	0	8	0.018
	18	Vajarahalli	114	458	0	315	0.688
	19	Belladamadugu	266	1107	230	134	0.329
	20	Marithimmanahalli	218	842	77	39	0.138
	21	Channapattana	260	1087	21	232	0.233
Kolar	22	Yalduru	993	4110	598	516	0.271
	23	Pathamuthukapalli	211	951	346	11	0.375
	24	Kolthur	262	1190	273	205	0.402
	25	Laxmisagara	279	1345	290	186	0.354
	26	Seegehalli	270	1195	287	0	0.240
	27	Ganganatta	17	107	12	95	1.000
	28	Seethareddahallai	157	687	184	0	0.268
	29	Cheekapalli	76	-	-	-	-

Source: Census of India 2011

Experimental Instructions

Part I: Questions about related households in the village:

[Show the village household list to the participant. As a supplement, give them an election list, which consists of each individual's picture.]

This is a village household list, and it consists of all the households in the village. The first column is the house number, the second column is the household head name and the third column is the name of the father of the household head. In addition, please use this election list of the village, where you can see images of the individuals.

Now you have to identify the households which are kin to you or to any member of your household and mark that household as ***kin***. To call a household 'kin', any member of the household (including you) should be related to any member of the other household in the list within a three-generation link, not beyond that. That is, any type of relationship you have with the other household should be after the grandfather generation. Let me explain what kind of relationship falls under this condition.

[Enumerator has to read out the following relationships that come under the three-generation link and explain the relationship. If subjects do not understand, you have to explain again.]

- Direct blood relationship with the household head or member of the household, namely parents, children, brother, sisters.
- Indirect relationship from mother's and father's side, namely cousins, aunts and uncles from the mother's or father's side, which is within three generations.
- Relationship created through marriage, namely father-in-law, mother-in-law, sister-in-law and brother-in-law, which is within three generations.

[Do not rush to the identification phase until they completely understand what we mean by 'kin']

You have now understood the meaning of '*kin household'* in our context. Now you have to identify the kin households on the household list and have to mark (√) in front them.

[Make sure that they fill in the household list properly.

If the subject is illiterate, show the list which consists of pictures of individuals in the village to identify the kin households and mark this in the household list on behalf of them]

Part II: Questions about the closeness of household/s in the village:

We now ask you to select the 10 households in the village household list that are closest to you. A household which is selected as #1 indicates the closest household and #10 indicates the 10^{th} closest.

The household at number 1 would be someone you know well, you are very close with, and who is your relative or friend or neighbour. The household at #10 would be someone you know and may not be as close to as the 9^{th} household. Therefore, as you move from your selected household, numbers 1 to 10 represent decreasing close-intimate relationships.

Now you have to rank the households in the list as explained above.

[Given the village household list to rank the households]

*[***Do not forget to insert the village household list into the instruction booklet***]*

Part III: Terms and conditions of decision-making

We start the first phase now.

You will now be confronted with a decision situation that involves real money. How much you will earn depends on the choices you and your matched participant make, and it may happen that you earn nothing.

- The other participant is a household head in the village.
- The other participant is also paid a participation fee of INR 100 and receives information, just like you.
- You will not know who the other participant is, and that participant will not know who you are.
- Your choices and outcomes are confidential.
- Please do not talk to anyone during the experiment.

You have been matched with two different participants. ***One of the participants is one of your kin,*** who is randomly selected from your kin in the village household list. The ***other***

participant is not your kin, and is a randomly selected household other than one of your kin households in the village household list.

You have to make two decisions for each of the two above-mentioned participants. Thus, in total, you have to make four decisions. From them, two decisions will be randomly selected for actual payment. However, you do not know which one, when you make your decisions. Since the payoff decisions are randomly selected, each decision that you make is equally likely to be a payoff decision. The random selection decision will be done after conducting the interviews with the other participants you are matched with by tossing a coin and you will be paid within a day.

To make this simple, we have printed copies of real money on paper when you make your decisions. We will, of course, pay you with real money at the end of the experiment. Thus, you should consider your decisions seriously.

Situation I

Let us call the person you have been matched with person B.

To begin with, you have been given INR 200 as an endowment. This is in addition to the INR 100 as a participation fee. You have to decide how much of INR 200 you would like to send to person B. You may choose to keep it all for yourself or to send a part or all of it to person B. That is completely your choice.

When you have decided how much of the INR 200 to send to person B, we will triple that amount and give it to B. For instance, if you decide to send INR 100, person B will receive INR 300.

Person B will be asked how much of the received money he/she would like to send back to you. Person B will be informed about the fact that you have received INR 200 to start with, and he/she will be given the same information as you. Person B is free to keep all, some, or none of the tripled amount. We will deliver any amount that person B sends back to you when you come to…… (place) at ……(hour). You will then keep that amount of money, and person B will keep the remaining amount.

For example, if you send INR 100 to person B, person B will get INR 300. If B then returns INR 150 to you, you will have INR 250 at the end. This is figured by subtracting the INR 100 that you sent to B from your initial INR 200 and then adding INR 150 that you received back from B. If, on the other hand, B returns nothing, you will have INR 100 in the end. This is figured by subtracting the INR 100 you sent to B from your initial INR 200. If B

returns everything, you will have INR 400 in the end. This is figured by subtracting the INR 100 you sent from your initial INR 200, and then adding the INR 300 that you received back from B. Remember that you also have the opportunity to send nothing to B, i.e., to keep your INR 200.

Do you fully understand what I have explained and what you have to do?

[If not, enumerator explains again until they completely understand the payoff.]

Decision phase:

As I have said, you are matched with two household heads in the village. Now you need to make a decision for these two matched persons for the situation explained above.

First, person B is your ***kin,*** who is randomly selected from the list of your kin households (Indicated by you in the village household list). '*How much of the INR 200 would you like to send to person B?'*

Choose (√) for the amount you would like to send to your kin in multiples of INR 20 from the following table.

For *example,* if you would like to send INR 100, then tick (√) any 5 boxes next to INR 20s or if you would like to send nothing, tick (√) the box next to zero.

Amount (in INR)	Tick (√/X)	Amount (in INR)	Tick (√/X)
Zero (0)			
			
			
			
			
			

The total amount that you have chosen to send to your matched kin person is INR _____

Given the amount that you have decided to send to person B who is your *relative*, we will triple this amount, which then becomes INR ____. *[Multiply the amount they decided to send and fill in the blank]*

How much of this amount do you think this person will send back to you? INR ___

Second, I will ask you to make your decision when person B is ***not your kin***. The person is from a randomly selected household other than your kin households in the village household list. '*How much of the INR 200 would you like to send to person B?'*

Choose (√) the amount you would like to send to your kin in multiples of INR 20 from the following table. For *example*, if you would like to send INR 100, then tick (√) any 5 boxes next to INR 20s or if you would like to send nothing, tick (√) the box next to zero.

Amount (INR)	tick (√/X)	Amount (INR)	tick (√/X)
Zero (0)			
			
			
			
			
			

The total amount that you have chosen to send to your matched *non-kin* person is INR _____

Given the amount that you have decided to send to person B who is *not your relative*, we will triple this amount, which then becomes INR ____ *[Multiply the amount they decided to send and fill in the blank]*

How much of this amount do you think this person will send back to you? INR ___

Situation II

Now we are moving to the second decision-making situation. You have to make two more decisions here.

To begin with, you have been given INR 200 as an endowment. This is in addition to INR 100 as a participation fee. You have to decide how much of INR 200 you would like to send to person B. You may choose to keep it all for yourself or send a part or send all of it to person B. That is completely your choice.

Person B will be informed about the fact that you have received INR 200 to start with and he/she will be given the same information as you. Once you have made a decision to send an amount to person B, the amount will be given to B within a day. At the end, person B will keep the amount that you sent and you will be left with the remaining amount.

For example, if you send INR 100 to person B, person B will get INR 100. Thus, you will be left with INR 100 and person B will end up with INR 100. This is figured by subtracting the INR 100 you sent to B from your initial INR 200. Remember that you have the opportunity to send nothing, i.e., to keep your INR 200.

Do you fully understand what I have explained and what you have to do?

[If not, enumerator explains again until they completely understand the payoff]

Decision phase:

As I have said, you are matched with the same two household heads in the village as in the previous decision situation. Now you need to make a decision for the situation explained above.

First, I will ask you to make your decision when person B is ***your kin***, who is randomly selected from your kin households list (Indicated by you in the village household list). '*How much of the INR 200 would you like to send to person B?'*

Choose (√) for the amount you would like to send to your *kin* in multiples of INR 20 from the following table.

For example, if you would like to send INR 100, then tick (√) any 5 boxes next to INR 20s or if you would like to send nothing, tick (√) the box next to zero.

Amount (INR)	Tick (√/X)	Amount (INR)	Tick (√/X)
Zero (0)			
			
			
			
			
			

The total amount that you have chosen to send to your *kin person* B is INR _____

Second, I will ask you to make your decision when person B is ***not your kin***, but is a person randomly selected from households other than your kin households in the village household list. '*How much of the INR 200 would you like to send to person B?'*

Choose (√) the amount you would like to send to your non-kin in multiples of INR 20 from the following table.

For example, if you would like to send INR 100, then tick (√) any 5 boxes next to INR 20s or if you would like to send nothing, tick (√) the box next to zero.

Amount (INR)	Tick (√/X)	Amount (INR)	tick (√/X)
Zero (0)			
			
			
			
			
			

The total amount that you have chosen to send to non-kin person B is INR _____

Part IV: Payoff decision

You have completed all the decisions to be maken in the first phase. In total, you have made four decisions, two decisions for each kin and non-kin person B in the village. Two out of the four decisions will be realised. The random selection of the decisions will be made after finishing the interview with the matched kin and non-kin person B.

You will be informed about the decisions made by the matched kin and non-kin person B, and also about the decisions chosen for pay-out. The payoff will be calculated based on your and the matched person's decisions as discussed previously, and the real money will be paid out accordingly. Therefore, we request you once again to meet us at the above-mentioned place and time.

Previous doctoral theses in the Department of Economics, Gothenburg

Avhandlingar publicerade innan serien Ekonomiska Studier startades
(Theses published before the series Ekonomiska Studier was started):

Östman, Hugo (1911), Norrlands ekonomiska utveckling
Moritz, Marcus (1911), Den svenska tobaksindustrien
Sundbom, I. (1933), Prisbildning och ändamålsenlighet
Gerhard, I. (1948), Problem rörande Sveriges utrikeshandel 1936/38
Hegeland, Hugo (1951), The Quantity Theory of Money
Mattsson, Bengt (1970), Cost-Benefit analys
Rosengren, Björn (1975), Valutareglering och nationell ekonomisk politik
Hjalmarsson, Lennart (1975), Studies in a Dynamic Theory of Production and its Applications
Örtendahl, Per-Anders (1975), Substitutionsaspekter på produktionsprocessen vid massaframställning
Anderson, Arne M. (1976), Produktion, kapacitet och kostnader vid ett helautomatiskt emballageglasbruk
Ohlsson, Olle (1976), Substitution och odelbarheter i produktionsprocessen vid massaframställning
Gunnarsson, Jan (1976), Produktionssystem och tätortshierarki – om sambandet mellan rumslig och ekonomisk struktur
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Lönnroth, Johan (1977), Marxism som matematisk ekonomi
Johansson, Börje (1978), Contributions to Sequential Analysis of Oligopolistic Competition

Ekonomiska Studier, utgivna av Nationalekonomiska institutionen vid Göteborgs Universitet. Nr 1 och 4 var inte doktorsavhandlingar. (The contributions to the department series 'Ekonomiska Studier' where no. 1 and 4 were no doctoral theses):

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