Economy and Environment Program
for Southeast Asia
Tanglin PO Box 101
Singapore 912404
Phone: (65) 6831-6854
Fax: (65) 6235-1849
E-mail: eepsea@idrc.org.sg
Web site: www.eepsea.org

RESEARCH REPORT

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Transaction Costs In Water Markets In China's Heihe River Basin

Junlian Zhang
College of Resource and Environment
China Agricultural University
No. 2 Yuanmingyuan West Road
Beijing 100094, PRC
(junlian88@sohu.com/junlian@cau.edu.cn)

This study assesses the transaction cost related to the Water Use Rights (WUR) system that is in operation in Zhangye City, Gansu Province, Northwest China. The study was carried out to see whether these costs were a significant barrier to a properly functioning system, and, if this was the case, to see what could be done to reduce them.

Zhangye City is severely short of water. It is located in one of the driest areas in the world and is mainly watered by the Heihe River. Almost all the water from this river is currently extracted for irrigation and this has caused widespread desertification. The WUR system, the first of its kind in China, was introduced in 2002 to try and distribute water fairly and efficiently between agriculture and industry. Under the system, every water user gets a water quota fixed by the government. These quotas can be traded.

Farmers and officials in the area were interviewed to get information and opinions on the effectiveness of the scheme. Transaction costs for both the implementation of the system itself and the WUR trading scheme was assessed.

It was found that transaction costs were a significant barrier to the proper functioning of the system. It was also found that these costs were linked to the key social and administrative barriers that stand in the way of the system working properly. In light of this, the study advises that to bring transaction costs down – and improve the implementation of the scheme – these social and administrative problems must be tackled head on.

TRANSACTION COSTS IN WATER MARKETS IN CHINA'S HEIHE RIVER BASIN

Junlian Zhang

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Comments should be sent to Mr. Junlian Zhang, College of Resource and Environment, China Agricultural University, No.2 Yuanmingyuan West Road, Beijing, 100094 China.

Email: junlian88@sohu.com or junlian@cau. edu.cn

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ABSTRACT

The high transaction costs (TC) of water trading is a possible reason why water rights trading markets do not work effectively. This paper identifies and analyzes the TC involved in the implementation of water use rights (WUR) systems and WUR trading in the Heihe river basin in northwest China. Both primary and secondary data were used to achieve the objectives of this study. Primary data was gathered by conducting questionnaire surveys in five selected irrigation areas in the Heihe river basin. The respondents included farmer households, and officials from the selected irrigation areas. This paper explores the relationships between TC and other barriers to WUR trading and analyzes the factors influencing TC using regression analysis. Finally it offers recommendations on how to minimize TC.

1. INTRODUCTION

1.1 Literature Review

Transaction costs (TC) economics was first discussed in economic literature by Coase (1937) in his paper 'The Nature of the Firm'. According to him, the decision on whether to have a transaction within a firm or not is determined by the TC involved. Currently, a number of useful definitions of TC are available from literature such as Cheung (1969), Randall (1972), Williamson (1973, 1975 & 1981), Dahlman (1979), Barzel (1989), and North (1990). Although TC economics was initially developed to study economic organization in the industrial sector, it has been increasingly applied in studies on natural resources management (Colby 1989; Kuperan et al. 1998; Berner and Wittmer 2000; Sumalde and Pedroso 2001; Mburu et al. 2003). When activities involved multiple individuals and where complex activities must be coordinated over time and space, parties may attempt to reduce the uncertainties though various forms of implicit or explicit agreements that involve costly activities. In fisheries co-management, Kuperan et al. (1998) broadly categorized the major cost items of TC into: (i) information costs; (ii) collective fisheries decision-making costs; and (iii) collective operational costs. Using Williamson's (1975) identification of TC, the first two are ex-ante and the latter, ex-post TC. (Ex-ante TC are the costs of establishing a system, including information costs, decision-making costs, contracting costs, etc. while ex-post TC are the costs of implementing a system, including monitoring costs, enforcement costs, etc.) Kuperan et al. (1998) also developed a method to empirically measure TC. This was the first empirical study on the TC of the co-management of natural resources. Later, Sumalde and Pedroso (2001), and Mburu et al. (2003) did empirical research on the TC of community-based coastal resource management and wildlife co-management, respectively.

1.2 Scope and Objectives of Study

The size of transaction costs (TC) could be one of the reasons why water rights trading markets do not work effectively. Taking off from the study on barriers to water trading (Zhang 2005a), this paper goes further to discuss the TC of WUR system implementation and trading. Bauer (1997) considered the obstacles and TC of water trading in Chile, but focused his analysis mainly on obstacles or barriers to trade. To date, no empirical study on the TC of water markets has been reported.

This study focuses mainly on the rural area of Zhangye City in Gansu Province and its irrigation water use. The city is 42 thousand km^2 in size and covers six counties. Located in one of the driest zones in the world, the Heihe River basin, Zhangye City consists of many oases mainly watered by the Heihe River, the second longest inland river in China. The primary water source of the Heihe River is snow-melted water from the Qilianshan Mountain. Zhangye City is severely short of water resources. It has only 9,937 m^3 of water per hectare of farmland. Meanwhile, irrigation water use efficiency is only 20-30 percent. Agricultural water use accounts for about 95% of all water uses, and the extreme shortage of ecological water (water for maintaining the functioning and balance of the eco-system, such as protecting wetlands and rivers) has led to severe desertification and the drying out of lakes in downstream Heihe. In early 2002, the Ministry of Water Resources initiated an experimental first-of-its-kind project in China – establishing a water-saving society in Zhangye City. The aim of the project was to establish a tradable WUR system and to reallocate and use water resources reasonably and efficiently through market-based instruments. However, it was found that it was hard to implement such a system and that WUR trading was not popular. (See Zhang 2005a for a more detailed account of the study area.)

The aims of this paper are to: (1) identify and analyze the TC of the implementation of a WUR system and WUR trading; (2) identify and analyze the factors influencing TC by regression analysis; and (3) offer ways to reduce TC.

The succeeding section presents the research methodology. Section 3 identifies the TC of WUR system implementation and WUR trading while the last section provides the conclusions.

2. METHODOLOGY

2.1 Conceptual Framework

Barriers and Transaction Costs

There are several barriers to WUR system implementation and WUR trading. Sometimes, high TC is considered one of these barriers. In this study, the role of TC in water trading is analyzed separately from the other barriers. It is assumed that there are two kinds of relationships between the other barriers and TC: (1) some of barriers have no relationship with TC; they just prevent water trading; (2) some of the barriers cause TC to increase.

Classification of Transaction Costs

In a water market, water use rights (WUR) systems underlying well-defined property rights must first be established and well implemented for water trade to

work. In Zhangye city, the WUR system has been designed and promoted. Water trading would be difficult and even impossible if the WUR system is not well implemented. This study considers two different and independent processes, WUR system implementation and WUR trading, separately. The analysis on WUR trading is based on the proper implementation of the WUR system. The Hongshuihe irrigation area is one with a well-implemented WUR system although other WUR systems have not been well implemented in most other areas of Zhangye city. In this study, the TC of implementing a WUR system are first analyzed in areas of Zhangye city other than the Hongshuihe irrigation area. Then the TC of water trading are analyzed in the Hongshuihe irrigation area, based on the well implemented WUR system found there. According to Williamson (1975), TC are classified as ex-ante and ex-post (see Table 1).

Table 1. The classification of transaction costs

Transaction Costs (TC)	**Component**	**Symbol**
TC of WUR System Implementation	Ex-ante costs: (1) Research and information costs (2) Bargaining and decision/contracting costs (3) Accommodation, transportation, advertising costs, etc.	TC1
	Ex-post costs: Monitoring and enforcement costs.	TC2
TC of WUR Trading	Ex-ante costs: (1) Research and information costs, and (2) Bargaining and decision/contracting costs.	TC3
	Ex-post costs: Monitoring and enforcement costs.	TC4

Source: adapted from Williamson (1975)

TC1 reflects the opportunity costs of the total time that all the officials and local residents took to collect information, carry out promotions/discussions/ negotiations/meetings, and make decisions on the establishment of the WUR system in Zhangye city; and other related expenses for research, information search, advertising, transportation, accommodation, and so on. It is a one-time cost that occurs at the time of establishing the system. TC2 includes the costs that local governments and water agencies have to bear to maintain the WUR system through monitoring and enforcement of system regulations. It is a continuous cost for the whole duration of operating the system. It can be measured annually in Chinese Yuan (CNY) per cubic unit of water per year.

TC3 includes the opportunity costs of the total time that the water traders took to collect information, carry out

promotions/discussions/negotiations/meetings, and make decisions and contracts on WUR trade; and other related expenses, such as information search fees, advertising costs, and transportation charges. TC4 covers the monitoring and enforcement costs that occur during the process of WUR transfer from seller to buyer. TC3 and TC4 are one-time costs that occur in the period of WUR trading.

Water Fees, Transaction Costs, and Production Costs

Based on the distinction between production costs and TC used in industrial economics (North and Wallis 1994), Mburu et al. (2003) went on to postulate that the costs arising from technical measures (such as building and maintaining canals, installing water meters, etc.) are regarded as production costs, while the costs arising from creating and implementing institutional arrangements (such as WUR systems, water use rules, etc.) are regarded as TC.

In Zhangye city, a perfect self-flowing irrigation system has been formed. Water melts on snow-covered mountains and flows to rivers, then to reservoirs, main canals, and finally to farmlands. The process is self-flowing due to the difference in topography from highland to lowland. All reservoirs and main canals are state-owned or collective-owned. As many water users, such as farmers, have no reservoirs, water agencies on behalf of the government, are engaged to manage irrigation systems and water quotas. Water users can get water according to their water quotas by paying water fees to the water agencies which then guarantee the distribution of water to users and the maintenance of the WUR system.

The water fee that is paid to local water agencies by water users includes administration costs (TC2) and production costs. TC2 are the costs of administering the WUR system namely, the monitoring and enforcement costs. The main task of local water agencies is to monitor and enforce WUR system regulations. The production costs are the costs of installation and maintenance of the irrigation system and water meters. As non-profit organizations, water agencies should not set out to earn profits but merely recover their costs. Therefore, it is postulated here that the water fee comprises only TC2 and production costs, and is not the market price of water.

2.2 Data Analysis

The sources of data and collection methods are those used in the study on barriers to water markets in the Heihe River Basin in Northwest China (Zhang 2005a). Both primary and secondary data were used to achieve the objectives of the two studies. Primary data was gathered by using questionnaire surveys in five selected irrigation areas. The respondents included farmer households and officials from selected irrigation areas. Based on the pre-survey from 15 May to 2 June 2004, the survey strategy and questionnaires were designed. Sixteen college students from Gansu Agricultural University who originated from Zhangye city were hired to conduct the main questionnaire surveys through interviews with the respondents in July and August 2004. To provide the students with a firm understanding of the objectives of the study and survey instruments, a three-day training course was given. During the two-month survey period, two telephones hotlines were made available to the students. In the pre-survey and survey phases, efforts to collect, measure, and quantitatively analyze data for all the kinds of TC were exerted.

It was, however, found out that most components of the TC consisted mainly of the time officials and farmers spent at various meetings and on transactions. It was difficult to value the opportunity costs of the time involved as most of the meetings had occurred occasionally over the past few years and there were not many records of these. It was also difficult for respondents to estimate the time they expended because the meetings were usually held sporadically. Fortunately, a way to collect data on TC2 and analyze such costs quantitatively was found by analyzing the water fee and related production costs as TC2 is equal to the water fee minus the production costs. This is explained in the upcoming paragraphs.

In this study, TC1, TC3 and TC4 were analyzed using qualitative rather than quantitative methods based on information from the field surveys and findings of the study on barriers to water markets by Zhang (2005a). Firstly, it was ascertained whether there were other barriers that affected TC and what the relationships between TC and the other barriers were. Secondly, it was analyzed how the other barriers affected TC by using the theories of transaction costs and institutional economics. Finally, it was examined how TC could be reduced through overcoming the barriers.

The following are the field survey and analysis methods for TC2. The analysis on TC2 was conducted by taking water management units (WMU) of the lowest level from the Hongshuihe irrigation area in Minle county, as samples. The lowest level of WMU is usually the “administrative village” (hereinafter referred to as “village” in this report). Usually, the WMU is the village administrative committee. In order to have democracy in water management and to encourage farmers to participate directly in water management, water user associations have been established in some villages. In this case, the WMU is the association instead of the village administrative committee. Primary data by sampling survey was used to analyze TC2. In the Hongshuihe irrigation area, there are about 78 villages. Forty were selected while the available number was 39. The survey in one village was uncompleted.

The questionnaire for the TC2 analysis consisted of three sections. Section 1 contained information on the water fee and water production costs of the village respondents. Section 2 covered the characteristics of the villages, such as population, location, water use, and water management. Section 3 sought information on the characteristics of water user organizations, such as the type of organizations and the characteristics of their leaders. The regression analysis covers the results of this survey.

A quantitative method was used to analyze TC2. An econometric model was developed to identify the influence of different factors on TC2. See equation (1) below.

$$TC2 = a+\beta x+E \qquad \textit{Equation (1)}$$

where, TC2 is the dependent variable; a is a constant; β is a set of regression coefficients; x is a set of explanatory variables; and E is an error term.

The variables are shown in Table 2. TC2 are measured in CNY per cubic meter of water. The explanatory variables include two groups of variables: village characteristics and WMU characteristics. Village characteristics cover terrain, population, area of irrigated land, and whether there is groundwater for irrigation. WMU characteristics are organization types, how the leaders are selected, and the personal characteristics of the leaders.

The effect of the factors on TC2 is assumed as follows:

1) Terrain: Generally speaking, TC2 in low-lying areas should be low due to the advantageous terrain and the irrigated land parcel being centralized. In contrast, in hilly and mountainous areas, the land parcels are dispersed, so TC2 are high.

2) Population and irrigated land area: If a village has more irrigated land area, TC2 will be lower due to scale economies. Conversely, if a village has a large population, TC2 are higher because water resources become more scarce and harder to manage.

3) Whether there is groundwater for irrigation: If a village has groundwater and surface water that can be irrigated at the same time, TC2 are higher and harder to manage.

4) WMU: The TC2 of a WMU with a water user association are lower than in one without a water user association due to more democracy in water management. If a good leader is elected by vote, TC2 would be further reduced.

Table 2. Variables included in the econometric model

Variable	Meaning
Dependent variable	
TC2	The total water fees of a WMU less the costs of installation and maintenance of the irrigation and metering systems, divided by the total actual water use of the WMU, measured in CNY/ m^3.
Explanatory variables	
(A)Village characteristics	
Terrain	Dummy variable = 1 if mountainous, 2 if hilly, and 3 if low
Population	Population of the village (in number of persons)
Area of irrigated land	The total area of farmland that can be irrigated, in *mu**
Groundwater	Dummy variable = 1 if there is groundwater to irrigate, otherwise = 0
(B) WMU characteristics	
Organization types	Dummy variable = 1 if the organization is a farmer water user association, otherwise = 0
Selection of leaders	Way leader of the organization was selected. Dummy variable = 1 if the leader is selected by vote, otherwise = 0

Age	Ages of the leaders in years	

Note: * A Chinese unit measuring acreage – a *mu* is one-fifteenth of a hectare

3. EMPIRICAL FINDINGS

3.1 Transaction Costs of WUR System Implementation

The field survey showed that WUR systems were not well implemented in most irrigation areas with plenty of groundwater except for the Hongshuihe irrigation area where the groundwater is scarce and deep (Zhang 2005a). In irrigation areas with plenty of groundwater, bargaining among all levels of government, water agencies, and water users, including irrigators, for improving the implementation of the WUR system is still necessary. TC1 is the major component of transaction costs. In irrigation areas without groundwater where a WUR system has been established and well implemented, monitoring and enforcement would be the main tasks in sustaining the WUR system. TC1 are no longer relevant at this stage; it is TC2 that are the main costs.

3.1.1 TC1: Ex-ante costs in WUR system implementation

Why could not the groundwater quotas be well implemented while surface water quotas could? In fact, the technical costs of monitoring groundwater are not high. For farmers to dig a well, they must first obtain approvals to tap groundwater and to use electricity. These two are controlled by local water agencies and electricity agencies respectively and are not difficult to monitor. Stealing electricity is especially dangerous as well as easily discovered by the agencies. So, monitoring is not a physical and technical problem. The fact is that existing social and administrative barriers cause larger TC1 in irrigation areas with groundwater than in the irrigation areas without groundwater. Social barriers arise when local farmers cannot be forced to limit their water use and endure the loss caused by water shortage, while administrative barriers arise when local water authorities have no incentive to restrain local farmers from over-using water (Zhang 2005a). The following paragraphs explain why these barriers enlarge TC1.

The total annual amount of surface water is certain in any given area. When one water user uses more than his water quota, it means another user must use less than his quota. This is a self-monitoring mechanism among water users. Using more surface water is easy for others to detect and criticize. All water users value their water quotas and realize that it is impossible to increase their water quotas or water uses by bargaining with others and the government.

For groundwater, however, the total annual amount of useable water is uncertain in any given area. There would be no discernable effect on others in nearby areas in the short term if any water user uses more than his water quota. There is no self-monitoring mechanism among the water users as there is for surface water. Groundwater provides a good alternative for farmers in solving their water shortage problems. Yet, if groundwater is over-used, many adverse impacts would result, for example, nearby wetlands would disappear, and many wells would dry up and have to be abandoned (Zhang 2005a). In order to prevent these adverse

impacts, the government and water agencies should monitor the farmers' use of groundwater to ensure that they follow their quotas strictly. However, in reality, it is hard for local government authorities and water agencies to do this. Due to limited surface water, farmers tap groundwater until they get enough water for their crops even if it means exceeding their groundwater quotas as otherwise, their harvests and thus, livelihoods would suffer. They need alternative solutions, such as water-saving technologies or financial aid provided by government. Due to the lack of such solutions, many officials are concerned that monitoring and constraining farmers' water use will lead to many social issues, such as conflicts and disturbances. These in turn would make bargaining between the users and agencies difficult.

Furthermore, using groundwater has a negative externality not only to water users but also to local government bodies. Local government authorities and water agencies could benefit from more groundwater use by local farmers by way of higher water fees and taxes which would be used to develop the area. Local governments and water agencies have no incentive to monitor water users. On the contrary, they have incentives to bargain with upper levels of government for increasing water quotas or water uses. In Zhangye city, the water quotas, including groundwater quotas, are distributed for different areas by different levels of government. For example, the water quotas of all the counties are granted by the Zhangye City government while the water quotas of all the townships are granted by the related county-level government authorities. Lower levels of government have to get additional water quotas from the higher levels. Due to the difficulty in monitoring groundwater use, bargaining between the upper and lower levels of government is difficult.

Obviously, the existence of social and administrative barriers increases TC1 in the irrigation areas with plenty of groundwater, which in turn jeopardizes the successful implementation of WUR systems. If these social and administrative barriers could be overcome, TC1 would be reduced and WUR systems could be well implemented.

3.1.2 TC2: Ex-post costs in WUR system implementation

In the Hongshuihe irrigation area, the good implementation of the WUR system there indicates that the barriers do not exist or do not cause or increase TC1. However, TC2 still exists although not so much as to make the system fail.

According to the survey of the 39 sample villages, the average TC2 is about CNY0.076/m^3, the maximum being CNY 0.163/m^3, and the minimum, CNY0.054 /m^3. The characteristics of villages and WMU are given in Table 3. Table 4 shows the estimated results in ordinary least square estimates.

Table 3. Characteristics of villages and WMU

Variables	Characteristics
TC2	Mean CNY0.076/m^3, max CNY 0.163/m^3, min CNY0.054 /m^3
Terrain	9 villages on mountains, 4 villages on hills, 26 villages on low plains
Population of the village	Mean 971, max 2312, min 117
Irrigated land area of village	Mean 3115 *mu*, max 10450 *mu*, min 260 *mu*
Whether there is groundwater for irrigation	Yes: 5 No: 34
Whether water user associations are established	Yes: 21 No: 18
The way the leader of the WMU was selected	27 villages elected the leader by poll while 12 village leaders were appointed by superiors (township-level government)
Ages of leaders of the WMU	Mean 43, oldest 60, youngest 24

Source: field survey

Note: n = 39

Most of the results are consistent with theoretical expectations that: (1) TC2 are low in villages with good terrain; (2) the larger the population, the higher the TC2 in the village; (3) the more irrigated land the village has, the lower the TC2; (4) TC2 is lower in the villages that have water user associations; (5) TC2 is lower if the leader of the WMU is selected through a democratic process.

The anticipation that TC2 would be higher if a village has groundwater is not proven. This indicates that less attention is paid to monitoring groundwater use and proves that local water agencies do not restrain local farmers from over-using groundwater.

Table 4. Analysis of TC2 at village level in the Hongshuihe irrigation area

	Coefficient	T - value
Dependent variable: TC2		
Terrain (mountainous=1, hilly =2, low =3)	-0.0167	-1.82*
Whether there is groundwater	0.0223	1.44
Population	3.50E-05	2.09**
Irrigated land area	-8.12E-06	-1.84*
Type of WMU (farmer water user association = 1)	-0.0672	-4.2***
Way the leader is selected (vote election = 1)	0.0529	2.13**
Age of the leader	-0.0016	-1.6
Constant	-0.0167	-1.82*
Observation	39	
R-squared	0.615	
Adjusted R-squared	0.511	

Note: *, ** and *** are significant at 10%, 5%, and 1%, respectively

3.2 Transaction Costs of WUR Trading

The field survey shows that there is no WUR trade to be found in the irrigation areas where there are groundwater sources and that WUR trade is low even in the Hongshuihe irrigation area where the WUR system is well implemented.

There are two kinds of water trading in the Hongshuihe irrigation area, long-term trades with land and short-term trades (Zhang 2005a). Long-term trades with land are ones in which water and land use rights are transferred together, usually for several years. Short-term trades usually arise from surplus/saved water from water quotas within the current year. Long-term trades with land are greater in number and scale than short-term trades. As mentioned earlier, the TC of WUR trading can be classified as TC3 and TC4.

3.2.1 TC3: Ex-ante costs of short-term trades

The TC3 of short-term trading are very low. Short-term trades are usually small in size and occur between farmers within the same village. It is very easy to make a deal. Why are there few short-term trades if the TC are low? This is because there are some barriers that discourage the farmers from saving and trading surplus water. According to Zhang (2005a), these barriers are management, legal, administrative and fiscal ones. Management barriers are risks to farmers in

increasing areas devoted to low water-intensive crops. Due to the management barriers, few farmers have surplus water to sell. Legal barriers are caused by the Land Administration Law of China under which every household gets a small area of farmland which is segmented into many little parcels which are not connected. It is difficult for water buyers to buy land and water use rights from small farmers with small parcels. Administrative barriers arise when the government reduces the farmers' water quotas and transfers irrigation water to other sectors (if the farmers start selling off too much water). Fiscal barriers are brought about when the government is not willing to buy surplus water that farmers fail to sell in water markets. All these barriers hinder short-term trades but do not cause nor increase TC3.

3.2.2 TC3: Ex-ante costs of long-term trades

In Zhangye city, being an arid area, land loses its productivity fast and its value drops sharply as its water resources are depleted. So, a long-term trade of land_usually occurs with a long-term trade of water. The use rights of land and water are transferred together. Buyers of long-term trades mostly want to achieve economies of scale. However, due to the legal barriers and small landholdings of farmers (Zhang 2005a), buyers who want to buy a large parcel of farmland with its water have to bargain with many sellers at a time because a large parcel usually belongs to many owners. According to the survey, the average total area of farmland of every household is 1.22ha, and the average number of farmland parcels per household is 10.13. It means the average area of every parcel is only 0.12ha. In this case, it is very difficult for a farmer who wants to buy land and water use rights to achieve economies of scale because he has to negotiate with many farmers at the same time. It makes TC3 of long-term trading very high. One way to reduce TC3 is for the government to introduce policies to encourage farmers to either enlarge their landholdings or quit farming and migrate to urban areas for non-agricultural jobs. The urbanization rate of China in 2000 is 36.2%, and is estimated to reach 63.2% in 2020. It means that a large rural population will migrate to urban areas in the years to come (Tian 2003). Similar to the national level, the urbanization rate in Zhangye city is very low now but many farmers are expected to migrate from rural to urban areas in the future (Zhangye City Municipal Government, 2000). This means there will be many farmers surrendering their water and land resources which, in turn, could improve the economies of scale for other farmers. Admittedly, however, this policy is difficult to implement.

3.2.3 TC4: Ex-posts costs in WUR trading

TC4 are very low within the irrigation area because WUR trading involves only the transfer of water quotas from seller to buyer. The operational process of the trading is easy and almost costless. Meanwhile, the government's monitoring costs are low because there is nearly no third party effect within the irrigation area. Water trades do not change the kind of water use nor move water to other irrigation areas. Therefore, they would not affect other water users nor create any adverse impacts in the area.

4. CONCLUSIONS

In areas with groundwater, the existence of social and administrative barriers raises ex-ante TC (TC1), and makes the implementation of WUR systems difficult. TC1 could be reduced through overcoming these social and administrative barriers. Zhang (2005a) cited some ways to do this. To overcome social barriers, a social security system for the rural local community should be set up; to overcome administrative barriers, local water management institutions should be reformed and the farmers' water quotas fixed for a long term period. In areas where there is little groundwater, TC1 are low due to a self-monitoring mechanism among water users although social and administrative barriers still exist. The average ex-post transaction costs (TC2) of the WUR system implementation in the Hongshuihe irrigation area is about CNY0.076/m^3 with a maximum value of CNY 0.163/m^3 and a minimum value of CNY0.054 /m^3; rather high relative to the water price of CNY0.2/m^3 (Zhang 2005a). TC2 are significantly affected by factors like terrain, population, irrigated land areas, and the type of WMU (water management units). The results of the regression analysis of TC2 indicate that one could decrease TC2 through reducing the population of a WMU, establishing water user associations, and democratically electing the leader of a WMU. A good way to reduce the population of a WMU would be to encourage some farmers to quit farming and thus, surrender their land and water resources.

For WUR trading, management, administrative and fiscal barriers do not raise ex-ante costs (TC3) but inhibit water saving and short-term water trading. Legal barriers result in long-term water buyers trying to trade land with many sellers at the same time, thus increasing bargaining costs and making ex-ante TC become very high. These legal barriers can be overcome by setting up policies to encourage farmers to enlarge their landholdings or quit farming and surrender their water and land resources (Zhang 2005a). Ex-post costs (TC4) of WUR trading are usually very low. Because WUR trading involves just the transfer of water quotas from seller to buyer within the same irrigation area, the operational process of the trade is easy and almost costless. Meanwhile, the government's monitoring costs are low because there is nearly no third party effect within the irrigation area.

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