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CONTRACT THEORY AND ITS APPLICATION TO GROWNDWATER MARKETS IN INDIA

By

Kei Kajisa

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ABSTRACT

CONTRACT THEORY AND ITS APPLICATION TO GROWNDWATER MARKETS IN INDIA

By

Kei Kajisa

This dissertation explores the mechanisms of contract choice and price determination under bilateral transaction between an owner of irrigation systems and a non-owner at groundwater markets. A sample of owners and non-owners in six villages in Madhya Pradesh in India is used for empirical analysis. The analyses of contract choice show that risk-sharing is the factor underlying the choice of sharecrop contract over either fixed-rent or flat-charge contract. The analyses of price determination show that the unit water price becomes higher under sharecrop contract since the water buyers pay a risk premium to the sellers when risk is transferred from the buyers to the sellers by sharecrop contract. The other notable result of price analyses is that in contrast to the conventional notion of seller's monopolistic pricing, the market structure rather works in favor of the buyers in that they are charged no greater than the cost of irrigation. Thus, the water markets in the study area are described such that while the water prices are not exploitative, in risky environment sharecrop contract is chosen with a payment of a risk premium from the buyers to their sellers.

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To my parents

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INTRODUCTION

Incompleteness and imperfection of markets are salient features in less developed economies. Some markets such as credit and contingent markets are missing, and thus an opportunity of transactions may be limited. Asymmetric information gives considerable scope for all kinds of opportunistic behavior such as cheating, shirking, and moral hazard. Consequently, transaction costs associated with the use of markets for exchange may become very high and sometimes prohibitive.[1] In response to these circumstances, exchanges may be limited to a face-to-face informal contract as opposed to the open market transaction.

The most famous example in agrarian economies is the existence of various arrangements of land-tenancy and labor-employment contracts (Hayami and Otsuka, 1993; Bardhan, 1989, 1984). Unfortunately, however, it is not well known how similar informal contracts are observed for groundwater markets between owners of private irrigation systems and non-owners. As well as land tenancy, the transactions of groundwater markets carry interesting features which we cannot observe under perfectly competitive markets (Saleth, 1998; Meinzen-Dick, 1996; Fujita and Hossain, 1995; Kahnert and Levine, 1994; Janakarajan, 1993; Shah, 1993; Pant, 1991). First, different types of contracts coexist. Second, variations in water price are very large not only across villages but also across individual pairs of owners and non-owners. These two characteristics of groundwater markets provide us with an opportunity to tackle the long-standing research issues in the field of the economics of contracts: what are the economic

[1] Transaction costs typically involve the cost of information, search, negotiation, screening, monitoring, coordination, and enforcement.

factors underling the choice of a particular type of contract; what are the determinants of price under informal contracts. Yet, the groundwater markets have not systematically been analyzed within the framework of contract theory.

The research objective of this paper is to explore theoretically and empirically the mechanism of contract choice and price determination of groundwater markets. The theoretical argument in this work is based on the economics of contracts. For empirical study, I use our original data set from India. India provides an interesting case because private irrigation systems have been rapidly proliferating since the cut back of public investment in large scale canals in the late-1960s, and consequently ground water markets have been emerging in many villages (Rosegrant, 1997). I begin with an analysis of contract choice in the following chapter; chapter 4 explores water price determination under different types of informal contracts; chapter 5 synthesizes the previous chapters' conclusions and policy implications.

Chapter 1

CHARACTERISTICS OF GROWMDWATER MARKETS IN SURVERY AREA

The six villages chosen for this study are located in two adjacent districts, Hoshangabad and Narshimhapur, in Madhya Pradesh. In these villages, a research project on an integrated analysis of natural resource management was conducted from December 1997 to April 1988. The number of water buyers in each village is not so large since most of the farmers own tubewells (Table 1-1). Among 569 households in the surveyed villages, there are 41 water sellers and 79 water buyers (Table 1-1). The number of sellers is smaller than the number of buyers since some sellers sell water to multiple buyers. We also confirmed who sells to whom in order that the samples became matched data set.

The surveyed villages are homogeneous in terms of agronomic condition. The climate is characterized as monsoon with deep-black soil.[2] The farmers in the area cultivate soybeans during rainy season (*Kharif*) without relying on irrigation, and they cultivate mostly wheat and sometimes chickpeas with electric pumps and tubewell irrigation systems during dry season (*Rabi*).[3] The household samples I use in this study are 26 sellers and 38 buyers who cultivate wheat.

All water sellers are self-cultivators using their own tubewells, and there is no pure-seller who owns tubewells but do not farm by himself. Sellers are usually sell water after meeting the needs of their own fields, and thus it is claimed that sellers are selling

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[2] There is no major difference in terms of annual rainfall, but it increases gradually as we move from west to east.

[3] Sugarcane is cultivated through a year but it is the minor activity in the study villages.

"surplus" water (Shah, 1993). All tubewells for irrigation are powered by electric pump and there is no diesel pump in our survey field. By the government policy the electric charge is free in village A, B and C. In village D, E, and F, if pump is smaller than 5 horsepower the well owners can use electricity for free, but if larger, the well owners have to pay fixed amount of electricity charge by season.

All the buyers are also self cultivators and thus there is no specific case in the sample wherein the landlords provide water to the tenants as a part of interlinked land tenancy. In villages A, D, E and F, some farmers who do not own tubewells irrigate their land by water from stream (Table 1-1). Among 38 water buyers, there is no buyers who answered that they would irrigate their land by stream if current seller refused to sell water, but 8 buyers answered that they would buy water from another tubewell owner, and 30 buyers answered they have no water source other than the current seller. This indicates that easiness of water access varies among buyers.

Although a wide variety of contracts exist in Indian water markets, the contracts we observed in the study area are classified into three: sharecrop, fixed-rent, and flat-charge contract.[4] Under sharecrop contract, buyers and sellers share buyers' harvest for water charge; under fixed-rent contract, water-buyers pay a fixed amount of cash for certain acreage of irrigation for a season; under flat-charge contract, the buyers can

[4] Besides these three types of contracts, Shah (1993) observes several different types in Andra Pradesh in India. First is labor contract under which the buyer provide labor and draft power to the seller in return for water. Second is crop and input sharing contract under which the seller provides water, and shares buyer's input costs and the harvest (interlinked contract). Fujita and Hossain (1995) observed the contract called "*chaunia*" in Bangladesh under which the well-owner rents in land during dry season from the landlord who does not own irrigation systems. We observe no such contracts as those observed by Shah; there is only one case in our data set which resembles a *"chaunia"* contract.

irrigate as much as they want at a given per-acre-water-price.[5] Although each contract is observed 17 %, 13 % and 8 % respectively over the study area, distribution of three types of contracts in each village is skewed (Table 1-2). We observe all three types only in village C and D. I talk about the methodological issue caused by this in next chapter.

In order to clarify the terms of contract, I have a few remarks on linkages of water contract with other inputs. First, all water buyers cultivate their own land, and thus there is no specific case in our sample wherein the landlords provide water to the tenants as a part of interlinked land tenancy.

Second, there might exist linkages with other inputs such as animal, tractor or labor. Water buyers might rent capital inputs (animal or tractor) from sellers, or buyers might provide labor works to sellers as a part of payment. Unfortunately I do not have this kind of information in our data set. In our sample, however, the farmers pay village-homogeneous rental fee to capital inputs, and village-homogeneous daily-wages to hired labors. Thus, even if buyers use seller's animal or provide labor works to sellers, there seems not to be interlinked with water transaction. As for seed, fertilizer and pesticide, all sample households purchase them at either public or private store, and thus there is no possibility of interlinked contract through these inputs.

Third, there are several cases in our sample wherein sellers do not allow buyers to operate irrigation systems (pump transportation, pump driving, and channel digging). The salient feature of these cases is that all these sellers also do not handle their irrigation systems by themselves but hire an irrigation manager who conducts all irrigation activities. Since these hired managers are also in charge of buyers' irrigation operations,

[5] A unit of measurement is the area irrigated. This is common in the area where farmers use electric pumps, and electricity is provided for free or fixed amount payment per season, while hourly payment is

buyers do not operate irrigation systems by themselves. I discuss about this in next chapter.

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common for diesel pumps since diesel consumption is linked to hours of operation.

Table 1-1: Characteristics of irrigation in six villages

	Village						
	A	B	C	D	E	F	<Total>
Number of ag household	70	106	93	100	101	90	560
Number of well-owner-cum-non-sellers	40	82	74	49	34	32	311
Number of well-owner-cum-water-sellers	3	9	7	8	8	6	41
Number of water buyers	4	9	12	15	27	12	79
Number of households irrigated by stream	3	0	0	18	8	12	41
Irrigated agricultural households (%)	71%	94%	100%	90%	76%	69%	83%

Table 1-2: Types of Water Contract across Villages

	Village						
	A	B	C	D	E	F	Total
Number of Contract Observed in Village							
(3) Sharecrop	1	0	3	4	9	0	17 (45%)
(2) Fixed-rent	1	3	6	1	0	2	13 (34%)
(3) Flat-charge	0	4	2	2	0	0	8 (21%)
Village total	2	7	11	7	9	2	38

Chapter 2

CONTRACT CHOICE AT GROWNDWAER MARKETS

2.1 Introduction

It is well known that there exist variety types of contracts for land tenancy all over the world. A number of researchers have theoretically and empirically investigated the relevant economic factors underlying the choice of a particular type of contract over others.[6] Unfortunately, however, the same amount of effort has not been devoted to the analysis of the contractual choice for groundwater markets, despite the existence of different forms of contracts. Moreover, few studies pay attention to the uniqueness of groundwater market contracts

A unique phenomenon at groundwater markets is that we observe not only sharecrop and fixed-rent contracts but also flat-charge contract under which water fee is charged either hourly basis or acreage basis, and payment is done when water buyers use irrigation systems (Saleth, 1998; Meinzen-Dick, 1996; Shah, 1993). Different from land, un-bulky input like irrigation water can be sold according to volume. Still a certain portion of sellers and buyers choose fixed-rent payment. There may exist economic reasons underlying the choice of flat-charge contract over fixed-rent contract. On the

[6] For review of theoretical achievements, see Hayami and Otsuka (1993) and Singh (1989). For econometric empirical works on contract choice at land rental markets, see Tunali (1993), Allen and Lueck (1992), Rozenzweig (1988), Datta et. al. (1986), Alston et. al. (1984). For descriptive empirical works, see Sharma and Dreze (1996), Roumasset and Uy (1987), Robertson (1982), Bliss and Stern (1982), Rao (1971).

other hand, two contracts can be practically indifferent if rescheduling of fixed-rent contract is allowed when unexpected events happen after they enter into the contract. In this regard, the issues of contract choice at groundwater markets are not only an identification of the determinants but also a clarification of the reasons of existence of flat-charge contract. Yet these issues have not been addressed systematically considering the past theoretical achievement of contract choice, nor adequately tested by data from water markets.

The purpose of this paper is to explore the mechanisms of contract choice among sharecrop, fixed-rent and flat-charge contracts at groundwater markets for a sample of wheat-cultivating water sellers and buyers in six villages in Madhya Pradesh, India. Recent theoretical treatments regard an incidence of a particular type of contract is a response to risk, limited access to contingent market, input market imperfections, asymmetries in information (Hayami and Otsuka, 1993; Singh, 1989). I examine whether these factors significantly affect farmers' contractual choice among three options, especially between fixed-rent and flat-charge contracts. The sample I use has a notable advantage for this purpose; I can match water sellers and buyers, so that I can observe both parties' characteristics. Thus, my econometric results do not suffer the omitted variable problem which is due to using only one party's characteristics in an analysis of two parties' choice problem.

Section 2.2 is devoted to the empirical strategy; Section 2.3 presents variable construction and hypotheses; Section 2.4 and 2.5 present analytical results quantitatively and qualitatively; Section 2.6 highlights the main conclusion and suggests relevant policy implications.

2.2 Methodological Issues

An empirical strategy commonly used for multiple choices is either the ordered logit or the multinomial logit model. According to the "agricultural ladder" argument, sharecrop contract should be ranked lower than fixed-rent contract since sharecroppers are regarded as more dependent on their renter in terms of agricultural management (Hayami and Otsuka, 1993; Spillman, 1919). While this argument is widely accepted in literature on land tenancy, we are not sure *a priori* where we can rank flat-charge contract which is not observed in land tenancy. Thus, I use multinomial logit model for choice among three types of contracts in this paper. I also perform likelihood ratio test in order to check whether fixed-rent and flat-charge contracts are statistically indifferent, and then if so, I conduct logit analysis for choices between sharecrop contract versus fixed-rent and flat-charge contracts.

Another feature of the empirical strategy in this paper is that I include characteristics of both sellers and buyers as explanatory variables. Since choice of contract involves both parties, my econometric results suffer less from the bias caused by problems associated with omitted variables than the empirical literature in the past that uses either sellers' or buyers' characteristics alone.

The last is about treatment on village-fixed effects. Much of contractual difference is undoubtedly due to complexity of historical, sociological, and political factors peculiar to different places. These factors are difficult to be observed and thus usually assumed to be captured by village dummies in cross-section analysis. Unfortunately, however, as we mentioned in chapter 1, due to zero incidence of a particular type of contract in several villages in our data set, I have to give up using village dummies in my econometric analysis. The omission of village dummies would result in potential bias in estimates, even if the six villages are located in agriculturally homogeneous area. For compensation of this shortcoming, I also provide descriptive analysis in section 2.5, where I investigate the relationship between dominant contract forms in the villages and village level characteristics.

2.3 Variable Construction and The Hypotheses

In this section I list covariates I use in this paper and hypothesize them based on the models presented in the literature on contract choice (for the detail of each model, see Appendix A). However, flat-charge contract is not discussed there simply because land tenancy contract is the literature's main interest and there is no flat-charge in land tenancy contracts. Hence, I first review how tenancy literature discusses the choice between sharecrop and fixed-rent, and then make remarks on peculiar character of flat-charge contract at the end of this section. I divide covariats into variables that attempt to measure household wealth, management ability, alternative opportunity, and factor related with moral hazard. The descriptive statistics of covariates are presented in Table 2-1.

Household Wealth

Wealth plays an important roll in two fundamental models of contract choice: risk-sharing and limited liability models. The former recognize contract as a risk-sharing device in environments characterized by missing contingent markets and asymmetries in information (Stiglitz, 1974). Sharecrop contract has benefit of transferring risk from buyers to sellers, while it could cause the Marshallian inefficiency problem. On the other hand, fixed-rent contract let buyers shoulder the entire risk without Marshallian inefficiency problem. Given this tradeoff, benefit from sharecrop contract would become bigger as buyers get more sensitive to the risk and sellers get more willing to bear some of it. Assuming risk-averse is decreasing in wealth, the larger the buyers' wealth, the more likely is the buyers to shoulder the risk and thus the more likely fixed-rent contract is to be chosen, whereas the converse holds for seller's wealth.

Limited liability explains the relationship between wealth and contract choice in a different way (Sengputa, 1997; Basu, 1992; Shetty, 1988). Due to non-existence of contingent markets in an agrarian economy, liability of buyers' payment is limited by their initial wealth. Sellers will know that the default on fixed-rent may occur when the harvest fails and buyers are poor, while the possibility of complete default is lessened by sharing the harvest. Hence, for buyers with large wealth, fixed-rent contract would be more likely to be chosen.[7] Meanwhile, sellers' wealth does not matter in this argument since sellers are receivers of the payment.

The wealth-variables I use in my empirical analysis are buyers' and sellers' last year's animal holdings (the number of oxen plus cows) and total land holdings (acre). These variables may not be truly treated as exogenous because farmers adjust these variables in their long term decision process. However, they can be still treated as "quasi"-exogenous for cross-section estimation process. Land holdings are seldom adjusted. The last year's number is given to the current year activity, although the number of current year's animal is a part of the entire production decision.

Management Ability

I use management ability in my regression for three reasons. First, the risk-sharing argument supports the inclusion of this variable. Management ability is considered to be closely related with vulnerability toward risk in production. The agent can make the risky environment less risky if he has the management ability. Thus, the higher buyers' (sellers') ability is, the less likely buyers (sellers) hesitate to shoulder the risk by fixed-rent contract (by sharecrop contract), resulting in getting positive (negative) sign on buyers' (sellers') ability variables for the choice of fixed-rent over sharecrop contract.

Second, importance of managerial inputs in contract choice is also pointed out by Eswarn and Kotwal (1985). It has been noted that resource owners often provide managerial inputs to sharecroppers, while fixed-rent farmers are more independent in terms of their farm management. If water buyers have little experience in irrigation agriculture, they would expect suggestion from water sellers who have longer experience of irrigation agriculture and know better about their irrigation systems. On the other hand, if buyers are already experienced, they would rather choose fixed-rent contract to manage their cultivation by themselves. Thus, the higher the buyers' ability, the smaller the benefit from sharecrop contract, while the larger the sellers' ability, the larger the

---

[7] This hypothesis holds without assuming risk-averse agents (see review in Appendix 2 for the detail).

benefit of receiving their managerial input through sharecrop contract. The other way round, I predict positive (negative) sign on buyers' (sellers') ability variables for the choice of fixed-rent over sharecrop contract.

Third, the model called screening model claims that sellers can design a menu of contracts such that high ability buyers will prefer fixed-rent contract and low ability buyers will prefer sharecrop contract (Newbery and Stiglitz, 1979; Hallagan, 1978). Sellers have incentive to do this since they cannot directly observe buyers' true ability and since buyers might mimic themselves as low ability in order to be charged low prices. Thus, buyers' management ability would be positively correlated with the incidence of fixed-rent contract, while sellers' management ability does not matter in this argument. The model is, however, criticized that the ability is generally revealed sooner or later in small rural community (Singh, 1989; Eswarn and Kotwal, 1985). Thus, the sign on buyers' ability variable may not be explained by this logic. There is also difficulty in empirical procedure since true ability is very difficult to measure correctly. One way to circumvent this problem is to find a good proxy, but if good proxy exists, sellers screen buyers by that but not by a menu of contracts, (so that sellers do not have to propose the menu of different types of contracts). Nevertheless, the sign hypothesized by this model does not conflict with those derived from previous two explanations, and thus my prediction does not change.

The management ability variables I use are buyers' and sellers' schooling years and age of household head, which are assumed to measure managerial knowledge and experience. Arguably, these variables are not current year's choice variable.

Monitoring Cost

Monitoring cost is inevitable when there is asymmetry of information between sellers and buyers and thus there is a possibility of cheating in production activities (Allan and Lueck, 1995, 1992; Roumasset and Uy, 1987; Datta et. al., 1986; Alston et. al., 1984). For example, labor-effort must be monitored if there is an incentive to shirk; usage of irrigation systems must be monitored if there is an incentive to overuse them; sharing the harvest also must be monitored if there is a possibility of underreporting. A number of researchers claim that monitoring of these activities is costly and that a particular type of contract is chosen to minimize the sum of these monitoring costs.

Under sharecrop contract, if monitoring of buyers' labor-effort is very difficult, buyers put less labor-effort than the optimal since they receive a portion of their marginal products (the Marshallian inefficiency). On the other hand, since the entire harvest is obtained by buyers, fixed-rent contract entails no cheating in labor-effort. Hence, given other things being equal, the more costly it is to monitor labor-effort, the more likely a fixed-rent contract is offered. Moreover, the more labor-intensive crop cultivation is, the larger the potential losses from cheating, and thus the more likely fixed-rent contract is to be chosen.

Sharecrop contract, however, has advantage in reducing the possibility of buyer's overuse of irrigation systems since increment of outputs achieved by overuse must be shared with sellers. Meanwhile, under fixed-rent contract buyers may overuse sellers' irrigation systems since the entire harvest goes to buyers. Thus, the more difficult to monitor irrigation overuse, the less likely fixed-rent contract is to be chosen. Sellers would be concerned about buyers' overuse if their irrigation systems are vulnerable and precious. Thus, the larger the potential damages on irrigation systems, the less likely fixed-rent contract is to be chosen.[8]

The variables related with monitoring in our data set are the total amount of investment to irrigation systems, whether seller and buyer belong to the same caste group, whether a buyer has alternative water seller, and whether buyers operate irrigation systems by themselves.[9] Regarding the amount of investment, the more expensive the systems, the larger the potential damages by buyers' overuse, resulting in low possibility of fixed-rent contract.

The dummy for caste matching has multiple effects. If both parties belong to the same caste group, it might be easier to build trust between them. Buyers' overuse of sellers' irrigation systems is less likely to occur, resulting in high possibility of fixed rent contract. Meanwhile, cheating in labor-effort may be also less likely to occur within the same group, and thus fixed-rent is less likely to be chosen. Hence, the sign on this variable is an empirical question.

The dummy for existence of alternative water seller may or may not have effect on buyers' cheating activities. The buyer who has alternative seller may have larger incentive to do cheating activities since he can go to another seller in case of rejection from current seller after a disclosure of his cheating activities. If so, this dummy, which is related both with labor-effort shirking and irrigation overuse, has multiple effects as

[8] Monitoring the harvest-sharing arouses cost, too. Buyers know exact amount and quality of their harvest since they harvest by themselves, but sellers have to guess it. If the cost of physical measurement and division of harvested crop is very high, buyers would have incentive to underreport their harvest to the sellers. Thus, the more costly the harvest sharing, the more likely fixed-rent contract is to be chosen. Since I use the samples of wheat cultivator, difficulty of measurement does not vary across samples. Thus, we do not discuss the monitoring cost aroused by harvest-sharing.

caste matching dummy does. In a small village, however, loosing reputation would reduce the opportunity of transactions with other villagers. The buyer may not do cheating activities regardless of the existence of alternative seller. Thus, the empirical question is whether this dummy becomes significant or not, and if significant, how the existence of alternative buyer effect incentive of cheating and then contract choice.

I also allow for dummy whether buyers' irrigation operation is conducted by the irrigation manager who is hired by sellers. If so, sellers do not have to worry about buyers' overuse of their irrigation systems even under fixed-rent contract. Hence, this dummy may have positive sign for the choice of fixed-rent over sharecrop contract. However, as I mentioned in chapter 1, managers operate buyers' irrigation only when sellers hire managers for sellers' own irrigation activities. Moreover, there is neither the case such that sellers themselves operate irrigation systems for buyers nor the case such that sellers hire someone just for buyers irrigation operation, which would have been observed if sellers just wanted to reduce the possibility of irrigation overuse by buyers. Hence, the variation of this dummy may not due to the reason claimed by monitoring cost model but probably due to management inertia, resulting probably in undeterministic sign on this dummy.

Before concluding this subsection, it is better to mention about potentiality of the endogenous variable problem of the dummy for hired irrigation manager. Since this is a part of production decision, estimates would be biased. Given limited information in our data set, however, I can neither adequately address the nature of potential bias in the parameter estimates due to this problem, nor can I adequately instrument these

---

[9] Total investment to irrigation systems consists of the cost of well digging, electric pump, and sprinkler systems.

endogenous variables. Alternatively, I run regressions without these dummies to see robustness of the results.

Remarks on Flat-charge Contract

There are differences and similarities between fixed-rent and flat-charge contract. The most remarkable difference is the nature of risk each party faces. Sellers receive certain amount of payment from buyers for sure under fixed-rent contract, while under flat-charge contract sellers may not be sure since buyers can stop buying water from him in the middle of the season if they get enough amount of irrigation water by rain. Thus, sellers also face the risk, but the nature of that risk is different from the one transferred from buyers to sellers under sharecrop contract which depends on buyers production outcomes but not on buyers decisions about buying or not buying. Therefore, flat-charge contract may have different coefficient on the household wealth and management ability which are assumed to be related with the attitude toward risk. Besides, seller will not worry about buyers' default (limited liability) under flat-charge contract since payment is done when buyers use irrigation systems. This may also change the coefficient on buyers' wealth.

The structure of monitoring cost does not vary between fixed-rent and flat-charge contract. Under either contract, buyers have incentive to overuse irrigation system unless detected, while there is no possibility of cheating of labor-effort. Thus, coefficient on the variables related with monitoring cost may not be different.

Furthermore, there seems to be no practical differences between two contracts. In land tenancy contract, it is observed that landlords reschedule fixed-rent contract when unexpected events happen (Ishikawa, 1975). If the amount of fixed-rent can be rescheduled according to the actual frequency of water application, fixed-rent contract becomes akin to flat-charge contract. Sellers and buyers would not strictly distinguish two contracts. Therefore I have no clear-cut hypothesis as to flat-charge contract, but have empirical question of whether fixed-rent and flat-charge are practically different, and if so how wealth and ability variables have different effect on the choice of fixed-rent over flat-charge contract.

2.4 Econometric Results

Comparison of Three Types of Contract

The results of multinomial logit analysis on three types of contracts are given in Table 2-2. The comparison group is sharecrop contract. Model 1 is without dummy for hired manager and Model 2 is with it. I perform the likelihood ratio tests to examine whether all coefficients are equal across fixed-rent and flat-charge contracts (x^2 statistics and associated p-values are in the table). The null hypotheses is that all coefficients across fixed-rent and flat-charge are same but different from sharecrop contract. The test results indicate that I cannot reject the null hypotheses at any acceptable significant level (p-values are 0.43 and 0.49).[10] Given these test results, I should not call the difference between fixed-rent and flat-charge significant. As I talked in the previous section, sellers and buyers in our study area do not practically distinguish the two contracts. They probably answered the closest option between fixed-rent and flat-charge, while the actual payment schedule may be more flexible depending on contingent events. Meanwhile, the farmers still distinguish sharecrop from non-sharecrop contracts. I discuss this issue in next subsection.

Comparison between sharecrop and non-sharecrop contract

I combine samples of fixed-rent and flat-charge contract into one group. The results of logit regression analysis on choice of fixed-rent and flat-charge contracts over sharecrop contract are given in Table 2-3. Since the qualitative results are not altered dramatically between Models 1 and 2, I will confirm my discussion to the model with the dummy for hired manager.

The variables significant at 10% level are seller's animal holdings and schooling years which have negative effect on the choice of fixed-rent and flat-charge contracts, consistent with my conjecture from risk-sharing model and division of managerial input. Allen and Lueck (1992, 1995) claim that empirical evidences do not support risk-sharing model. However, their argument is based on the data from the United States of America and mainly from non-agricultural sectors where contingent markets are relatively better organized and people are more tolerant to risk than any agrarian economies in less developed countries. My results tell us that risk-sharing can still be a motivation of choosing a particular type of contract in agrarian economy in developing countries. On the other hand, the limited liability model is not supported by our data since the effect

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[10] First, I run multinomial logit regressions with the constraint such that null hypothesis is true (see Appendix B for the results). Then, likelihood ratio statistics are calculated from unconstrained and constrained results.

from *buyer's* wealth is statistically very weak. This is probably because the possibility of complete default at water markets can be circumvented by flat-charge contract.

The factors affecting monitoring cost do not have very strong statistical relationship. Thus, cheating activities in terms of labor effort and irrigation overuse are not serious problems in a small community where people know each other and reputation plays important role in transaction. The statistical relationship of manager dummy is also very weak, implying that the reason of managers' operation for buyers is just due to management inertia.

2.5 Village-level Determinants

I will explore qualitatively the village-level determinants underlying contractual choice. The village-level effects would be clearly recognized by focusing on two extremes, namely the villages B and E where only fixed-rent-and-flat-charge contracts or sharecrop contract exists in large (Table 2-4). The village characteristics I use are weather shock, credit access, remoteness, and health condition presented from rows 4 to 10 in Table 2-4.

The weather shock is measured by the number of drought in the last ten years, district-level means and standard deviations of rainfall from 1901 to 1950. The remarkable feature is that weather shock is harsher for the village B than for the village E. The village B had experienced droughts, having lower mean and higher standard deviation of rainfall (rows 4, 5, and 6). However, the village B seems to be reckless of this climatic risk as nobody chooses sharecrop contract. One potential reason is that all sample farmers are irrigated and thus are not vulnerable to weather shock. Another potential reason is the existence of well-functioning credit and asset markets for consumption smoothing. In drought years, the suffered farmers in the village B either borrowed money or sold their asset to compensate their losses (not shown in Table 2-4). As for credit markets, they claimed that 90 percent of villagers have access to formal credit in the village B (row 7 in Table 2-4). On the other hand, only 47 percent of the villagers have access to formal credit in the village E, implying that means of relief are very limited.

In general, the accessibility to the means of relief is also measured by the remoteness of the village. The remoteness, which is measured by distance from the block headquarter (row 8), distance from the nearest agricultural market (row 9), and accessibility to vehicles (row 10), tells us that the village E is not only located the farthest from the block headquarter but also seasonally limited to the access to vehicles. While the village B is not the least remote village, the stretch to the city is not so long since it still has access to vehicles all seasons.

In sum, while the village B faces risks in agricultural production due to unstable weather condition, their annual income would be rather stable since they have access to several means of relief such as credit and asset markets. One the other hand, the village E faces limited access to the means of income smoothing. Therefore, it is natural to conjecture that the village-level factors associated with risks have significant effects on contractual choice. Thus, omission of village dummies in regression analysis would cause the omitted variable problem; all coefficients might be biased. Nevertheless, it is consistent with village-level explanation in this section that the risk covariates in regression analysis (i.e. relative animal holdings and schooling years) have strong statistical relationship with contractual choice. Getting individual and village level analysis together, what I can still insist is that risk-sharing motivation is significantly affecting contractual choice.

2.6 Concluding Remarks and Policy Implications

In this paper, I explore the factors underlying the contractual choice at the groundwater markets for a sample of wheat-cultivating water sellers and buyers in the six villages in Madhya Pradesh, India. In the study area we observe three types of contracts: sharecrop, fixed-rent, and flat-charge contracts. A notable feature of water markets is the existence of flat-charge contract which is not used for land tenancy. However, a flexibility of informal contractual agreement in agrarian economy makes us wonder whether the villagers practically distinguish flat-charge and fixed-rent contracts. The results from multinomial logit regression analysis show that there is no statistical difference in the choice between flat-charge and fixed-rent contracts. This is probably because it is allowed to reschedule fixed-rent payment according to the actual frequency of irrigation. Unfortunately, our data set does not have the information on contractual rearrangement; further detailed investigation of this issue would be required. Meanwhile, the results obviously show that the farmers distinguish sharecrop contract and non-sharecrop contracts.

The logit regression analyses are conducted to quantify the determinants underlying the choice between these two options. Given the availability of variables, the explanations I employ are risk-sharing, limited liability, managerial input sharing, screening, and monitoring cost models. Putting individual-level econometric analysis and village-level qualitative analysis together, what I can safely state is that risk-sharing is among the motives of choosing sharecrop contract in the study area. While Allen and Lueck (1992, 1995) rejected risk-sharing motivation by using the data from United States of America, it is still an important determinant of contract choice in developing countries where contingent markets are not adequately developed. The econometric analysis shows that sharecrop is more likely to be chosen when sellers own animals (i.e. being less risk-averse), and when sellers are educated (i.e. having risk management ability). The village-level analysis shows that sharecrop contract is skewed in the village that faces limited access to means of income smoothing.

Given imperfection of contingent markets and asymmetries in informaion, sharecrop contract is a "locally optimal" outcome. However, since there may exist the Marshallian inefficiency problem under sharecrop contract, the "local optimum" does not necessarily correspond with the "global optimum" which could have been achieved under perfect markets and no asymmetries in information. The empirical literature on land tenancy shows the existence of inefficiency under sharecrop contract in India (Shaban, 1987; Bell, 1977). If there exists the Marshallian inefficiency also at groundwater markets under sharecrop contract, policy makers had better to consider how to reduce the production risk in villages and also to increase access to means of risk hedge. Further detailed investigation of production environment and detection of inefficiency would help guide policy makers in designing appropriate strategies to obtain "global optimum" at groundwater markets in Indian villages.

Table 2-1: Descriptive Statistics of Variables

Variable	Mean	Standard Deviation
Household Wealth		
Buyer's last year's animal holdings	2.26	1.81
Seller's last year's animal holdings	3.13	1.66
Buyer's land holdings (acres)	5.07	4.79
Seller's land holdings (acres)	9.63	9.95
Management Ability		
Buyer's schooling years	5.58	4.99
Seller's schooling years	4.32	4.29
Buyer's age	44.42	11.01
Seller's age	45.97	15.04
Factor related with Moral Hazard		
Total amount of investment (000Rs.)	6.08	3.87
Caste matching dummy	0.61	0.50
Existence of alternative seller (dummy)	0.24	0.43
Hired manager dummy	0.11	0.31

Table 2-2: Multinomial-logit Regression Analysis of Determinants of Contract Choice
(The comparison group is sharecrop contract)

	With Hired manager dummy		Without Hired manager dummy	
	Fixed-rent	Flat-charge	Fixed-rent	Flat-charge
Household Wealth				
Buyer's animals	0.112	-0.090	0.066	-0.155
	(0.34)	(0.19)	(0.19)	(0.32)
Seller's animals	-1.113	-1.627	-1.214	-1.658
	(1.37)	(1.77)	(1.38)	(1.74)
Buyer's land holdings	0.096	0.025	0.097	0.015
	(0.60)	(0.11)	(0.58)	(0.06)
Seller's land holdings	0.152	0.208	0.137	0.190
	(1.17)	(1.31)	(1.02)	(1.20)
Management Ability				
Buyer's schooling	0.032	-0.088	0.038	-0.107
	(0.24)	(0.50)	(0.28)	(0.58)
Seller's schooling	-0.307	-0.214	-0.365	-0.190
	(1.56)	(0.78)	(1.58)	(0.60)
Buyer's age	-0.075	-0.075	-0.055	-0.069
	(1.22)	(0.86)	(0.86)	(0.70)
Seller's age	-0.001	0.065	-0.001	0.072
	(0.01)	(0.83)	(0.01)	(0.87)
Factor related with Moral Hazard				
Total investment	-0.114	-0.469	-0.085	-0.449
	(0.47)	(1.51)	(0.34)	(1.40)
Cast matching dummy	2.088	5.360	1.598	5.010
	(0.87)	(1.94)	(0.65)	(1.82)
Alternative seller dummy	2.603	4.371	2.601	4.171
	(1.02)	(1.51)	(1.03)	(1.47)
Hired manager dummy	.	.	1.872	0.748
			(0.96)	(0.27)
Constant	4.217	1.901	3.854	1.892
	(1.01)	(0.35)	(0.93)	(0.33)
Likelihood ratio test				
x^2 statistics	11.12		11.49	
(H_0: coefficients are same)	[0.43]		[0.49]	
Observations	38		38	
x^2 statistics	30.78		31.81	
	[0.10]		[0.13]	
Pesudo R^2	0.38		0.39	
Log Likelihood	-24.69		-24.17	

The comparison group is sharecrop contract
Numbers in parentheses are absolute value of z-statistics. Numbers in brackets are p-values.
* significant at 10% level; ** significant at 5% level, *** significant at 1% level

Table 2-3: Logit Regression Analysis of Determinants of Contract Choice
(1 if non-sharecrop (i.e. fixed-rent or flat-charge) is chosen)

	Without hired manager dummy	With hired manager dummy
Household Wealth		
Buyer's animals	0.078	0.047
	(0.25)	(0.15)
Seller's animals	-1.304	-1.299
	(1.73)*	(1.69)*
Buyer's land holdings	0.070	0.077
	(0.47)	(0.50)
Seller's land holdings	0.180	0.159
	(1.42)	(1.26)
Management Ability		
Buyer's schooling	-0.003	-0.001
	(0.03)	(0.01)
Seller's schooling	-0.297	-0.330
	(1.65)*	(1.68)*
Buyer's age	-0.076	-0.057
	(1.31)	(0.93)
Seller's age	0.018	0.016
	(0.33)	(0.29)
Factor Affecting Monitoring Cost		
Total investment	-0.244	-0.204
	(1.08)	(0.90)
Caste matching dummy	3.315	2.823
	(1.44)	(1.23)
Alternative seller dummy	3.443	3.461
	(1.37)	(1.44)
Hired manager dummy	.	1.444
		(0.83)
Constant	4.405	3.808
	(1.11)	(0.96)
Observations	38	38
X^2 statistics	19.66	20.41
	[0.050]	[0.060]
Pesudo R^2	0.38	0.39
Log Likelihood	-16.30	-15.92

Numbers in parentheses are absolute value of z-statistics. Numbers in brackets are p-values.
* significant at 10% level; ** significant at 5% level, *** significant at 1% level

Table 2-4: Types of Water Contract and Selected Characteristics Across Villages

	Village						
	A	B	C	D	E	F	Total
Number of Contract Observed in Village							
(3) Sharecrop	1	0	3	4	9	0	17 (45%)
(2) Fixed-rent	1	3	6	1	0	2	13 (34%)
(3) Flat-charge	0	4	2	2	0	0	8 (21%)
Weather Shock							
(4) Number of drought in the last ten years	1	3	1	0	0	0	-
(5) Mean of rainfall (mm/year) [a]	1295	1295	1295	1361	1361	1361	-
(6) Standard Deviation of rainfall (mm/year) [a]	297	297	297	217	217	217	-
Access to Credit							
(7) Percentage of villagers who can access to formal credit [b]	100	90	100	95	47	25	-
Remoteness							
(8) Distance from block headquarter (km.)	30	25	4	13	50	17	-
(9) Distance from the nearest agricultural market (km.)	30	30	4	12	13	17	-
(10) Accessibility to Vehicles	all season	all season	all season	all season	seasonal	All season	-

Notes

[a] District data

[b] Formal credit institutes includes commercial bank, cooperative bank, governmental bank.

Chapter 3

PRICE DETERMINATION UNDER BILATERAL TRANSACTION

3.1 Introduction

In South Asian countries including India, private lift irrigation systems, i.e. wells, pumps and water conveyance networks, have been rapidly proliferating since the cutback of public investment of large scale canals in the late-1960s (Rosegrant, 1997). Consequently, groundwater markets are emerging in villages, and we observe informal but repeated water transactions between LIS owners and non-owners. In India, the area irrigated through water markets is estimated to be reaching nearly 50 percent of gross irrigated area with LIS, making significant contribution to increasing agricultural production (Shah, 1993).

There has been concern, however, about water sellers' exploitative pricing behavior toward water buyers, which stems from the conventional wisdom of treating water sellers as "water-lords" (Bagchi, 1995; Campbell, 1995; Kahnert and Levine, 1994; Pant, 1992; Dhawan, 1988). In response to this concern, a number of researchers have investigated the relationship between sellers and buyers at groundwater markets, and they have also addressed the factors underlying high water prices. Most of the case studies on these issues has been in terms of village-level comparisons. A consensus that has emerged from these case studies suggests that the water sellers' pricing behavior is not necessarily monopolistic, but rather depends on village-level factors such as depth of water table, rainfall pattern, energy source, and density of wells (Shah and Ballabh, 1997; Fujita and Hossain, 1995; Shah, 1993). At the same time, noticing price variations within villages, several articles have emphasized the effect of individual characteristics of sellers and buyers on price, albeit the statistical evidences is limited (Saleth, 1998; Meinzen-Dick, 1996; Janakarajan, 1993; Pant, 1991). In fact, as I talk later, in small agrarian communities where both sellers and buyers know each other and usually have some forms of personal relations, they often complete exchange through a face-to-face transaction as opposed to an open-market transaction. Furthermore, even within the same village, there exist different forms of contract for water transaction purpose. Thus, a village level analysis may be inappropriate for an analysis of groundwater markets, but rather, we should also focus on individual-specific differences. Groundwater markets have not been analyzed either theoretically or empirically at the individual level in a systematic way within a bilateral transaction framework that takes into account of the differences in contracts.

The objective of this paper is to explore the seller-buyer relationship and the determinants of water price in groundwater markets. Theoretically, I use Nash's (1950) two-person bargaining model, and specify a reduced form groundwater price function. The bargaining model is chosen since it encompasses a commonly used model -- the principal agent model -- as its special case. I also compare pricing mechanism under different types of contracts. Empirically, I conduct regression analysis on our original data set from Madhya Pradesh in India. A notable advantage of this data set is that it allows us to match water sellers and buyers, so that I can involve both parties' individual characteristics in the analysis, and with this new perspective, I can examine the claim that sellers are not necessarily exploiters.

Section 3.2 provides a description of the groundwater markets in the study area with a comparison with past empirical studies; Section 3.3 lays the formal model of bilateral transaction; Section 3.4 and 3.5 present variable construction and econometric results; Section 3.6 highlights the main conclusions of this study and suggests relevant policy implications.

3.2 Structure of Water Market in the Study Area

Monopoly Power

One of the simple but prevalent methods of analyzing a market structure is to estimate the price-cost ratio. Researchers use the ratio to judge whether markets are monopolistic or competitive. Table 3-1 shows the summary of the past case studies and estimation results from our study area. Shah and Ballabh (1997) and Shah (1993) conclude that the water markets in areas with high ratio are not competitive but monopolistic. On the other hand, even though Fujita and Hossain (1995) obtain high value of the ratio (2.59 or 2.00), they regard the "rent" as return to seller's capital investment in irrigation systems, given that the rate of return to capital (69 %) is close to the interest rate on the informal financial market (38 – 61 %). They conclude that if we take into consideration the risk of investment in irrigation systems, the water price is economically reasonable, and "the groundwater market cannot be characterized as monopolistic, but rather it is competitive and efficient."(pp. 456)

Following the method used by Fujita and Hossain (1995), I calculate the weighted average of water-charge-cost ratio and the rate of return of irrigation investment in our study field (see chapter 2 for general characteristic of the water markets in our study field).[11] While the ratios in our study area are relatively high (3.43 and 2.15), the difference between the rate of return to irrigation investment (29 %) and the interest rate of the credit program that well-owners have used for irrigation installation (12 – 15 %) is not as large as the difference in Fujita and Hossain (1995); the difference is not large enough to warrant concerns of monopolistic behavior.[12] Thus, similar to Fujita and Hossain's implication, the rate of return in the study area on average does not radically exceed the interest rate at the formal credit market which the buyers would have used if they borrowed money to have their own irrigation systems. Therefore, we may have reason to doubt monopolistic water market in our study area.

Individual Price Variations

The absence of monopoly, however, does not necessarily imply existence of a competitive market which the past literature implies. In fact, water prices vary across

[11] First, I calculate the ratio of per-acre water charge to per-acre operational cost for all individual pairs of sellers and buyers, and then take average weighted on the buyer' s area of irrigation. Operational cost compose of such item as the cost of electricity, the cost of repairs and necessary parts, and wage payments to labors. Wages are paid for such works as excavating channels, operating pumps, and supervising buyer's pump-use. A shadow wage (i.e. village wage) is used for cost calculation when sellers do these works by themselves. The ratio of per-acre water charge to the sum of operational and depreciation costs is calculated in the same way. The depreciation cost of irrigation investment is estimated by the constant amount method assuming a life of 20 years of the system. The rate of return of irrigation investment is per-acre profit over per-acre profit, where profit is per-acre water charge minus per-acre operational cost. The weighted average of each pair's rate of return is the number reported in the text. See Appendix C for detail.

pairs of sellers and buyers depending on specific characteristics and relationships between sellers and buyers, implying existence of bilateral transaction instead of single market in each village. Table 3-2 shows simple regression results of individual-level input prices on village dummies. If a market is competitive, we should not see large price variations at least within a village. As for seed, urea, super phosphate, and DAP, significant variations in prices are explained by the village dummies (R-squared = 0.41 for seed, 0.68 for urea, 0.70 for super phosphate, 0.73 for DAP), implying that these input prices do not significantly differ within villages. On the other hand, the regression of water price shows that there remain huge part of unexplained variations even after removing the village-level variation (R-squared = 0.20). One potential reason is existence of only one price study area with large variation due perhaps to measurement errors. It also seems natural to conjecture that each water transaction carry a different water price which could be explained not by village-level factors as the past literature suggests, but by individual-specific characteristics of sellers and buyers.

In sum, the seller may be neither monopolist nor a price-taker at a competitive market. Given this fact, now the question arises: what is the sellers' position in the water markets and whether individual characteristics of the seller and the buyer affect the water price, and if yes how do they determine the price. These issues need to be investigated empirically, but prior to the econometric analysis a formal model is presented to underpin the empirical work.

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[12] Interest rates at informal credit market vary from 36 % to 60 % per year in our study area, which is usually used for the relief from short term liquidity constraint such as wedding and purchase of modern

3.3 The Model

I assume an economy consists of two individuals: a water seller (who owns irrigation systems and provides water for production) and a water buyer (who has no irrigation systems but provides other inputs such as land and labor). There is uncertainty in production; the state of nature is represented by the random variable, θ, which is treated as a multiplicative factor distributed with $E\theta = 1$ and finite variance. The payment from the buyer to the seller is assumed to be expressed by the following linear function:

$$\alpha\theta f(a, x; h_b) + wa$$

where α is a parameter representing the output share to the seller; *f(.)* is the buyer's production function which depends on the amount of irrigation water (a) and the vector of inputs (x) given the buyer's production technology and agrarian characteristics (h_b), and is assumed to be a concave and linearly-homogeneous with the usual properties of positive but decreasing marginal product; w is unit water charge in case of fixed-rent or flat charge contract.[13]

For simplicity the seller is assumed to bear the entire cost of irrigation while the buyer takes care of other inputs. Hence, the seller's and the buyer's profit from water transactions are respectively defined as:

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agricultural inputs instead of long term investment.

[13] Under fixed-rent contract, w and a are set by the seller, and only w is set by the seller under flat-charge contract. There is no difference between these contracts when the contractual parameters are determined cooperatively between the seller and the buyer.

$$\pi_s \equiv \alpha\theta f(a,x;h_b) + wa - c(a;h_s)$$

$$\pi_b \equiv (1-\alpha)\theta f(a,x;h_b) - wa - p_x x$$

where *c(.)* is the irrigation cost function which depends on the amount of water (a) given irrigation technology and seller's agrarian characteristics (h_s); p_x is the vector of input prices; the output price is normalized to one. Following previous work on agrarian contracts, I further assume a risk-neutral water seller and a risk-averse water buyer (Stiglitz, 1974; Bell, 1989)[14] Thus, the seller's utility is measured by expected profit ($E\pi_s$) and the buyer's utility is expressed as $Eu(\pi_b)$ where $u'>0$ and $u''<0$.

Both parties do not enter into the contract unless it provides them with utility at least equal to their reservation utility. The reservation utility is formally defined as the utility that a party would get, in case of disagreement, from the best alternative usage of his resource which is currently in use. Thus, the seller's reservation utility may be a function of the amount of water currently used by his buyer (a) and also on productivity of the alternative way of water usage which is determined by the capacity of his irrigation facility and ability of himself (h_s). Likewise, the buyer's reservation utility may be a function of the amount of resources he takes care of (x) and his ability to utilize them (h_b). Due to the different attitudes toward risk, each reservation utility is written as

$$\bar{\pi}_s(a,h_s)$$

$$\bar{u}(\bar{\pi}_b(x,h_b))$$

where $\bar{\pi}_i(.)$ is increasing with respect to a and h_s for the seller, and with respect to x and h_b for the buyer.

[14] The data of our study field shows that the sellers are wealthier than the buyers in terms of lands, animals, and tractors, and this holds generally in Indian water markets (Saleth, 1998). Given the widely accepted idea of decreasing risk aversion in wealth, this assumption would not be unacceptable.

The principal-agent solution has been the most common framework for examining bilateral transactions (Salanie, 1997; Hayami and Otuska, 1993). It assumes that the principal (either the seller or the buyer) has ultimate power of bargaining, and the agent is not free to propose another contract. However, there may be the case that both parties have some power of bargaining and then the contract is formed through bilateral negotiation. We should not exclude this kind of market structure *a priori* when we look at newly emerging markets. Otherwise, an econometric specification would miss necessary explanatory variables and then have model specification bias in the results. Thus, we should start from a more general model.

The solution concept to be employed in this paper is Nash's (1950) solution to two-person bargaining problem.[15] This solution is more general than the principal agent approach in that it covers not only the principal-agent solution as its polar case but also the case that both parties have some power of bargaining. Now define

$$\Gamma \equiv \{E\ \pi_s(\alpha, w, a, x; h_s h_b) - \bar{\pi}_s(a, h_s)\}^{\delta} \times \{E\ u(\pi_b(\alpha, w, a, x; h_s h_b)) - \bar{u}(\bar{\pi}_b(x; h_b))\}^{1-\delta}$$

which is simply the product of the two parties' gains from transaction, relative to their reservation utilities with weight, δ, where $0 \leq \delta \leq 1$. Putting weight is the natural generalization of Nash's program when the parties have different bargaining powers

[15] Bell and Zusman (1976) is the first paper which introduces the bargaining solution to tenancy problems. Bell (1989) shows more generalized model by adding fixed-rent contract option into the previous paper in which only sharecrop and fixed-wage are contractual options. Frisvold and Caswell (1995) apply this solution concept to water markets.

(Dasgupta, 1993). Assuming cooperative bargaining, Nash's solution is the contract that yield the greatest value of Γ subject to both parties' incentive constraints.[16]

$$\max_{\alpha,w,a,x} \quad \Gamma = \{E\ \pi_s(.) - \bar{\pi}_s(.)\}^{\delta} \{E\ u(.) - \bar{u}(.)\}^{1-\delta}$$
$$s.t. \qquad E\pi_s(.) \geq \bar{\pi}_s(.)\ ,\ E\ u(.) \geq \bar{u}(.)$$

Note that when $\delta = 1$, the seller is assumed to possesses ultimate bargaining power and the bargaining problem becomes equivalent to the principal-agent problem in that the seller, as a principal, maximizes his profit such that the buyer, as an agent, receives at least as much as his reservation profit. The converse holds when $\delta = 0$.

The unit water price is defined as

$$p_w \equiv \frac{\alpha\theta f(.)}{a} + w$$

Assuming relative strength of bargaining power, δ, is exogenously determined by both parties technologies and agrarian characteristics, namely h_s, and h_b, then the equilibrium-unit-water-price becomes the function of all exogenous variables, i.e.

$$p_w{}^* = p_w{}^*(p_x; h_s, h_b) \qquad \textbf{(1)}$$

This function implies that the unit-water price may vary across the pairs of the sellers and the buyers depending on their technologies and agraian characteristics. I estimate a linear approximation of this function in the empirical section.

Another distinctive implication from this model is that the unit-water price would become higher under sharecrop contract. Under sharecrop contract ($0 < \alpha < 1$, $w = 0$), equation (1) is more specifically written as

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[16] The cooperative solution implies that there is no shirking in input provision. This may not be unacceptable assumption in the small agrarian community where people easily observe each other's activity

$$p^{\bullet}_{w(share)} = \left[c(.) + \bar{\pi}_s(.) + \frac{\delta}{1-\delta} \frac{1}{Eu'(.)\theta} \{Eu(.) - \bar{u}(.)\} \right] \frac{1}{a(.)} \qquad (2)$$

where the functions on the right hand side are all at equilibrium points. This equation tells us that the seller receives the irrigation cost and his reservation profit so that he enters the contract, plus the extra profit that is transferred from the buyer depending on the relative strength of the seller's bargaining power, ($\delta/1-\delta$). Under fixed-rent or flat charge contract, it becomes [17]

$$p^{\bullet}_{w(fix/flat)} = \left[c(.) + \bar{\pi}_s(.) + \frac{\delta}{1-\delta} \frac{1}{Eu'(.)} \{Eu(.) - \bar{u}(.)\} \right] \frac{1}{a(.)} \qquad (3)$$

Since $Eu'\theta < Eu'$, the third term becomes larger under sharecrop contract.[18] Intuitively the term $1/Eu(.)\theta$ (or $1/Eu(.)$) converts buyer's utility to the seller's utility (i.e. monetary term).[19] The inequality, $Eu'\theta < Eu'$, means that when the seller also shoulders the production risk (sharecrop contract), one unit of buyer's utility is more appreciated in terms of money. In other words, if buyer can get the same amount of utility he is willing to pay more when the risk is shared. Thus, the difference of the third term between equations (2) and (3) may be considered as a risk premium payment from the buyer to the seller in return for the partial transfer of the production risk through sharecrop contract. Consequently, the unit water price under sharecrop contract becomes higher than under fixed-rent or flat-charge contract, given other things being equal. This implication is consistent with the principal-agent solution in the past literature (Hayami and Otsuka,

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(Bardhan, 1984, chapter 7). Empirical evidence is presented by Otsuka *et al* (1986).

[17] Under the assumption of cooperative bargaining, amount of water also becomes choice variable. Thus, there is no difference in solutions between fixed-rent and flat-charge. Actually, this is consistent with my empirical analysis which shows that there is no statistical distinction whether choosing fixed-rent or flat-charge contract (see chapter 3).

1993). A comparative statics with respect to p_x, h_s, and h_b is not informative because changes of these parameters shifts both the seller's supply schedule and the buyer's demand schedule as well as their bargaining power. In the empirical analysis I allow the data to inform us on the signs of the effects of the different parameters.

3.4 Variable Construction

The dependent variable I use is unit-water-price, which is calculated such that the ex-post total payment for water is divided by area irrigated and by the number of water applications, and then divided by wheat price to convert to wheat term.[20] Researchers on water markets are concerned about qualitative difference in irrigation water. The sellers usually irrigate their own plots first and then allow the buyers to use their irrigation systems, and thus the buyers' irrigation may be physically constrained in terms of timing and amount. As I explain later, I control for this as much as I can in my econometric analysis. Besides, I do not find notable difference in water quality in our samples, although the available information is limited.[21]

Turning now to the explanatory variables, for one of the seller's characteristics, h_s, I use the total investment in irrigation systems which consists of the investment of

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[18] $Eu'\theta = Eu'E\theta + cov(u', \theta)$. Since $u'' < 0$, $cov(u', \theta) < 0$. Since $E\theta = 1$, $Eu'\theta = Eu' + cov(u', \theta) < Eu'$.

[19] Note that the numerator is the seller's marginal utility which is equal to one.

[20] The farmers in our study area use water rates on an acreage basis which is common in the area irrigated by electric pump with free or fixed power cost. Hourly bases are prevalent measurement units in areas where people use diesel pump or electric pump with pro rata power cost (Saleth, 1998; Shah, 1993).

[21] I suppose that the constraint is reflected by the number of times of water application by the buyers. The data, however, indicates no big difference in frequency of water application among buyers. The buyers cultivating wheat apply water 4.4 times on average ($\sigma = 1.3$; min = 2; max = 6). Chick pea cultivators' average is 2.1 ($\sigma = 0.9$; min = 1; max = 3).

well digging, electric pump, and sprinkler systems. This variable attempts to measure the capacity of irrigation systems such as horsepower, length of pipelines, and availability of sprinkler systems. The capacity would determine not only the cost structure of irrigation systems to provide one unit of water, *c(.)*, but also the seller's reservation utility $\bar{\pi}_s(.)$, because it also constrains the number of potential buyers that the seller can supply.

Another variable I use for h_s is the total area irrigated by others. One well irrigates multiple plots. One of them is obviously the buyer's plot. The others are the plot irrigated by the seller himself and sometimes by other buyers. For example, let's assume that a seller has one well, irrigates 5 acre of his own plot and sells water to two buyers; the first buyer irrigates 3acres and the second buyer irrigates 2 acres. When we look at water price charged to the *first* buyer, the area irrigated by others means the sum of his seller's and the *second* buyer's irrigation area (i.e. 5+2=7). Thus, this variable measures the demand for water in the absence of the buyer we are looking at. The higher this demand, the higher the seller's reservation utility, $\bar{\pi}_s(.)$ and thus the higher the water price. At the same time, this variable would also effect the quality of irrigation water. The larger the area irrigated by others, the more constrained is the buyer to get sufficient amount of water at correct timing, resulting in low quality of water and a cheaper price. The net effect would be empirically determined.

Unfortunately, however, this variable may not be exogenous because the seller himself is among the decision makers. If so, the bias in this variable would bias all the other coefficients. Given limited information in this data set, I can neither adequately address the nature of potential bias in the parameter estimates due to problems associated with endogenous/omitted variables, nor can I adequately instrument this endogenous variable. Alternatively, I run regression without (Model 1) and with (Model 2) this variable to see the robustness of the results.

The other variables which attempt to measure h_s are the seller's agrarian characteristics such as last year's animal holdings (oxen and cows), land holdings (acre), schooling years of household head, and age of household head. As I mentioned, all sellers in our field use their irrigation systems also for their own plots, so that if a current buyer exits from the transaction (i.e. disagreement), at least seller himself would become less constrained in terms of his own irrigation activity. The amount of profit from utilization of that additional water (and hence his reservation utility) depends on the seller's agrarian characteristics mentioned above. These variables may not be truly treated as exogenous because the farmers adjust these variables in their long term decision process. However, they can be still treated as "quasi"-fixed for cross-section estimation process. Arguably, schooling, and age are not current year's choice variables. Land holdings are seldom adjusted. Since the farmers sell their animals for input purchase occasionally, the number of *current* year's animals is endogenous. But the last year's number is given to the current year activity.

The explanatory variables on the buyer's side are their agrarian characteristics which consist of the same variables as the seller's agrarian characteristics. It seems to be straightforward that these variables specify the buyer's production function, $f(.)$. Since buyer's reservation utility, $\bar{u}_b(.)$, depends either on the performance of his agricultural activity without irrigation water or on the profit from non-farm activities, these variables would also affect water prices through changes in reservation utility. I also introduce dummy variables if the buyer has alternative water sellers or not. Since all buyers currently choose to irrigate their plots, in case of rejection by the current seller, the buyers who have alternative water sellers could have higher profit thus higher reservation utility than the buyers who have only one seller.[22] The existence of alternative water sellers available to a particular buyer is exogenously determined.

Besides the variables suggested by the model, I use several covariates as controlling variables. First, kinship is among the most important socioeconomic factors affecting an outcome of bilateral transaction. Transactions among closer relationships are usually claimed to reduce transaction costs by ensuring a payment, although there is always the converse story of costly transactions with relatives due to difficulty of collecting a payment (Meinzen-Dick, 1996). Unfortunately, our data set does not contain data on kinship relationship. Alternatively, what I introduce is a dummy variable for whether the seller and the buyer belong to the same caste group. Although this broad-meaning proxy may have complicated effects, I still think it plays an vital role in the Indian context.

Second, I control for village fixed effect. Since significant variations in input prices, p_x, are also captured by the village dummies (Table 3-2), I do not include other input prices in my regression analysis, while they appear on the theoretical model.

Finally, I allow for a dummy variable to capture whether the payment schedule chosen by pairs of sellers and buyers is sharecrop or not. The payment schedule, however, may be chosen simultaneously with other endogenous variables. There are no extra exogenous variables which determine the payment schedule but do not appear on water charge function (i.e. under-identified) since sellers and buyers regard the payment

[22] Buying water from an alternative seller is a contingent event so that his existence does not change *current* production technology *f(.)*.

schedule and water charge as a set of contract. If this is the case, we have no way but estimating the reduced form water charge function, and thus we can not know how sharecropping is related with water charge. On the other hand, we may claim that they make their decision stepwise: they first choose the payment schedule and then talk about how much the water charge is. The payment schedule may be persistent when it is decided in the past. If this is the case, the system becomes recursive one, and then I can use the sharecrop dummy as predetermined exogenous variable in our water charge function. Nevertheless, we can never deny the simultaneity of their decision process, so that I run regressions with this dummy for a comparative purpose (Model 3 without the area irrigated by others, Model 4 with it). The descriptive statistics of the variables I use are summarized in Table 3-3.

3.5 Regression Results

Market Structure

The results from OLS regressions and joint hypothesis tests are given in Table 3-4. A robust result across the models is that the variations in unit water price are statistically explained by the seller's characteristics, h_s, but not by the buyer's characteristics, h_b. We can see this by checking significance levels of each variable. Joint hypothesis tests are also performed to see whether variables classified under h_s (h_b) are jointly zero or not (see the bottom of the table). The test results indicates that the seller's variables as a whole have quite significant effect on the unit water price, while the buyer's variables do not.

This result implies two potential market structures. The first but less plausible one is the case that all buyers have the same demand schedule for irrigation water so that the price is determined solely by the shift of the seller's supply schedule. As we see there is considerable heterogeneity among the buyers (Table 3-3), thus this type of market structure would not be plausible.

The other potential structure, which is also claimed by the existing case studies, is that the sellers sell "surplus" water after meeting the needs of their own fields, and thus do not ask more than the cost of irrigation (Saleth, 1998; Meinzen-Dick, 1996; Shah, 1993). In this case, regardless of the buyers' demand schedule, only the sellers' characteristics which are related with irrigation cost becomes significant.

It may sound too good for buyers that no matter how strong the sellers bargaining power they do not charge more than the cost just because water is "surplus." However, in closed society like agrarian villages "maximizing profit from water sales could lose goodwill and cost the seller more in the long run (Meinzen-Dick, 1996, p. 39)." Saleth (1998) also claims that "the sellers may not exercise their power because of social constraints (p. 198)." Thus, sellers would set price so as not to enjoy too much excess profit. This is consistent with my result in section 3.2; on average the sellers do not enjoy large amount of extra profit from water sales. Furthermore, the sellers' bargaining power may not strong enough to enjoy excess profit from water sales. As I mentioned, irrigation facilities are not scarce in the villages. Besides, informal talks with the respondents during the survey revealed that the villagers felt that aquifer levels were sufficient even during dry season. Taking into account of these stylized facts at groundwater markets, there appears to be no empirical justification of characterizing seller's water pricing behavior as exploitative, i.e. "water-lord." Rather, price is set according to the cost structure of the irrigation systems which is determined by sellers characteristics.

Determinants of Unit Water Price

We now turn to interpretation of determinants of water price. It may be better to first note that the magnitude of the coefficients do not vary across models when they are significant under all models. The results discussed below are robust across the models.

The results show that variations in unit water price are explained not only by village-level factors (see joint F test for village dummies) but also by individual characteristics. Comparing with the regression result in section 3.2 (OLS regression of water price on village dummies), the adjusted R-squared and the F statistics of the models in Table 3-4 are improved. One possibility of the low explanatory power of the regression of water price in section 3.2 would be due to measurement errors. However, the results in Table 3-4 do not support this conjecture, but do support the idea that price variations are explained by individual-specific characteristics as well as village factors.

Looking at each explanatory variable, the amount of total investment in irrigation systems has positive and significant effect on unit water price, which may be explained by two reasons. First, this variable represents the capacity of the irrigation system. The capacity relates with the quality of irrigation water since water is conveyed without loss if pipelines are available, and water is applied timely if horsepower is strong; the value of water becomes higher in this case. Second, the absolute amount of seller's loan repayment in each year is high when the amount of investment is large, and thus the seller would ask high price to make his buyer partially shoulder the repayment.

The area irrigated by others have very weak statistical relationship with water price, implying that the sellers' reservation profit does not change even when the demand for water by others is high. This supports the fact that sellers sell "surplus" water. If the water sold is "surplus," reservation profit from that water is always nil. Thus, the variable related with the amount of reservation profit has no effects on water price.

Among seller's agrarian characteristics, animal holdings and schooling years are statistically significant. The positive sign on schooling years is consistent with my conjecture claiming that increased schooling increases the seller's reservation profit due to his high ability to utilize additional amount of irrigation water. However, again, the sellers seem to sell "surplus" water, so that the returns from additional amount of water is zero regardless of their ability. Thus, the reasoning based on the seller's reservation utility is not relevant for schooling years. Since the seller's schooling years may measure other factors, they probably become significant for different reasons. One possibility is a quality-related reason; the irrigation systems owned by the sellers with high management skills may have better maintenance, and thus the quality of water provided by them may be reasonably good to ask higher price. The other possibility is that the sellers might sell irrigation water with their water management skills, so that the sellers with high ability can provide better irrigation service and can ask higher price.

The animal holdings are negatively correlated with unit water price. The reasoning based on reservation utility argument is not convincing under the market structure in our study field, rather a specific feature of the rural credit/asset markets explains the situation well. In rural India, people regard animals not only as inputs for agricultural production but also as asset, and they often sell animals when they need money (Rosenzweig and Wolpin, 1993; Walker and Ryan 1990). Thus, the sellers who hold enough animals could completely or partially self-finance their investment in irrigation systems. Small or no burden of loan repayment would let the sellers ask low water price to the buyers, resulting in negative sign on animal holdings. Then, why the coefficient on sellers' land holdings, another important form of asset, is not significant? Note that the role of land and animals are different. Land is not sold as often as animals, but it plays an important role as collateral for a loan especially at informal credit markets. However, the sellers who need credit for investment in irrigation systems use formal programs (such as irrigation development program) which charge relatively homogeneous interest rates, instead of informal credit. Thus, at water markets land is not related with the amount of loan repayment and thus with unit water price.

Belonging to the same caste group has no statistical relationship with unit water price. The descriptive statistics in Table 3-3 tells us that 39 % of transactions are conducted between different caste groups. However, the percentage sharply declines to 13 % if we look only at transactions between very "distant" caste groups (ex. between Brahmin and scheduled caste/tribe). Thus, water transactions may be restricted among individuals belonging to the same or closely related caste groups. We have to wait for further empirical investigation to answer the questions of whether caste group actually restricts water transaction, and if so, how is water price determined when caste groups are "distant."

Lastly, it is worth noting that sharecrop dummy is positively related to unit water price in the Models 3 and 4, albeit I am ignoring the potential endogenous problem. As shown in the theoretical section, this may be taken to imply the existence of a risk premium payment from buyers to sellers. Shah's (1993) observation in India, however, suggests another potential interpretation. He claims that, as irrigation systems have been disseminated, there is a tendency of disappearance of sharecrop contract. If so, farmers in the less irrigated area (therefore, high water price area) might selectively choose sharecrop contract, giving multiple meanings to this dummy variable: not only a risk premium payment but also water scarcity. However, since water scarcity is already controlled by area irrigated by others and also by village dummies, we can not deny the existence of a risk premium payment in our study area.

3.6 Concluding Remarks and Policy Implications

Based on the two-person bargaining model, this paper analyzes the structure of the groundwater markets and price determination for a sample of water sellers and buyers in highly irrigated villages in Madhya Pradesh, India. I do not find strong evidence that supports seller's exploitation of buyer. The market structure in the study area rather seems to work in favor of the buyers in that water charge is based on the cost of irrigation systems. This is partly because social constraints do not allow the sellers to enjoy unacceptable amount of excess profit. The result may also stem from over investment in private lift-irrigation systems. In other words, the number of irrigation systems in the villages may be more than the village-optimal (so that sellers have no bargaining power to enjoy excess profit). All farmers do not necessarily have to have their own irrigation systems as long as there exist adequate water transactions. It is worth reevaluating the current irrigation development schemes which could be inducing farmers' over-investment in private lift-irrigation systems. The supportive schemes may be better restricted to the farmers who have difficulty in access to irrigation water due to either geographical or social reasons.

My analysis also clarifies whether and how individual-specific characteristics affect unit water price, albeit, with potential bias in the parameter estimates due to problems associated with endogenous variables. The results show significant effects of individual characteristics on water pricing. The *seller's* characteristics -- amount of total investment in irrigation systems, animal holdings, and schooling years -- are important determinants of groundwater price. Different prices are also charged depending on the types of contracts. In general, unit water price becomes higher when seller's physical capital (total amount of investment) and human capital (schooling years) stocks are well equipped. Hence, apart from the obvious effect from physical capacity, the results show that human capital is also important, as it is in most of agrarian economies. Another notable relationship is that an increase in amount of loan repayment (amount of investment and animal holdings) may increase unit water price. Types of contracts also significantly affect water price; the price becomes higher under sharecrop contract due to a risk premium payment from buyers to sellers. This implies that some buyers have few means but sharecrop contract for their income smoothing. Access to credit for this purpose may be limited. As I mentioned, on the other hand, access to credit for the purpose of irrigation investment may be relatively easy, thanks to the irrigation development schemes. While dissemination of irrigation systems contributes to productivity increase of both sellers and buyers, the sharecrop-buyers' welfare may not improve as much as the others unless they have more options of income smoothing. Further detailed investigation of the production environment of the sharecrop-buyers would help guide policy makers in revising not only irrigation development schemes but also other forms of credit programs.

Table 3-1: Ratio of water charge to irrigation cost and Return to Capital Investment in different case studies

Location	Ratio of water charge to variable cost	Ratio of water charge to the sum of variable and depreciation cost	Return to Capital Investment (%)
Case Studies Summarized by Shah (1993:75) [a]			
West Godavari, India	1.2 – 1.3		
West U.P. and Punjab, India	1.3 – 1.7		
East and Central U.P., India	1.7 – 2.0		
North Kheda, India	1.89		
Midnapur dist. West Bengal, India	2.3		
Panchmahal dist. Gujarat, India	2.7 – 3.0		
Madurai dist. T.N.; Karimanagar dist. A.P., India	2.7 – 3.5		
Case Study by Shah and Ballabh (1997) [a]			
North Bihar, India	2.5 – 3.0	1.25 – 1.8	
Case Study by Fujita and Hossain (1995) [b]			
Barind tract, Bangladesh	2.59	2.00	69 %
My Study [c]			
Madhya Pradesh, India	3.07	1.87	21 %

Notes: [a] The unit is Rs. per hour of pumping.
[b] The unit is Taka per irrigated acre
[c] See Appendix for detail

Table 3-2: Price variations within and across villages by types of input goods

	Dependent Variable				
	Seed price	Urea price	Super phosphate price	DAP price	Unit water price
Village B dummy	-0.394	0.400	0.250	0.250	-4.821
	(1.04)	(2.22)*	(1.88)	(0.63)	(0.38)
Village C dummy	-0.316	-0.005	-0.100	-0.523	3.081
	(1.00)	(0.03)	(0.74)	(1.40)	(0.25)
Village D dummy	-1.138	-0.462	-0.250	-1.432	13.250
	(3.21)**	(2.62)*	(1.84)	(3.28)**	(1.05)
Village E dummy	-0.686	-0.250	-0.037	-1.139	5.741
	(1.97)	(1.47)	(0.29)	(2.77)*	(0.47)
Village F dummy	-0.560	0.361	-0.167	-0.917	24.259
	(1.26)	(1.67)	(1.12)	(2.10)	(1.54)
High yield dummy	0.269				
	(1.48)				
Constant	1.625	0.750	0.500	2.250	35.000
	(5.64)**	(4.91)**	(4.13)**	(6.31)**	(3.14)**
Observations	36	34	25	23	38
R-squared	0.41	0.68	0.70	0.73	0.20
Adjusted R-squared	0.29	0.62	0.62	0.65	0.08
F statistics	3.36	11.65	8.76	9.03	1.60
	[0.01]	[0.00]	[0.00]	[0.00]	[0.19]

Numbers in parentheses are absolute t-values. Numbers in brackets are p-values.
* significant at 10% level; ** significant at 5% level, *** significant at 1% level

Table 3-3: Descriptive Statistics of Variables

Variable	Mean	Standard Deviation
Dependent Variable		
Unit water price (kg. of wheat)	40.08	16.39
Explanatory Variables		
Seller's Irrigation Technology and Agrarian Characteristics: h_s		
Amount of total investment (1000 kg. of wheat)	6.08	3.87
Area irrigated by others (acres)	2.71	2.97
Seller's last year animal holdings	3.13	1.66
Seller's land holdings (acres)	9.63	9.95
Seller's schooling years	4.32	4.29
Seller's age	45.97	15.03
Buyer's Production Technology and Agrarian Characteristics: h_b		
Buyer's last year animal holdings	2.26	1.81
Buyer's land holdings (acres)	5.08	4.79
Buyer's schooling years	5.58	4.99
Buyer's age	44.42	11.01
Alternative water seller dummy	0.24	0.43
Controlling Variables		
Caste matching dummy	0.61	0.50
Village B dummy	0.18	0.39
Village C dummy	0.29	0.46
Village D dummy	0.18	0.39
Village E dummy	0.24	0.43
Village F dummy	0.05	0.22
Sharecrop contract dummy	0.45	0.50

Table 3-4: OLS Regression Analysis of Determinants of Unit Water Price

	Without sharecrop dummy		with sharecrop dummy	
	Model 1	Model 2	Model 3	Model 4
Seller's irrigation technology and agrarian characteristics: h_s				
Amount of total investment	1.911	1.721	2.033	1.878
	(2.06)	(1.85)	(2.44)*	(2.22)*
Seller's last year animal holdings	-5.274	-6.919	-6.156	-7.402
	(1.91)	(2.27)*	(2.47)*	(2.68)*
Seller's land holdings (acres)	1.399	0.523	0.791	0.134
	(1.74)	(0.49)	(1.04)	(0.14)
Seller's schooling years	1.955	1.769	1.930	1.786
	(2.10)*	(1.90)	(2.32)*	(2.12)*
Seller's a	0.322	0.343	0.398	0.410
	(1.12)	(1.20)	(1.53)	(1.58)
Area irrigated by others		1.321		1.037
		(1.20)		(1.04)
Buyer's production technology and agrarian characteristics: h_b				
Buyer's last year animal holdings	-0.612	0.062	-0.569	-0.042
	(0.39)	(0.04)	(0.41)	(0.03)
Buyer's land holdings (acres)	-0.022	0.213	0.222	0.394
	(0.03)	(0.27)	(0.32)	(0.55)
Buyer's schooling years	-0.037	0.039	0.300	0.343
	(0.06)	(0.06)	(0.49)	(0.56)
Buyer's age	0.406	0.162	0.275	0.090
	(1.40)	(0.46)	(1.04)	(0.28)
Alternative water seller dummy	8.913	8.690	9.180	8.991
	(1.27)	(1.25)	(1.46)	(1.43)
Controlling variable				
Caste matching dummy	-1.249	2.243	0.841	3.477
	(0.20)	(0.33)	(0.15)	(0.56)
Village B dummy	25.779	10.991	14.446	3.410
	(0.94)	(0.37)	(0.58)	(0.13)
Village C dummy	40.447	28.534	22.307	13.874
	(1.38)	(0.93)	(0.82)	(0.49)
Village D dummy	48.571	29.925	29.676	15.995
	(1.95)	(1.03)	(1.26)	(0.59)
Village E dummy	23.627	12.596	-3.776	-11.047
	(0.84)	(0.43)	(0.14)	(0.39)
Village F dummy	25.296	22.721	32.010	29.648
	(1.44)	(1.29)	(2.00)	(1.84)
Sharecrop contract dummy			16.273	15.448
			(2.49)*	(2.35)*
Constant	-41.780	-22.260	-26.313	-11.772
	(1.25)	(0.61)	(0.86)	(0.35)
Joint *F* test	3.65	3.35	3.94	3.48
(H_0: $h_s = 0$)	[0.02]	[0.02]	[0.01]	[0.02]
Joint *F* test	0.64	0.35	0.65	0.51
(H_0: $h_b = 0$)	[0.67]	[0.87]	[0.66]	[0.76]
Joint *F* test	2.31	1.59	3.21	2.42
(H_0: all village dummies =0)	[0.08]	[0.20]	[0.02]	[0.07]
Observations	38	38	38	38
R-squared	0.61	0.63	0.70	0.71
Adjusted R-squared	0.31	0.32	0.45	0.45
F test	2.06	2.07	2.79	2.7
	0.06	0.06	[0.02]	[0.02]

Numbers in parentheses are absolute t-values. Numbers in brackets are p-values.
* significant at 10% level; ** significant at 5% level, *** significant at 1% level

SUMMARY AND CONCLUSION

This paper explores the mechanisms of contract choice and price determination under bilateral transaction between a owner of irrigation systems and a non-owner at groundwater markets. I use a sample of water sellers and buyers in the six villages in Madhya Pradesh in India for empirical analysis.

In our study field, we observe three types of contracts: sharecrop, fixed-rent, and flat-charge contracts. However, the multinomial logit regression analysis in chapter 3 shows that there is no statistical difference in the factors associated with the choice between flat-charge and fixed-rent contracts. This is probably due to the flexibility of informal contracts which allows farmers to reschedule fixed-rent payments according to the actual frequency of irrigation. Meanwhile, the results show that farmers significantly distinguish sharecrop over non-sharecrop contract (i.e. fixed-rent and flat-charge contract). I conduct both a logit regression analysis and a village-level qualitative analysis on the choice of these two types. The analyses show that risk-sharing is the factor underlying the choice of sharecrop contract; other factors such as limited liability, managerial input sharing, screening and monitoring cost are not significant determinants.

This result is consistent with my finding in chapter 4, where OLS regression results show that the unit water price becomes higher under sharecrop contract, implying that the buyers pay a risk premium to the sellers when the risk is transferred from the buyers to the sellers by sharecrop contract. The other significant factors affecting the unit water price are the sellers' physical (irrigation systems) and human (education) capital. The buyers' characteristics have no effect at all. As the existing literature suggests, this is probably because the sellers sell "surplus" water after meeting the needs of their field, and because social norms does not allow the sellers to charge a high price for surplus. In this case, regardless of the buyers' characteristics, only the seller's characteristics which are related with the cost structure of water become significant. Thus, in contrast to the conventional notion that a seller operates as a monopolistic exploiter, the market structure in the study area rather seems to work in favor of the buyers in that they are charged no greater than the cost of irrigation systems.

In sum, while the water prices charged to the buyers are not exploitative, in a risky environment with limited means of income smoothing, the sharecrop contract is chosen with a payment of a risk premium from the buyers to their sellers. Therefore, there arises two concerns for sharecrop-buyers in terms of efficiency and equity. First, the Marshallian inefficiency may exist in the sharecrop buyers' production as we see in the sharecrop land tenants' production in India. Second, while the dissemination of irrigation systems contributes to a productivity increase by all water users, the sharecrop buyers' welfare may not improve as much as others since they pay a risk premium from their inefficient outputs. If these conditions persist for the buyers, policy makers had better consider how to increase access to means of income smoothing and also how to reduce risk in agricultural production. For future research, detailed investigation of production environments and outcomes of the sharecrop-water-buyers would help guide policy makers in designing more detailed strategies to enhance efficiency and equity.

APPENDICES

APPENDIX A

REVIEW OF LITERATURE ON CONTRACT CHOICE AT LAND RENTAL MARKETS

When a landlord decides not to cultivate his own land by himself, he may lease out his land to a tenant by using either sharecrop or fixed-rent contracts, or he may offer wage-labor contract to farm his own land. There are five primary microeconomic models explaining contractual choices between a landlord and a landless in economic literature: (1) risk-sharing, (2) limited liability, (3) screening, (4) double incentive, and (5) Monitoring cost models.[23] In general, a probability of a particular type of contract *j* (*j* = fixed-rent, sharecrop, fixed-wage) being chosen between a pair *i* of the landlord and the worker is expressed as a function of four sets of variables:

$$P_i^j = f\,(risk,\ wealth,\ ability,\ and\ transaction\ costs)$$

In this section I discuss how each model relates these variables to contract choice. Basic paradigms and the list of the four sets of variables are summarized below.[24]

Risk-sharing Model

One of the views first presented in the literature is the recognition of contract as a risk-sharing device under the environment of missing insurance markets (Cheung, 1969).

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[23] Some papers consider only fixed-rent and sharecrop contracts.

[24] I cover only basic models so that I can contrast models and see the differences. Moreover, because of the purpose of this study, I will not explain all features of each model, but highlight the logic of the contract choice. Hayami and Otsuka (1993) and Singh (1989) give us an intensive review of different theories of contract.

Stiglitz (1974) and Newbery and Stiglitz (1979) complete this approach by introducing a trade-off relationship between risk-sharing and work incentive. Introducing plausible assumption that the landlord can not perfectly enforce contract regarding the tenant's labor effort, share contract may become the best institutional arrangement for risk-sharing. Fixed-rent contract provide perfect incentives since all the output is obtained by the tenant, while it provides no risk-sharing (the tenants shoulder all the risk); on the other hand labors would shirk under fixed-wage contract given certain amount of wages for sure when contract is unenforceable. Given this trade-off relationship, sharecrop contract arises to share risks and also to provide incentives. Hence, not only the parties' risk attitude and risk itself, but also the laborers' reaction to incentives (i.e. share of output) matter for contract choice

The hypothesis derived in this model is that assuming the landlord is always risk-neutral the greater the landless' the risk-aversion and the greater the risk, the closer the optimal contract approximates fixed-wage contract. Besides, the greater the labor supply elasticity, i.e. the more sensitive the worker is to incentives, the greater the share, i.e. the closer to fixed-rent contract (Stiglitz, 1974, 1987).

Limited Liability Model

Limited liability may be a plausible reason to let some tenants choose sharecrop contract and let others choose fixed-rent without assuming risk-averse tenants. The intuitive logic is as follows. Due to nonexistence of contingent market in an agrarian economy, liability of tenant's payment is limited by their initial wealth. The landlord will know that the default on fixed-rent may occur when the harvest fails and the tenant is poor. One way to lessen the possibility of entire default is for the landlord to lower the rent in bad states and raise it in good states, which is akin to sharecropping. Shetty (1988) shows that the poor tenant will receive sharecrop contract given the assumption of production uncertainty, limited liability, variation in tenants' wealth, and non-observability of labors' effort.[25]

Note these models are incomplete in the sense that they exclude fixed-wage contract from their spectrum of contracts. Nevertheless, among several useful propositions derived in their theoretical works, the most important one for my research purpose is that: for the tenant with small wealth, the share cropping contract is likely to be chosen over fixed-rent contract given non-observability of labor effort as well as uncertainty in production and limited liability.[26] As the model assumes risk-neutral individuals, risk-sharing factors do not matter in this model.

Screening Model

The screening model represents another approach to explain the existence of a variety of contracts between risk-neutral individuals under the environment of unenforceable contract. A landlord, who cannot directly observe tenant's true ability, offers a menu of contracts which is designed such that tenants with low ability do not mimic themselves as high ability tenants but they select a low profile contract by themselves. A high ability tenant will prefer fixed-rent contract regardless of higher rent,

---

[25] Along this line, Basu (1992) and Sengupta (1997) point out that non-obserbability of project-choice also plays an important role in contract choice under limited liability. Under fixed-rent contract, the tenants would prefer riskier but higher return projects even though such projects lower overall surplus. This is because the tenant's income does not fall below the outcome of bad states, but can keep all residual in good sates being realized. Under the share contract the tenants' income, on the other hand, moves in proportion with the output realized, resulting in choosing the project that yields the highest joint surplus.

because he gets to keep his high marginal product entirely. But this amount of rent is too high to accept for a low ability tenant, and thus the low ability person does not enter market for high ability individuals. On the other hand the low ability tenant prefer fixed-wage contract which guarantees specific amount of revenue to him regardless of his (poor) performance. And the individual in between chooses share contract. Thus, improvement in management ability increases the occurrence of fixed-rent contract and decreases the occurrence of fixed-wage contract.

Hallagan(1978) and Newbery and Stiglitz (1979) independently show that the landlord can design such a contract under some circumstances. However, this model is criticized that the ability is generally revealed sooner or later especially in small rural community. Hence, this model is claimed to be valid only when there are a perennial in-migration of fresh tenants in the community (Ray, 1998, ch 12; Singh, 1989; Eswaran and Kotwal, 1985). An increase in the number of new immigrants, who are perceived having low ability, has negative effect on fixed-rent but positive effect on fixed-wage contract.

Double-incentive Model

All models mentioned so far assume perfectly unobservable labor efforts. This model, however, assume several activities (including labor efforts) can be *costly* monitored. Eswaran and Kotwal (1985) present a model in which wage contract is chosen when a landlord can cheaply supervise hired labor, fixed-rent is chosen when a landless can cheaply provide managerial inputs, and sharecrop is chosen when both are

---

[26] This implication is consistent with the notion of 'agricultural ladder' which explains the landless farmers' step-up from wage-labor to owner cultivator as they mature (Shetty, 1988; Ray, 1998, ch. 12).

expensive. They assume (1) both management and supervision are important in production, (2) the landlord is more efficient at management while the tenant is more efficient at supervision, because the landlord has better access to agricultural information while the tenant is better at supervising his family labor, and (3) neither service is unobtainable at the market. Thus, both landlord and tenant are required to apply their inherent inputs. Since each party has different incentive regarding how much they apply their effort, this model has double-incentive problem (Ray, 1998, ch. 12). Note that in this model both parties are risk-neutral again, so risk-sharing does not enter as a determinant.

Let me denote t_i as managerial input provided either by landlord ($i = l$) or by tenant ($i = t$), and similarly s_i as supervisory input. The idea of differential efficiency is quantified by the parameter γ_i where $0 \leq \gamma_i \leq 1$. For example, the closer γ_l is to one, the closer the landlord's supervision efficiency is to the tenant's (note that tenant's supervision efficiency is always one). Likewise, the closer γ_t to one, the more efficient the tenant's management efficiency is. Given these assumptions, if fixed-wage contract is chosen, production is realized by the combination of (t_l, $\gamma_l s_l$), since all production decisions are made by the landlord. The landlord is the residual claimant in this case. On the other hand under fixed-rent contract, the tenant takes all production decision and is the residual claimant. Hence production is realized by the combination of ($\gamma_t t_t$, s_t). Under share-cropping contract, each party jointly provide one of the unmarketed inputs. Thus, they provide the factor who has the most advantage, namely t from landlord and s from tenant, and production is realized by the combination of (t_l, s_t), and output is shared between them. Finally, the landlord compares the profit achieved under three alternative contracts, and chooses the most profitable one.

Eswaran and Kotwal show which contact is chosen when γ_l, and γ_t vary.[27] For high values of γ_l, the loss of efficiency is very small even if the landlord supervises the production processes, and so the landlord chooses the fixed-wage contract. By contrast, if the values of γ_t is high, the landlord is likely to offer fixed-rent contract because there is small loss in tenant's own management, and thus the landlord also can expect large amount of rent from the tenant. However, if the production requires both management and supervision, they should be jointly supplied under share-cropping contract.

Monitoring Cost Model

Another line of costly-monitoring approach is the one considering a trade-off relationship between labor-effort monitoring cost and land-quality monitoring cost (Roumasset and Uy, 1987; Datta *et al.*, 1986; Alston *et al.*, 1984). Basically they claim that monitoring costs of labor-efforts tend to decrease as rewards become more closely linked with efforts. For example, monitoring cost is greatest under fixed-wage contract because the labor receives fixed amount regardless of his actual effort. Contrarily, the costs are least under fixed-rent contract since the tenant is rewarded for his effort. They claim that sharecropping contract occupy an intermediate ground in terms of monitoring costs, so that the monitoring cost function is depicted as downward sloping curve in Figure A-1 in which horizontal axis, α, is share of output. On the other hand, the monitoring cost function for land-quality has opposite slope because they claim that it is reasonable to assume that the tenant's incentive to abuse land (and also landlord's capital embodied in his land) becomes larger as α get closes to one.[28]

Assuming the both functions are convex and independent as shown in Figure A-1, the optimal α is determined at the point where total transaction costs are minimized. Figure A-1 shows the situation that the sharecrop contract is optimal. If the effort-monitoring cost curve shifts upward through, for example, an increase of labor intensity, and/or the quality monitoring cost curve shifts downward through a decrease of land vulnerability, then fixed-rent contract becomes more likely to be chosen, and vise versa.

Allan and Lueck (1992) also consider additional transaction costs for physical measurement and division of harvested crop because the tenant has an incentive to underreport the harvest to the landlord under sharecrop contract. Under fixed-rent contract, however, the landlord does not have to worry about this as the rent is paid by cash in advance. Thus, the more difficult the harvest monitoring is, the less sharecrop contract (more fixed-rent contract) is chosen.

It is better to include production uncertainty as an explanatory variable because some of the papers with this approach obtain an opposite empirical result from the risk-sharing model: the greater the production uncertainty, the more likely fixed-rent contract is chosen (Allen and Lueck, 1992, 1995; Datta *et al.*, 1986). Since they assume risk-neutral tenants, they do not expect a contract as a risk-sharing device anymore. Moreover, they conclude that an increase of uncertainty in production makes detection of

---

[27] Since explicit analytical solution is not obtainable, Eswaran and Kotwal, assuming the Cobb-Douglas production function, do numerical simulations and draw the figure.

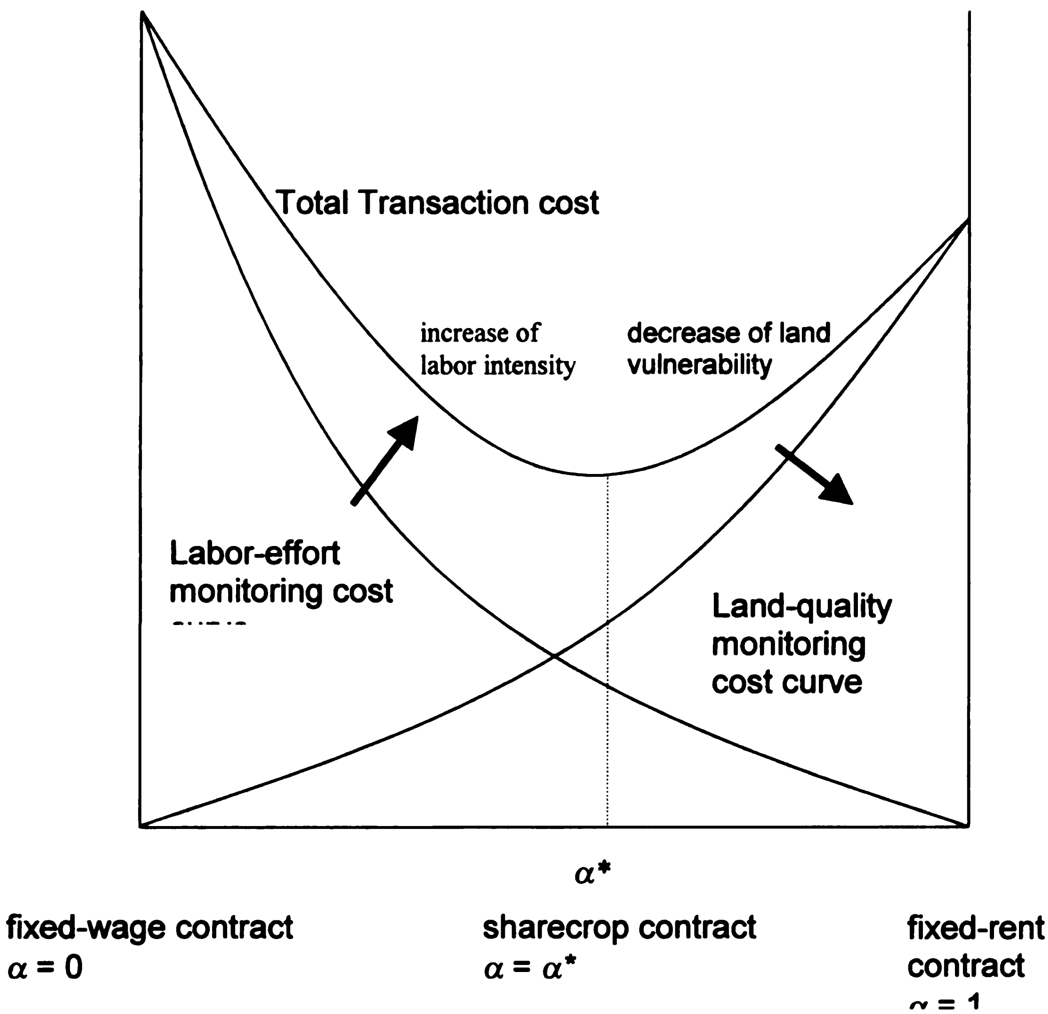
[28] They consider one period model. The tenant is implicitly assumed not to care about the effect of abuse on renewal of the contract.

labor-cheating more difficult (upward shift of labor effort monitoring cost curve in Figure A-1), resulting in choosing fixed-rent contract.[29]

Allen and Lueck criticize the assumption of risk-averse tenants, and support transaction cost approach. However, as they mention in their paper, this critique may apply only for the developed countries in which neither demography nor human capital between landlord and tenant differs so largely.[30] Note that this is the only variable I expect the opposite sign from the alternative models. In developing countries, assumption of risk-averse tenant is still plausible, while the assumption about monitoring cost is also reasonable. Thus, effect of production uncertainty on contract choice may be an empirical question. Hence, in this model contract choice is a function of not only several kinds of monitoring costs but also production uncertainty.

[29] Allen and Lueck (1992) likewise interpret that an increase of production uncertainty makes detection of underreporting of the harvest which supposed to be shared.
[30] Their empirical result rely on data from American Midwest.

Figure A-1: Transaction Cost and Optimal Contract Choice



Source: Hayami and Otsuka, 1993 (modified by the author)

APPENDIX B

SUPPLEMENTARY TABLE FOR CHAPTER 2

Table B-1: Multinomial-logit Regression Analysis of Determinants of Contract Choice (Constrained Models)
(The comparison group is sharecrop contract)

	With Hired manager dummy		Without Hired manager dummy	
	Fixed-rent	Flat-charge	Fixed-rent	Flat-charge
Household Wealth				
Buyer's animals	0.078	0.078	0.047	0.047
	(0.25)	(0.25)	(0.15)	(0.15)
Seller's animals	-1.304	-1.304	-1.299	-1.299
	(1.73)	(1.73)	(1.69)	(1.69)
Buyer's land holdings	0.070	0.070	0.077	0.077
	(0.47)	(0.47)	(0.50)	(0.50)
Seller's land holdings	0.180	0.180	0.159	0.159
	(1.42)	(1.42)	(1.26)	(1.26)
Management Ability				
Buyer's schooling	-0.003	-0.003	-0.001	-0.001
	(0.03)	(0.03)	(0.01)	(0.01)
Seller's schooling	-0.297	-0.297	-0.330	-0.330
	(1.65)	(1.65)	(1.68)	(1.68)
Buyer's age	-0.076	-0.076	-0.057	-0.057
	(1.31)	(1.31)	(0.93)	(0.93)
Seller's age	0.018	0.018	0.016	0.016
	(0.33)	(0.33)	(0.29)	(0.29)
Factor related with Moral Hazard				
Total investment	-0.244	-0.244	-0.204	-0.204
	(1.08)	(1.08)	(0.90)	(0.90)
Cast matching dummy	3.315	3.315	2.823	2.823
	(1.44)	(1.44)	(1.23)	(1.23)
Alternative seller dummy	3.443	3.443	3.461	3.461
	(1.37)	(1.37)	(1.44)	(1.44)
Manager dummy	.	.	1.44	1.44
			(0.83)	(0.83)
Constant	3.926	3.440	3.33	2.84
	(0.99)	(0.86)	(0.83)	(0.71)
Observations	38		38	
x^2 statistics	19.66		20.41	
	[0.05]		[0.06]	
Pesudo R^2	0.25		0.25	
Log Likelihood	-30.25		-29.88	

Numbers in parentheses are absolute value of z-statistics. Numbers in brackets are p-values.
* significant at 10% level; ** significant at 5% level, *** significant at 1% level

APPENDIX C

CALCULATION OF THE WATER-CHARGE-CST RATIO AND THE RATE OF RETURN TO IRRIGATION INVESTMENT

Following the method used by Fujita and Hossain (1995), I calculate the water-charge-cost ratio and the rate of return of irrigation investment. Table A1 summarizes the results for each of 45 samples used in my analysis. The average of the ratio of water charge to operational cost weighted by area of irrigation (col. 4) is 3.43. The average of the ratio of water charge to the sum of operational and depreciation costs is 2.15. The average of the return of investment is 29.22 %.

Table C-1: The Water-charge-cost ratio and the rate of return to irrigation investment

Sample	(1) *Water Charge/acre* (Rs.)	(2) Operational Cost/acre (Rs.) [a]	(3) Capital Investment/ acre (Rs.) [b]	(4) Area Irrigated by Buyer (acre)	(5) Ratio of Water Charge to Operational Cost [c]	(6) Ratio of Water Charge to the Sum of Operational and Depreciation Costs [d]	(7) Capital Return (%) [e]
1	300	324	1364	2	0.93	0.76	-1.77
2	333	733	6000	1.5	0.45	0.32	-6.67
3	360	387	2500	5	0.93	0.70	-1.07
4	375	380	2545	3	0.99	0.74	-0.20
5	375	300	800	4	1.25	1.10	9.38
6	375	745	3857	5	0.50	0.40	-9.59
7	400	50	700	1	8.00	4.71	50.00
8	450	138	4500	2	3.27	1.24	6.94
9	480	521	3118	2.5	0.92	0.71	-1.33
10	500	589	1500	2	0.85	0.75	-5.93
11	500	311	4000	1	1.61	0.98	4.73
12	500	363	4267	2.5	1.38	0.87	3.20
13	600	311	4000	1	1.93	1.17	7.23
14	600	343	1333	3	1.75	1.47	19.29
15	625	672	2023	0.4	0.93	0.81	-2.35
16	625	672	2023	6	0.93	0.81	-2.35
17	750	725	3200	1	1.03	0.85	0.78
18	750	672	2023	0.5	1.12	0.97	3.83
19	800	311	4000	0.5	2.57	1.57	12.23
20	900	107	5333	2	8.44	2.41	14.88
21	1000	267	667	5	3.75	3.33	109.90
22	1000	226	8571	1	4.42	1.53	9.03
23	1000	766	9600	0.5	1.31	0.80	2.44
24	1000	343	1333	3	2.92	2.44	49.30
25	1042	166	1882	6	6.27	4.00	46.53
26	1067	226	8571	1.5	4.71	1.63	9.81
27	1067	226	8571	1.5	4.71	1.63	9.81
28	1083	188	2412	1.5	5.78	3.52	37.14

Table C-1 (cont'd): The Water-charge-cost ratio and the rate of return to irrigation investment

29	1167	107	5333	1.5	10.94	3.13	19.88
30	1500	574	1091	2.5	2.61	2.39	84.90
31	1500	305	2339	4	4.92	3.55	51.09
32	1500	166	1882	4	9.03	5.77	70.88
33	1500	223	2083	4	6.74	4.59	61.32
34	1500	107	5333	1	14.06	4.02	26.13
35	1500	672	2023	1.5	2.23	1.94	40.91
36	1600	398	3750	2	4.03	2.74	32.07
37	1666	574	1091	3	2.90	2.65	100.09
38	2125	690	6400	1	3.08	2.10	22.43
Area-Weighted Average					3.43	2.15	29.22

Notes: [a] Operational cost composed of such items as the cost of electricity, the cost of repairs and necessary parts, and wage payments to labors. Wages are paid for such work as excavating channels, operating pumps, and supervising buyers' pump-use. A shadow wage (i.e. village wage) is used for cost calculation when sellers do these works by themselves.

[b] Total investment in irrigation systems consists of the cost of well digging, electric pump, and sprinkler systems.

[c] (5)=(1)/(2)

[d] The depreciation cost of irrigation investment is estimated by the constant amount method, assuming a life of 20 years of the system. The formula becomes (6)=(1)/((2)+((3)/20)).

[e] (7)=((1)-(2))*100/(3)

APPENDIX D

THE QUESTIONNAIRE

The Intensive Individual/Household Survey

<u>FOR WELL OWNERS</u>

District:___________________________________

Village:____

Name of Enumerator:________________________Date of Interview:_______________

1 Family

1.1 On the household head:

Name:____

Sex: 1=male 2=female

Age:______________

Ethnic/Caste/Religious group:_____________________________

Years of Schooling:_______________________________

Married? 1. Yes (___________years) 2. No

Occupation: 1. Farming 2. Non-farming (__________)

<u>In the past one year</u>, did you have any diseases? 1. Yes 2. No

If 1. Yes, when and what were the diseases?

____

____

Have you heard about "global warming"? 1. Yes 2. No

1.2 On his/her children:

How many children do you have (including ones living separately)? Boys ( ) and Girls ( )

How many of them are living separately? Boys ( ) and Girls ( )

How many children did the wife give birth to? Boys ( ) and Girls ( )

How many of them died before the age of five? Boys ( ) and Girls ( )

1.3 On the household (families sharing kitchen and food):

How large (how many household members) is your household?_______________

How many of them work on farm?______________(including wage labor)

How many of them work off farm?______________

*The above classification includes someone who work both on and off farm. In such a case, count twice in both categories.

How many married couples are there in your household?____________________

2 Agriculture

Note: Ask about 1996/97 dry season

2.1 Land ownership

How large agricultural land did your household CULTIVATE (including the land rented in) during dry season? ___________ha

Irrigation of cultivated land

	Area or Percentage irrigated	Distance from the source (m)
1. Well owned by yourself		
2. Well owned by others		
3. Common well/pond/tank		
4. River/Stream		
5. Large canal		
6. Others( )		

Distance: distance from the water source to your plot.

How large agricultural land does your household OWN?_________ha

How large of total owned land was irrigated in dry season ?______(ha or % of total)

How large of total owned land was rented OUT (cultivated by others) in dry season?

Irrigated:_____(ha or %) Unirrigated:__(ha or %)

Source of irrigation water:_______________

In addition to the owned land, how much is rented IN last year?

Irrigated:__________(ha or %) Unirrigated:________(ha or %)

Source of irrigation water:_______________

2.2 Tubewell

2.2.1 Tubewell Profile

How many tubewells do you have?:_______

If more than one, ask about the most important well on this questionnaire, and use the supplementary questionnaires for the other wells (and the plots irrigated by those wells).

Type: 1=Deep Tubewell 2=Shallow Tubewell 3=Other________________

Year of Installation:________, New? 1=Yes 2=No,

Total Cost of Investment:. for pump purchase___________Rs, for digging___________ ______Rs,

for pipe purchase ________Rs.

Payment: 1=Cash 2=Credit

In case of 2, how much?__________Rs., From where: _______________,

Unpaid: _____Rs.

Name of the maker:______________, Origin:________________, Horsepower:. ______hp

How large did THIS tubewell irrigate? (attention which year you are asking 1996/97 or 1997/98?)

For Own Cultivation:_______ha.

For Other Farmers' cultivation:__________ha.---> How many water buyers?:___ ______(visit these water buyers' after finishing this household.)

2.2.2 Operation and Maintenance Cost

If you use your own labor for operation and maintenance, please fill in the days and the numbers of people. Otherwise, please enter the amount of payment in Rs.

Cost Items	Cost	Does this cost include the expenditure for other farmers' operation?
Fuel / Electricity Bill (Rs.) a = fuel, b= electricity		1=Yes 2=No
Spare Parts (Rs.)		N/A
Repair and Maintenance (Mechanical Charge) (Rs)		N/A
Well Transportation cost from house to field (Rs)		1=Yes 2=No
Driver's / Linemen Salaries (Rs or days*#)		1=Yes 2=No
Canal digging (Rs or days*#)		1=Yes 2=No
Supervision Cost (supervision of buyers' tubewell use) (Rs or days*#)		N/A
Miscellaneous (Rs)		N/A

2.2 Agricultural Production

2.2.1 Agricultural Inputs and Outputs

Note-1: Ask about the most important plots irrigated by the well
Note-2: Ask about all crops in the most important plot.
Note-3: Be careful about the year you are asking (1996/97)
Note-4: Question about land value, ask one person (ex. village leader or equivalent) to evaluate all plots in the village to retain the consistency of valuation standard.

Basic Information
Total Plot size :__________________ha
Total value of the plot if sold at the market :________________Rs

(1) Crop	(2) Area of the Crop (ha)	(3) Inter-cropped? (Y/N)	(4) % irrigated of (4)	(5) Own / Rent (Y/N)	(6) Harvest (kg)	(7) % sold to the market (%)	(8) Unit Price sold at the market (Rs)	(9) Seed		
								type (HYV?)	qty (kg)	price (Rs/kg)

(Table cont.)

(1) Crop	(10-1) Fertilizer			(10-2) Fertilizer			(11) Manure			(12-1) Pesticide			(12-2) Pesticide	
	type	qty (kg)	price (Rs/kg)	type	qty (kg)	price (Rs/kg)	type	qty (kg)	price (Rs/kg)	type	qty (kg)	price (Rs/kg)	qty (kg)	price (Rs/kg)

Fill in total amount in the column from (10-1) to (14) if the household cannot divide the amount for each crop.

(Table cont.)

	(13) Draft Animals			(14) Tractor			(15) Labor	(16) bring to the mkt by yourself? (Y/N)
	number	days	price/day/unit (if rented)	number	days	price/day/machine (if rented)		
							use table Labor	
							use table Labor	
							use table Labor	
							use table labor	

Table: Labor

activities	which month?	Household Labor		Hired Labor		
		# of people	# of days	# of people	# of days	daily wage*
ploughing						
manure application						
seeding						
weeding						
harvesting						

Which month?: In which month was the activity carried out?
*If the wage is not pay per day basis, please specify the payment scheme below.

____

____

2.2.3 Water Management

If you use common water sources (common well/tank or canal) for another plot, do your household members participate in water management activities?

1. Yes (what kind?____________________________and how much ____________ ______Rs/day)

2. No

2.2.4 Dry Season without Water

How large did you cultivate UNIRRIGATED area during LAST DRY SEASON (1997)?_

______ha (% of area rented IN____%), Crop:_______________

Total Output:_______kg Price/kg:___________Rs (if sold)

2.2.5 Agriculture during Rainy Season

How large did you cultivated LAST RAINY SEASON (1997)?_________ha (% of area rented IN____%)

What was the most important RAINY-SEASON CROP LAST YEAR (1997)?_________

Area Planted:_______ha (% of area rented IN_________%)

High Yield Variety? 1=Yes 2=No

Total Output:_______kg Price:_______Rs (if sold)

2.2.6 High Yield Variety

When your household adopted high yield varieties, what was the most important source of information?

1. extension service
2. radio and/or TV programs
3. newspaper and/or magazines
4. neighbors
5. dealers/merchants of agricultural inputs
6. others:____

3 Forest

3.1 Forest Use

Does your household use forest for the following purposes?

Timber collection	1=Yes	2=No
Fuelwood collection	1=Yes	2=No
Fodder collection	1=Yes	2=No
Grazing	1=Yes	2=No
Grass collection	1=Yes	2=No
NTFP (non-timber forest products) collection	1=Yes	2=No

3.2 Forest Management Activities

Does your household members participate in forest management activities funded cy PUBLIC SECTOR ?

1 = Joint Forest Management   2 = other government work   3 = none

If 1 or 2, fill in the table.

Activities (circle all applicable numbers) in 1997	# of people from your household	Total days of working (sum of all participants)	Total Revenue	
			as wage	in kind
1 2 3 4 5 6			(wage rate ____ Rs/day)	

1=Plantation, 2=Trench digging, 3=Pruning, 4=Thinning, 5=Forest watching, 6=Other

Does your household members participate in forest management activities OTHER THAN the one mentioned above?

1=Yes (who organizes?________________)   2=No

If yes, fill in the table.

Activities (circle all applicable numbers) in 1997	# of people from your household	Total days of working (sum of all participants)	Revenue	
			as wage	in kind
1 2 3 4 5 6			(wage rate ____Rs/day)	

1=Plantation, 2=Trench digging, 3=Pruning, 4=Thinning, 5=Forest watching, 6=Other

3.3 Fuel

How often in a week does your household usually collect fuelwood?___________

______times

Who and how many people usually goes to the forest to collect fuelwood?

____

How much (kg) does your household collect fuelwood on average in one collection?_____

______kg

How many hours does your household spend collecting fuelwood in one collection?_____

______hours

Does your household use cow dung for cooking? 1. Yes (____________%)

2. No

Does your household use kerosene for cooking? 1. Yes (______

______%) 2. No

Does your household use agricultural residues for cooking? 1. Yes (______

______%) 2. No

*Percentage against total energy consumption for cooking.

3.4 Grazing and Livestock

3.4.1 Grazing

Animal	current # of animals	% of grazing	# of animals 10 years ago	% of grazing 10 years ago
Oxen				
Cow				
Buffaloes				
Sheep				
Goats				

Who takes care of grazing?

1=household members

2=neighbors

3=grazers (specialists)

4=other

If 1=household member,

Who? __________, How many people? __________, How many hours/day?

____

If 2 or 3, how much do you pay? (____

______)

3.4.2. Livestock Transaction

	transaction	kind of animal	number	unit price (Rs)	purpose of transaction
Sales in 1997	1				
	2				
	3				
	4				
Purchase in 1997	1				
	2				
	3				
	4				

4. Credit

Have you ever borrowed money from others?

1=Yes 2=No

	most recent	second recent
If yes: When?	________	________
How much?	________	________
From who	________	________
For what purpose?	________	________
Interest?	________	________

If no: Why? 1=Not needed 2=Not available 3=Expensive

5. Household Income

Note: Ask about household income LAST YEAR (1997).

Income Source		Amount (Rs)	activity and wage rate
Agriculture	farming (from sales of ag. products)		N/A
	working for other household's plot		wage rate _____Rs/day
Forest	sales of forest products		N/A
	working for JFM etc.		wage rate _____Rs/day
Non-farm activities in the village	your own business		activity__________ ________
	working for other's		activity__________ _______ wage rate________Rs/da y
Migration	your own business		activity__________ ________
	working for others		activity__________ ________ wage rate_________Rs/d ay
Remittance	money from non-household members		from whom___________ —

6 Household Assets

6.1 Asset Composition

Item	current qty	qty 10 years ago
Tractor		
Cart		
Automobile		
Bike		
Bicycle		
TV		
Radio		

7 Health and Nutrition

7.1 Nutrition

How many days in a week do your household members usually take beans/pulse?_

______days

How many days in a week do your household members usually take vegetables?__

______days

How many days in a week do your household members usually take meat?______

______days

What meat is it:___________________________________

Does your household purchase milk? 1. Yes 2. No

Does your household sell milk? 1. Yes 2. No

How many days in a week do your household members take dairy products (milk, cheese, etc.)

in milking season?______________days per week for _________months* per a year

How many days in a week do your household members take dairy products (milk, cheese, etc.)

in non-milking season?________________days per week for ___ ______months* per a year

*Total should be 12 months. Milking season is a period (a few months or a whole year) when one can milk cows continuously, but not necessarily every day. Non-milking season is a period when no milk is available from the household's own animals.

7.2 Health

7.2.1 Drinking Water

What is your household's major drinking water sources?

1. pond, lake, or dam
2. river, or spring
3. common well, or borehole
4. common hand pump
5. private well, or borehole
6. private hand pump
7. rainwater stored in tank
8. tap water from running water (is it disinfected?   1. yes   2. no)
9. buying from water seller

How often does your household collect drinking water in a day?______________

______times

Who and how many people usually collects drinking water?

____________________________________   ____________people

How many hours does your household spend collecting water in one collection?__

______hours

7.2.2 Diseases

<u>In the past one year</u>, did your household members have any diseases for which he/she had to go to health center/clinic/hospital? Please list all the cases.

(1) Who (sex, age) Househol d head?	(2) In which month?	(2) Name of disease or symptom	(3) Where did he/she go? Type and location	(4) Admitted to the hospital? If yes, how many days?	(5) Total expendit ure	(6) How did you manage to pay the expense?
1						
2						
3						
4						
5						

(1) If he/she is the household head, please write so.
(3) Where did he/she go: answer the type of medical facility, such as health center, clinic, hospital, and place where it is located (name of the city/town).
(4) Admitted to the hospital: If he/she had in-hospital care, answer "yes". Otherwise, "no". If yes, answer how many days he/she stayed in the hospital.
(6) Self-financed or borrowed. If self-financed, then how did the household do it? (e.g. saving, selling cows, selling wheat, and so on). If borrowed, then from whom did the household borrow? (e.g. neighbors, informal money lender, formal bank, and so on).

FOR NON-OWNERS

The difference between owner's question and non-owner's question is only section 2.2 (question on tubewell) which is shown below. The rest of the questions are the same.

2.2 Irrigation (about the plot questioned in Agriculture section)

From which owner did you buy water?___________________________________

(specify the well if the owner has more than one: __________________________)

Did you pay for water?

1=free

2=charged -> How much did you pay in total to irrigate the plot questioned above? __________________Rs (if pecuniary payment)

_______________kg of __________ (if in kind)

If 2=charged, how did you pay?

1=fixed rent per season (Rs__________. for _________ha)

2=crop sharing (___________% of the total harvest)

3=mixture of 1 and 2 (Rs _________for _________ha plus ____________% of the harvest)

4=charge per hectare per application (Rs__________)

5=charge per hectare per season (Rs__________)

6=charge per hour of pump-use (Rs__________per hour)

7=other (____)

How often did you apply water to the plot you are asked above?

___________times

How much did you apply water at each application?

1st application ____________ha (or ____________hour of pumping)

2nd application __________________ha (or ____________hour of pumping)

3rd application ____________ha (or ____________hour of pumping)

(more? write answer below)

Operational Cost Paid by Yourself

1=non

2=fuel (Rs_____)

3=Driver's / Linemen salaries (Rs_____) or (_____days by yourself)

4=transport (Rs_____) or (_____days by yourself)

5=chanel digging (Rs_____) or (_____days by yourself)

6=other (Rs_____) or (_____days by yourself)

Did you have another plot irrigated by the same well?

1=Yes (how large?_________ha) 2=No.

Opportunity of other activities

Choose the one best alternative opportunities from the following if the current well owner refused to sell water to you. (Note this is a hypothetical question to the household who actually used water last dry season.)

1=buying water from a different well owner (from whom? ____________________ ______,

how far ___________km)

2=buying water from other water source (type of irrigation?______________,

how far____________km)

3=farming without water (crop?_______________how large?_________ha)

4=non-farm family business (what kind?____________________)

5=non-farm labor work in the village (what kind?________wage rate?___
______Rs/day)

6=seasonal migration (what kind?______________wage rate?___
______Rs/day)

7=other (what kind?_____________wage rate?_________Rs/day)

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