AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE
10.1002/2013WR015125

Key Points:
- Changes due to fiscal reforms have reduced villages' capacity to fund irrigation works
- Since 2005, the central government has been the main village irrigation works investor
- Farmers remain the most stable source of investment for village irrigation projects

Correspondence to:
C. E. Boyle,
ceboyle@pdx.edu

Citation:
Boyle, C. E., Q. Huang, and J. Wang (2014), Assessing the impacts of fiscal reforms on investment in village-level irrigation infrastructure, *Water Resour. Res.*, *50*, 6428–6446, doi:10.1002/2013WR015125.

Received 2 DEC 2013
Accepted 8 JUL 2014
Accepted article online 12 JUL 2014
Published online 8 AUG 2014

Assessing the impacts of fiscal reforms on investment in village-level irrigation infrastructure

Christine E. Boyle[1], Qiuqiong Huang[2], and Jinxia Wang[3]

[1]Department of International Studies, Portland State University, Portland, Oregon, USA, [2]Department of Agricultural Economics and Agribusiness, University of Arkansas, Fayetteville, Arkansas, USA, [3]Center for Chinese Agricultural Policy, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China

Abstract This paper investigates investment trends into village-level irrigation projects and assesses the impact of fiscal reforms including the tax-for-fee reform and the elimination of agricultural tax on irrigation investment. The China Water Institutions and Management Panel Survey data show that village leaders, water user associations, farmers, and upper level governments have all contributed to irrigation investment in villages throughout the study period between 1996 and 2007. Both descriptive and multivariate analyses suggest that changes brought by fiscal reforms have significantly reduced village collectives' capacity to fund irrigation infrastructure in villages. There was a significant drop in upper level government investment during the posttax-for-fee period (2002–2004 in the sample areas). Since 2005, upper level government has increased its investment to prereform levels and partly filled the public investment void in irrigation infrastructure. Fiscal reforms had the least impact on farmers' investment, which has been the most stable source of funding for village-level irrigation projects.

1. Introduction

Irrigation has always been important to China's agriculture. More than half of China's cultivated land is irrigated [*Huang et al*., 2006], a higher share than most countries. New irrigation investment is urgently needed in rural China, particularly for village-level irrigation systems. In many areas, deteriorating and dysfunctional irrigation systems have negatively affected agricultural production and require significant renovation work. Investment is also needed to improve the efficiency of irrigation systems and cope with increasing water scarcity. China's irrigation efficiency is low, reaching only 0.46 in 2006 [*Ministry of Water Resources of China* (*MWR*), 2006], a level that is much lower than most developed countries. Improving irrigation efficiency is particularly important because China's water resource availability is among the lowest in the world. The most recent estimate of China's annual renewable freshwater resources per capita is 2093 m^3 [*Food and Agriculture Organization of the United Nations* (*FAO*), 2013], which is far below the estimated world average of 8349 m^3 [*ESCAP*, 2010]. In addition, northern China only has 21% of the country's water endowment [*Ministry of Water Resources of China* (*MWR*), 2011], making improving irrigation infrastructure in the region particularly urgent.

Since the start of China's economic reform in the early 1980s, a series of national policy changes have taken place and directly affected irrigation systems, especially at the village level. Before the 1980s, most rural infrastructure was constructed using teams of laborers under the communes and thus was naturally owned and managed collectively [*Lohmar et al*., 2003]. The household responsibility system (HRS) implemented nationwide in the 1980s allowed farmers to independently manage land allocated to them and retain profit from agricultural production [*Lin*, 1992]. However, the decentralized agricultural production system left it unclear who were the legitimate owners of rural infrastructure including many local irrigation systems, especially at the level of tertiary canals and below. The ambiguous property rights have produced weak incentives for irrigation managers to invest in and maintain local infrastructure. In 1994, China's central government began to recentralize its fiscal control via changes in the tax structure and revenue-sharing arrangements with localities [*Wong*, 1997]. Further fiscal reforms between 2000 and 2006 continued to reduce village leaders' ability to collect tax revenue and fees and mobilize village labor [*Oi et al*., 2012]. These reforms effectively moved fiscal control away from villages and shifted it to upper level governments (e.g., state, provincial, prefectural, and county governments). Consequently, villages increasingly relied on

fiscal transfers from upper level governments for funding public goods in the village including irrigation infrastructure.

Despite the significant changes in fiscal policies, few studies have examined their impacts on irrigation [*Liu*, 2004; *Mushtaq et al*., 2008]. Importantly, almost none of the studies have looked at the impact of fiscal policies on investment into village-level irrigation systems. The goal of this paper is to fill in this gap in the literature. The specific research questions include: What are the major irrigation investment trends in China's villages over the past two decades? Who has been funding rural villages' irrigation systems? What is the impact of shifts in national fiscal policies on overall investment into village-level irrigation systems? What are the impacts of these shifts on investment from the main stakeholders including farmers, village collectives, and upper level government? Answers to these questions will inform scholars and policy makers alike who are struggling to improve the effectiveness of limited public funds to reach specific policy goals and shed light on who will fund rural villages' irrigation systems in the future.

To answer these questions, this paper first describes the funding structure for village-level irrigation projects and constructs a timeline of fiscal policy shifts that are relevant to irrigation investment in China. Section 3 introduces the data source for this study, the China Water Institutions and Management (CWIM) Panel Survey. The use of village-level data provides a unique bottom-up view of irrigation investment portfolios and impacts of policy changes. Few studies have done this. Section 4 describes the trends in irrigation investment and changes in irrigation-related decision-making authority and fiscal autonomy. Section 5 presents a framework to assess the impacts of policy shifts on irrigation investment as well as the selection of explanatory variables and the estimation method. Section 6 reports estimation results. Section 7 provides conclusions. The focus of the paper is on surface water investment. Groundwater-related investment is not included.

2. Central-Local Fiscal Relations and Irrigation Investment

Understanding irrigation investment in China necessitates understanding both the larger bureaucracy for irrigation-related funding and village-level financial structures for irrigation projects. This section provides such information as well as describing the fiscal shifts that occurred between 1994 and 2006.

2.1. Village-Level Surface Water Infrastructure Investment Sources

In China, the Ministry of Water Resources (MWR) is the primary ministry overseeing irrigation water distribution and infrastructure development, among other water-related matters. Subordinate administrative units of the MWR are water resource bureaus (WRBs) that follow a hierarchal order of provinces, prefectures, counties, and townships [*Wong*, 1997]. WRBs at the prefecture and county levels have the direct responsibility of planning and constructing irrigation and flood control facilities, while the duties of township-level WRBs include constructing branch and lateral irrigation canals (those connecting villages to the larger irrigation system). Irrigation districts (IDs) are in charge of supplying irrigation water to villages. Most IDs fall within the administrative boundaries of counties and thus report to county-level WRBs. In this paper, this set of WRBs, IDs, and other affiliated ministerial agencies are referred to as *upper level government*. Funds for village irrigation projects that come from the MWR are channeled via a prefecture, county, township, or ID.

Aside from upper level government funding, village-level irrigation projects are also funded by intravillage sources. In many villages, village leaders are responsible for providing public services and infrastructure including irrigation infrastructure [*West*, 1997; *Hiroshi*, 2008]. Usually village revenue funds such projects and comes from agricultural tax, various fees, and other sources such as local enterprise revenue. Since the mid-1990s, China's government has been promoting water user associations (WUAs) as its main instrument of water management reform [*Huang et al*., 2009]. WUAs have spread quickly nationwide. In northern China, by 2004, WUAs had taken over the irrigation management responsibilities from village leaders in more than 10% of villages, and this share continues to grow over time [*Huang et al*., 2009]. WUAs also fund irrigation projects, mostly from the irrigation fees collected. In some villages, village leaders rent out one or more canals in the village to an individual contractor who manages the canals as a business. Farmers contribute cash as well as labor to irrigation projects. In the rest of the paper, funding that comes from village leaders, WUAs, contractors, and farmers are grouped as *local-level investment*. Within local-level investment, funding

from village leaders or WUAs are grouped as *village collective* funding. This grouping is partly due to the large overlap between the leadership of WUAs and villages [*Huang et al*., 2010]. Even by 2007, in more than 60% of the sample villages, the head of the WUA board was also a village leader and at least one or more WUA board members were also village leaders [*Huang et al*., 2010]. It should be noted that the focus of this study is capital projects such as the construction of tertiary canals and sluice gates or the installation of water measurement equipment. Operation and maintenance expenses are not included.

2.2. Timeline of Fiscal Policy Shifts: 1980–2007

In the early 1980s, in the same spirit of economic liberalization as the HRS, China's central government gave villages extensive control over locally collected revenues in order to motivate localities to mobilize resources to develop rural areas, especially rural industry [*Oksenberg and Tong*, 1991]. Villages were largely fiscally self-reliant administrative units with little oversight [*Wong*, 1997]. The decentralized fiscal system succeeded in boosting rural economic development [*Oi et al*., 2012]. However, the central government lost its claim to the growing coffers of local revenues. In addition, the decentralized fiscal structure affected the central government's ability to command local cadres to carry out national development strategies [*Oi et al*., 2012]. To regain control over local revenues and rein in the power of local cadres, the central government implemented the 1994 fiscal reform, which reduced tax revenues that provincial and local governments could access by reassigning much larger shares of local revenues to the central government [*Wang*, 1997].

Although the central government gained more control over fiscal resources after the 1994 reform, local cadres such as township and village leaders responded by levying more surcharges and fees on farmers to make up for the lost revenues, which caused widespread farmer discontent and thereby threatened rural stability [*Oi et al*., 2012]. The central government responded with the tax-for-fee reform (in Chinese: *fei gai shui*), which was piloted in some provinces in 2000 and implemented nationwide by 2003. The reform stripped village leaders of the authority to levy fees and surcharges on farmers, which benefited farmers. However, the consequent fiscal shortfalls in many villages rendered them incapable of providing public goods [*Oi et al*., 2012]. Despite local fiscal hardships, the central government made the somewhat surprising move to further centralize fiscal control [*Oi et al*., 2012]. Agricultural tax was completely eliminated in pilot provinces in 2004 and nationwide by the end of 2006. In addition, in the 2000s, in order to further protect farmers' income and the productive use of their time, provinces limited village leaders' ability to mobilize corvée labor [*Oi et al*., 2012]. For example, by 2004, Henan province had completely eliminated corvée labor.

The fiscal reforms addressed some of the problems that hampered irrigation management and development. For example, up until 2003, water fees were bundled with other taxes and fees that farmers paid to villages. The lack of separation between the irrigation budget and the general village budget was problematic, because water-related revenue was not set aside to be reinvested in the irrigation system. The tax-for-fee reform partly addressed this problem. However, in China, water-related revenue alone is not likely to be sufficient for funding irrigation systems. This is due to irrigation water being priced far below the supply cost in order to ease the burden on farmers and to implicitly subsidize agricultural production [*Lohmar et al*., 2003; *Shalizi*, 2006]. Although China's government began moving toward reforming water prices [*General Office of the State Council of China*, 2004], progress has been slow and no significant rise in agricultural water prices are likely in the near future. In addition, investments such as water measurement equipment are needed before water pricing reform can be implemented. Another fundamental problem is that property rights over village-level irrigation infrastructure remain vague. Therefore, the question remains as to who will fund China's irrigation systems before the issues of water pricing or property rights are addressed. In fact, because the large fiscal shortfalls caused by the tax-for-fee reform were not immediately replaced by budget transfers from upper level governments, a sharp decline in irrigation investment was observed nationwide [*Liu*, 2004].

The central government has implemented some measures to address the potential irrigation investment vacuum. The *2005 No. 1 Document*, an annual directive that serves as the central government's new-year policy pronouncement on rural issues, emphasized the nation's irrigation underinvestment problem and called for increasing budgets for irrigation investment at the central, provincial, and counties levels [*Central Committee of the Communist Party of China* (*CCCPC*) *and General Office of the State Council of China*, 2005]. Following the policy document, special funds for small-scale irrigation infrastructure construction grants

were set up [*Ministry of Finance of China* (*MFC*) *and Ministry of Water Resources of China* (*MWR*), 2005]. The new funding mechanism of "run by local people with assistance from the state (in Chinese: *min ban gong zhu*)" and fund allocation on a "project-by-project assessment (in Chinese: *yi shi yi yi*)" basis were promoted. Although such programs have positive aims, the impacts of these measures remain to be seen. For example, although farmers, WUAs, or other farmers associations and village collectives can apply for these funds, their applications need to be reviewed by layers of bureaucracy (finance and water resources bureaus at the county level, then province level, then state levels). In addition to the difficulty of organizing water users in villages to apply for such funds, with increasing direct investment and project oversight by WRBs and IDs, these measures also had the effect of shifting the levers of control over local irrigation investment further away from villages and up the bureaucracy.

3. Data

Data used in this study are part of the CWIM Panel Survey conducted in two of the sample provinces that use surface water for irrigation. Ningxia Province is located in the upper reaches and Henan Province in the lower reaches of the Yellow River Basin. Within each province, a stratified random sampling strategy was used to select villages with varying degrees of water scarcity. In Ningxia, five counties were randomly chosen within two IDs, one ID near where the Yellow River enters the province and one in the middle of the province. In Henan, counties were randomly selected from IDs at varying distances from the Yellow River. IDs further away from the river are typically associated with increasing water scarcity. In both provinces, after the counties were selected, sample villages were randomly chosen from a roster of all villages in the counties. Data were collected in the same villages in 2001, 2004, and 2007. In total, we obtained balanced panel data in 46 villages. Information used in this paper mostly come from data collected during interviews with village leaders and canal managers. Separate survey questionnaires were used with answers not disclosed to the other. Canal managers may be WUAs, contractors, or village leaders. Often the village leaders will hire an individual farmer to run the day-to-day operations, and this is the person interviewed.

In each round of the CWIM survey, canal managers and village leaders filled out investment worksheets specifying the types of irrigation projects, sources of funding, and cash and labor contributions. In the first survey round (2001), village leaders were asked to record all investments since 1981. This data allow us to produce a 26 year record of surface water irrigation investment in the sample villages. In this paper, only cash investment is included. Labor contribution is excluded due to the lack of wage data to convert it to cash equivalent amount. All dollar amounts are inflation adjusted to base year 2000 using the rural consumer price index calculated by the National Bureau of Statistics of China. Monetary figures were reported in Chinese Yuan (CNY) during the survey but are converted into United States dollars (USD) here, based on the respective year's exchange rate. It should be noted that although yearly investment data are available, in most of the empirical analysis, total investments made during the 1996–2001, 2002–2004, and 2005–2007 periods are used. A multiple-year period captures villages' investment activities better, because they do not necessarily take place every year.

4. Tracking Irrigation Investment and Shifting Levers of Fiscal Autonomy

4.1. Trends in Irrigation Investment

Overall, surface water irrigation investment trends between the early 1980s and 2007 display a cyclical pattern, with investments from both the upper level government and local-level sources peaking every few years (Figure 1). Since irrigation infrastructure mainly includes durable goods, this trend makes sense. On average, investment made by upper level governments between 1981 and 2007 increased. The local-level (including village leaders, contractors, and farmers) investment rate also trends up but is flatter than the upper level government's rate of increase. Such trends suggest that the government has been taking greater control of irrigation investment in China. Larger spikes in investment in more recent years are consistent with the policy priority established by the central government in 2005 to increase budgets for irrigation investment [*CCCPC and General Office of the State Council of China*, 2005].

Additional investment trends are also observed within smaller time periods. The 1980s marked the initial transition to economic liberalization nationwide and to HRS for farming. During this time annual

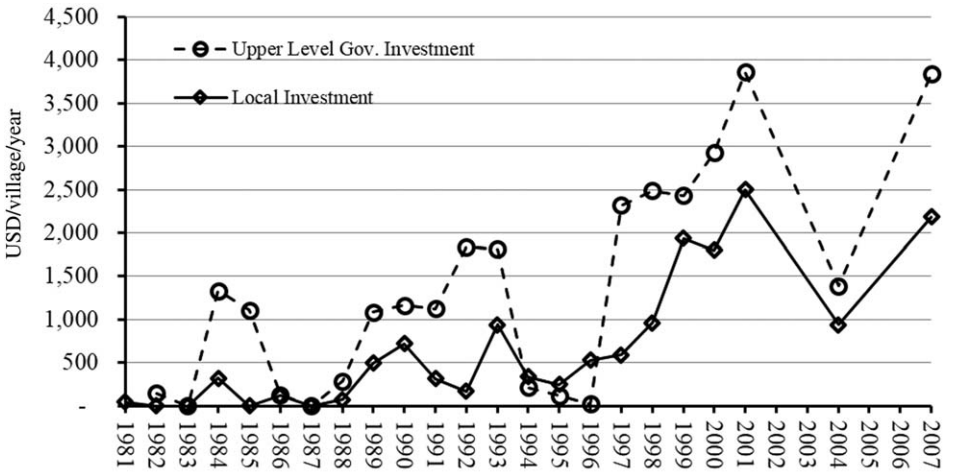

Figure 1. Average annual investment in village-level irrigation projects (USD/village/year, n = 46). Monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate. For years 1996–2001, 1 CNY = 0.121 USD; 2002–2004, 1 CNY = 0.121 USD; 2005–2007, 1 CNY = 0.132 USD. (a) *Upper level governments include provincial, county, and township WRBs and irrigation districts. (b) Local investment includes investment made by the village collective, WUAs, contractors, and farmers. (c) The 2004 data point is the annual average for the 2002–2004 period. The 2007 data point is the annual average for the 2005–2007 period. (d)* Investments were low but not zero in several years (e.g., 1982, 1983, 1985, 1987, and 1996).

expenditures per village remained low (Figure 1). Mandatory labor contributions allowed for general upkeep of systems, but little infrastructure or irrigation area development took place. Between 1990 and 1996, investment activity by local sources remained low (around US$465 per village annually). In contrast, upper level government invested an average of US$900 per village annually during the same time period (Figure 1). Upper level government investment dramatically increased in 1997 and reached US$2300 per village. Local investment in the 1990s peaked in 1999, reaching a high of US$1936 per village. This is consistent with findings in *Fan et al*. [2004] that the government increased investment in irrigation between 1997 and 1999 in response to the grain shortfall in 1995 that threatened the nation's grain supply. The upward trend of investment continued in 2001, marking a high of US$3872 per village from upper level government (Figure 1). A closer look by province in Table 1 shows this is mostly driven by the investment in one of the sample provinces, Ningxia Province. China's Western Development Strategy (in Chinese: *xi bu da kai fa*), outlined in *the Tenth Five-Year* (2001–2005) *Plan*, injected billions of dollars into the western part of the country including Ningxia Province [*Lin and Chan*, 2004]. This may in part explain the influx of investment made by the upper level government during the early 2000s. Investment, however, plummeted during the 2002–2004 period. This is probably due to the large fiscal void left by the tax-for-fee reform, which was not addressed by budget transfers from upper level governments until 2005. A severe drought that occurred in northern China in 2004 may have also contributed to investment declines during this period because most funds would have been diverted to mitigate the impacts of the drought. The drought may also explain the higher investment level observed between 2005 and 2007 because the threat of droughts in the future would raise the expected rate of return on irrigation investments by reducing potential system losses.

Despite fluctuations in investment levels, investment portfolios of village-level irrigation projects have retained diverse funding sources. In all three time periods, farmers, village collectives, and upper level governments invested into village-level irrigation projects (Table 1). However, investment portfolios varied across the sample provinces. In Ningxia Province, the upper level government has been the majority investor and invested 74%, 65%, and 68% of total investments in the 1996–2001, 2002–2004, and 2005–2007 periods, respectively. In contrast, in Henan Province, village collectives and farmers are the groups that contributed substantial amounts. The difference in the portfolios could be linked to dissimilarities between the two provinces' climates and province-level policies. The average annual rainfall between 2001 and 2007 was 79 cm in Henan Province and only 28 cm in Ningxia Province. Therefore, agriculture in Ningxia Province relies much more on irrigation. In addition, in Henan Province, only 30% of water supply comes from surface water [*Henan Bureau of Hydrology and Water Resources*, 2007]. In contrast, in Ningxia Province sample areas, almost 100% of irrigation water comes from surface water diverted from the Yellow River [*Ningxia Water*

Table 1. Total Irrigation Investment per Time Period and by Source[a]

	1996–2001[b]		2002–2004		2005–2007	
	Amount	Share	Amount	Share	Amount	Share
Full Sample						
Farmers[c]	2459	12.2%	1001	14.1%	5331	29.3%
Village collective[d]	5363	26.7%	1850	26.0%	1333	7.3%
Upper level government	12,277	61.1%	4271	60.0%	11,515	63.3%
Henan Province						
Farmers	3855	43.1%	524	11.4%	4770	47.8%
Village collective	2774	31.0%	2233	48.4%	715	13.7%
Upper level government	2324	26.0%	1857	40.2%	4494	45.0%
Ningxia Province						
Farmers	2976	7.8%	1179	15.3%	5199	24.1%
Village collective	6859	17.9%	1508	19.6%	1625	7.5%
Upper level government	28,526	74.4%	5026	65.2%	14,726	68.3%

[a](USD/Village/Period); monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate. For years 1996–2001, 1 CNY = 0.121 USD; 2002–2004, 1 CNY = 0.121 USD; 2005–2007, 1 CNY = 0.132 USD. Village annual mean is the annual average investment for the respective time period.

[b]To allow for cross-period comparison, the investment amount for the 1996–2001 time period is divided by 2 because it is a 6 year period, while 2002–2004 and 2005–2007 are 3 year periods.

[c]Farmers include both individuals and small groups of farmers. Contractors are also included.

[d]Village collective includes village collectives and WUAs.

Resources Bureau, 2007]. Because of this, Ningxia Province has been much more aggressive in investing in surface water irrigation projects. For example, a landmark project of the Western Development Strategy, the Ningxia Shapotou Hydropower Project of Yellow River, is located in one of the CWIM sample counties in Ningxia Province and was constructed between 2001 and 2005 [*Ningxia Water Resources Bureau*, 2002]. The purpose of the project was to divert water from the Yellow River to generate power and supply irrigation water. As a result, villages in Ningxia Province received large investments from the upper level government during this period. Partly because the 2004 drought exposed many problems with existing irrigation infrastructure, Ningxia Province started another round of investment in 2007 to renovate existing irrigation and drainage systems and improve irrigation efficiency [*Ningxia Water Resources Bureau*, 2007].

Despite their differences, both provinces experienced a shift in investment portfolios over time. Whereas village collectives in Ningxia and Henan provinces contributed 19.6% and 48.4%, respectively, of the total investment made by villages during the 2002–2004 period, in the 2005–2007 period, the shares in both provinces dropped sharply to around 7.5% and 13.7% (Table 1). The considerable drop may be explained by the smaller general village budgets after the tax-for-fee reform and the elimination of agricultural tax. Although the share contributed by the upper level government increased slightly to make up for the gap created by the declining investment from the village collective, the gap is mostly picked up by investments from farmers. Farmers in Henan Province only contributed 11.4% of the total irrigation investment during the 2002–2004 period but increased their contribution sharply to 47.8% during the 2005–2007 period. The increment in Ningxia province was of smaller magnitude but farmers' share still increased from 15.3% to 24.1%. The upward trends of both farmer and upper level government investments are consistent with the "run by local people with assistance from the state" principle that the central government has been promoting as the new model to fund village-level irrigation projects.

The data reveal that upper level government investment favors projects that would improve the performance of the irrigation system. The CWIM survey collected information on irrigation investment by types of projects (e.g., developing new canals, canal lining, purchasing pumps, water measurement equipment, and other equipment). During the survey periods (from 1996 to 2007), 92% of irrigation investments made by upper level government went to projects such as lining canals in the village. A much smaller portion (4.2%) went to projects such as developing new canals in villages. Competing irrigation demands by different villages is often the leading factor behind water conflicts among villages in a region. Developing new canals in a village, by increasing the irrigation demand of that village, is likely to intensify any existing water conflicts. On the other hand, lining canals, by reducing conveyance loss, can reduce the amount of irrigation

Table 2. Division of Fiscal Responsibilities (% of Villages)

	Sets Village Irrigation Fees[a]			Collects Irrigation Fees From Farmers[b]			Authority to Sign Contracts[b]		
	2001	2004	2007	2001	2004	2007	2001	2004	2007
Individuals[c]	0	0	0	31.8	35.4	19.6	4.30	3.60	7.70
Village Collective									
Village leader	19.6	18.8	6.5	56.8	45.8	15.2	56.5	60.7	41.0
Water user association	0	0	0	0	8.3	54.3	0	0	0
Upper Level Government									
Irrigation district	47.1	52.1	54.3	0	0	0	30.4	28.6	46.2
County or township WRBs	27.5	22.9	34.8	0	0	0	0	0	0
Other	5.90	6.30	4.30	11.4	10.4	10.9	8.70	7.10	5.10

[a]Other means irrigation fees are negotiated among multiple groups such as between the village leaders and the irrigation district.
[b]Other means no fees are collected.
[c]Individuals include contractors, individual farmers, and small groups of farmers.

water a village needs and thus helps alleviate water conflicts. This investment strategy departs from earlier strategies by the Chinese government to expand irrigated area [*Cai*, 2008], but the priority given to improving quality over expanding area aligns with China's other farmland development strategies in more recent years that focus on modernizing the agricultural sector [*Central Committee of the Communist Party of China* (*CCCPC*) *and General Office of the State Council of China*, 2012]. In contrast, village collectives and farmers seem to be less concerned with such issues. About 19% of irrigation investments made by village collectives went into developing new canals. About 66% of investments made by farmers went into developing new canals.

4.2. Changes in Decision-Making Authority and Fiscal Autonomy

As villages' irrigation investment portfolios changed over time, so did decision-making authority over irrigation-related fiscal matters within the villages (Table 2). Using the CWIM data, we examine three fiscal decision-making aspects: Who sets the level of irrigation fees to be collected from farmers? Who collects irrigation fees from farmers? Who signs the canal management contracts (for example, contracts that stipulate the amount of water the IDs will deliver to the village and the contracts with the canal contractors)? Consistent with the trend observed in the investment portfolios, village leaders' authority over irrigation-related fiscal matters receded in all three decision-making aspects over time. In both 2001 and 2004, roughly 19% of village leaders set irrigation fees, but by 2007 only 6.5% of village leaders retained this power. The drop is mostly due to county or township WRBs taking over this management task, which probably reflects the trend that villages' irrigation funding was increasingly being transferred from township and county WRBs after 2005. The share of villages in which county or township WRBs set irrigation fees increased from 22.9% to 34.8% from 2004 to 2007. In contrast, the IDs' share only went up from 52.1% to 54.3%, even though the irrigation fees are eventually remitted to IDs to pay for the cost of supplying water to villages after being routed through township and county WRBs. There is also a significant drop in the share of villages in which village leaders collected irrigation fees. This responsibility shifted to the hands of WUAs in many sample villages by 2007. The share of villages in which village leaders sign the canal management contract declined by 15.5 percentage points from 2001 to 2007 with IDs assuming this responsibility.

Another measure of villages' irrigation-related fiscal authority is the share of total irrigation fees collected that the village gets to keep instead of remitting to the ID or township WRB, which is called the *marginal revenue retention rate*, or MRR rate, in this paper. Several studies use the share of local revenue that the local government is allowed to keep to measure the degree of fiscal autonomy or fiscal incentives faced by China's local governments [*Jin et al.*, 2005; *Lin and Liu*, 2000; *Oi*, 1992; *Oksenberg and Tong*, 1991]. In particular, *Lin and Liu* [2000] used this measure as a proxy for the degree of fiscal decentralization at the province level. Findings from these studies suggest that higher MRR increases the discretionary spending power of local government and incentivizes revenue generation (such as making more efforts to collect more irrigation fees).

MRR exhibited a declining trend in the CWIM data (Table 3). In 2004, villages retained around 16% of irrigation fees, which was close to the 2001 level of 14%. The MRR dropped sharply to 3% by 2007 in both Henan and Ningxia provinces. Examining the total amount of irrigation fees reveals a similar trend. Irrigation fees

Table 3. Flow of Village Irrigation Fees

	2001		2004		2007	
	Mean	SD	Mean	SD	Mean	SD
Marginal Revenue Retention Rate						
Full sample	0.14	(0.21)	0.16	(0.23)	0.03	(0.09)
Henan Province	0.08	(0.19)	0.16	(0.27)	0.03	(0.08)
Ningxia Province	0.18	(0.21)	0.16	(0.19)	0.03	(0.10)
Annual Amount of Irrigation Fees (USD/ha/yr)[a]						
Total amount collected within village	62	(113)	63	(48)	90	(73)
Amount remitted to upper level government	53	(41)	52	(48)	88	(73)
Amount retained by village	9	(100)	11	(18)	2	(5.0)

[a]Monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate. For years 1996–2001, 1 CNY = 0.121 USD; 2002–2004, 1 CNY = 0.121 USD; 2005–2007, 1 CNY = 0.132 USD.

collected within villages remained constant between 2001 and 2004 at roughly US$63/ha/yr. One impetus of the government's push for WUAs was to improve the rate of irrigation fee collection [*Ministry of Water Resources of China* (*MWR*), *National Development and Reform Commission* (*NDRC*), *and Ministry of Civil Affairs of China* (*MCAC*), 2005; *Li*, 2009]. The average irrigation fee per hectare increased in 2007 to US$90/ha/yr. However, despite improvements in fee collection, the amount of fees that villages retained dropped from US$11/ha to a mere US$2/ha. By 2007 more than 90% of the fees were remitted to the upper level government. Such a trend could have multiple explanations. First, IDs were charging a higher price for water to reflect the increased cost of supplying water. It could be that MRR shrank because a higher portion of irrigation fees went to water purchased from IDs. However, the rate of water price increase was only between 2% and 5% in most villages. The moderate magnitudes of price increases were not enough to explain the sharp decline in MRR. Second, the shrinking MRR could also be a consequence of the fiscal centralization brought by the fiscal reforms, with the role of village collectives in irrigation investment diminished and greater reliance on WRBs and IDs to fund projects.

5. Assessing the Impacts of Fiscal Policy Shifts on Irrigation Investment

Overall, the reforms (tax revenue reduction, tax-for-fee, agricultural tax abolition, and corvée labor elimination) shifted fiscal control from villages to the central and upper level governments. Although the reforms were largely motivated by the power struggle between the central, regional, and local governments [*Oi et al*., 2012], they have the potential to affect irrigation investment in significant ways.

5.1. The Framework for Assessing the Impacts of Fiscal Policy Shifts

The investment decisions of all agents (upper level government, village collectives, and farmers) can be cast in a framework of cost-benefit analysis. Each agent maximizes the net benefit of irrigation investment subject to his budget constraint. For farmers, the benefit is captured by the potential of these investments to increase their individual agricultural incomes. For both upper level government and village collectives, the benefit of irrigation investment depends on how much the investment helps further the various social, economic, and political goals they may have. For example, among the main goals village leaders have in making public investments, summarized by *Zhang et al*. [2006], increasing incomes of villagers, raising village fiscal revenue, and improving the environment (e.g., conserve water resources) are most relevant to irrigation investment. Upper level government has a more complicated set of goals when making irrigation investment decisions. For example, in addition to regional growth goals such as economic development and improving living standards, upper level government is often concerned with reducing interregional externalities such as conflicts between upstream and downstream users. The upper level government is also more likely to make investment decisions that directly reflect the policy priorities of the central government, most of which are stated in the series of *No. 1 Documents*. The cost of irrigation investment is defined by its opportunity cost, that is, the next best investment activity. For upper level government and village collectives, these may be investments into nonirrigation public goods such as schools and public health. For farmers, it may be investments into children's education or off-farm employment opportunities.

The impacts of fiscal policy shifts can be analyzed through their influence on the benefit, cost, or the budget constraint of irrigation investment faced by each agent. Decentralized fiscal policy aims to incentivize local revenue generation and spur investments that provide benefits for local communities [*Faguet*, 2004]. The mid-2000s fiscal recentralization significantly reduced village leaders' budgets for providing village-level public goods. As such, the reforms restricted or removed the two means (collective fiscal resources and corvée labor) that village leaders previously had to invest in irrigation infrastructure. It is not difficult to show that ceteris paribus, a smaller budget will reduce the amount of irrigation investments village collectives make. The fiscal policy shifts also reduced the benefit of investment for village collectives. As investment in irrigation increases agricultural production and income [*Fan et al*., 2002; *Huang et al*., 2006], it raises collective fiscal revenue by increasing the amount of agricultural tax village leaders can collect from farmers. With the elimination of agricultural tax, the benefit of irrigation investment in terms of fiscal revenue is much reduced if not completely removed. As a result, the incentive of village collectives to invest in irrigation projects is also reduced.

The tax-for-fee reform has a similar shrinking effect on the budgets of some upper level governments, especially county-level governments, by restricting their abilities to levy fees [*Oi et al*., 2012]. Ceteris paribus, we would expect to see less irrigation investment made by upper level government. The elimination of agricultural tax further reduced the budget available to most upper level governments. However, the 2005 *No. 1 Document* also established the policy priority of increasing budgets for irrigation investment at the central, provincial, and county levels [*CCCPC and General Office of the State Council of China*, 2005]. Therefore, irrigation investment made by upper level government could either increase or decrease after 2005, depending on whether the negative impact of the elimination of agricultural tax on irrigation investment is offset by the new policy priority of a larger irrigation budget.

The tax-for-fee reform, by alleviating farmers' financial burdens, had the effect of increasing farmer incomes, which relaxes farmers' budget constraint. The elimination of agricultural tax is likely to relax farmers' budget constraint even further. Other factors held constant (e.g., the current conditions of irrigation infrastructure), we may see higher irrigation investments made by farmers due to larger household budgets associated with higher income levels. The positive relationship between the income level and the private provision of public goods is supported by both theoretical models [*Bergstrom et al*., 1986] and laboratory experiment results [*Chan et al*., 1996]. However, such effect may be of a limited magnitude. This is because the fund allocation mechanism of project-by-project assessment implemented alongside fiscal shifts often put a cap on the amount of cash allowed to be collected from farmers for the provision of village public goods [*MFC and MWR*, 2005]. The cap is usually set between 10 and 20 CNY (USD $1.61–$3.22) per capita.

5.2. Selection of Explanatory Variables

In addition to the fiscal policy shifts, investment decisions are also influenced by other factors. The management of local irrigation systems is well studied in the literature [e.g., *Fujiie et al*., 2005; *Lam*, 1998]. Using the framework identified by *Ostrom* [2007] to summarize the literature on irrigation system management outcomes including investment activities, *Meinzen-Dick* [2007] classified the critical factors into social, economic, and political settings, resource system, resource units, governance system, and users. *Faguet* [2004] identified a list of factors influencing public investments. Following *Meinzen-Dick* [2007] and *Faguet* [2004], we group the relevant factors for irrigation investment into the following categories: irrigation conditions, socio-economic conditions of users and villages, and governance system.

Three variables are used to characterize irrigation conditions: the length of the branch canal network, the share of the total length of canals in the village lined in the previous period, and the ratio of actual to maximum intended irrigated area. The first two variables measure the existing stock of irrigation infrastructure in the village. In general, the need to invest declines as the level of stock rises [*Faguet*, 2004]. The third variable reflects the extent to which the existing stock satisfies the irrigation needs in the village. These variables may influence the investment decisions by all agents, although to different degrees. *Faguet* [2004] argues that central government may be less responsive to local needs, reflected partly by the existing stock of infrastructure. So we may expect to see these variables to have larger impacts on the investment decisions made by village collectives and farmers than by upper level government.

Six variables are included in the category of socio-economic conditions of users and villages. The first three variables measure the characteristics of users: a dummy variable that equals one if the village relies

exclusively on surface water for irrigation, annual income per capita in the village, and the share of villagers working outside the villages. Greater reliance on surface water irrigation is likely to increase the need for irrigation investment. Higher income, ceteris paribus, may increase farmers' investment in irrigation because it means farmers have a larger budget for investment activities. China's government is committed to reducing poverty [*World Bank*, 2001], so a village's per capita income level is likely to be factored into upper level government's investment decisions. The share of villagers working outside the village reflects the exit-option farmers have from agricultural production, which has been shown to reduce users' tendency to contribute to public goods in the village [*Meinzen-Dick et al*., 2002]. The next two variables measure the potential leadership the village has to organize investment activities: share of villagers that graduated from middle school and the number of years of water management experience of the village secretary. More educated farmers may be more likely to organize among themselves for irrigation investment activities [*Meinzen-Dick et al*., 2002]. A village party secretary experienced in the irrigation sector may have a long history of working with upper level agencies, which may lead to greater upper level investment into irrigation. The last variable, annual revenue from village enterprises, is used to capture the fiscal resources village collectives have, which may influence their investment activities.

To measure the governance system, a dummy variable is used, which equals one if the management of the irrigation system has been transferred to WUAs or individual contractors. If village leaders are still in charge, this dummy variable equals zero. *Huang* [2014] has shown that WUAs and contractors have improved some aspects of irrigation systems including maintenance expenditures. It is likely these governance systems may increase investment activities in the village. WUAs also work directly with upper level governments such as IDs, which may attract more upper level government investment.

5.3. The Model

The general estimating equation for the determinants of irrigation investment can be expressed as:

$$I_{jtk} = \alpha + \mathbf{Y}_t\boldsymbol{\beta} + \mathbf{F}_{jt}\boldsymbol{\delta} + \mathbf{Z}_{jt}\boldsymbol{\gamma} + \varepsilon_{jtk} \quad (1)$$

where I_{jtk} represents investment made on irrigation projects in village j during period t. The subscript k is the designation for the dependent variable of the four versions of equation (1) that will be estimated: total investment, investment made by farmers, investment made by village collectives (village leaders and/or WUAs), and investment made by the upper level government (WRBs and IDs). Investments are measured in dollars per hectare per time period to control for the village size. The subscript t represents time periods ending in the years 2001, 2004, and 2007. Investments made during the 1996–2001 period are divided by 2 to be converted to a 3 year period in order to be on the same timescale as the other two periods (2002–2004 and 2005–2007). The vector $\mathbf{Z}_{jt}$ includes the set of variables on irrigation conditions, socio-economic conditions of users and villages, and governance system as explained in section 5.2.

The vector $\mathbf{Y}_t$ contains two period dummies: one for the 2002–2004 period and one for the 2005–2007 period. The base group is the 1996–2001 period. The tax-for-fee reform was implemented province wide in both Henan and Ningxia provinces in 2002 [*Chang*, 2003]. The period 2002–2004 captures the posttax-for-fee reform period. In both provinces, agricultural tax was eliminated province wide by 2005 [*Lei*, 2005; *Ningxia Daily News* (*NDN*), 2005]. So the period 2005–2007 captures the postagricultural tax elimination period. The vector $\mathbf{F}_{jt}$ contains variables that measure villages' fiscal autonomy: the MRR and an index of village decision-making authority. The index is created by using factor analysis to extract a common underlying factor from the three indicators (authority to sign contracts, authority to set fees, and authority to collect fees). Because the three indicators are highly correlated, if all three are included in the same regression, there will be a multicollinearity problem. It is more likely that investment levels observed in the current period are determined in the past period and thus are more influenced by the fiscal autonomy in the past. For both the MRR and the decision-making authority index, values from the previous time period are used. Since lagged values are predetermined, using them also helps avoid the endogeneity problem in which the explanatory variables are correlated with error terms. Because both MRR and decision-making authority are affected by macro-fiscal policies and vary over time, there may be a strong correlation between these two variables and the period dummies. In the empirical analysis, we estimate three specifications that have different combinations of the two groups of variables: both period dummies and fiscal autonomy variables; period dummies only; and fiscal autonomy variables only. Several other variables are also lagged to reduce

the possibility of endogeneity. These variables include log of total canal length in meters, % of lined canal in length, and the dummy variable that equals one if village relies exclusively on surface water for irrigation.

A standard ordinary least squares (OLS) model can be employed to estimate equation (1) but may produce biased estimates. Although equation (1) includes a large set of explanatory variables, some unobserved factors may be omitted because we do not have data on them. Bias arises if these omitted factors are correlated with any of the explanatory variables. For example, county-level policies may influence investments made in village irrigation projects (the dependent variable) and remain in the error term if not controlled for. County-level policies are also likely to influence villages' fiscal autonomy. Then the omission of county-level heterogeneity including the policy environment will lead to bias in OLS estimates of parameters in equation (1).

With a set of panel data at hand, we can use county fixed-effects estimators to control for unobserved heterogeneity at the county level. To illustrate how the fixed-effects estimator works, we first modify equation (1) by adding a term, $\boldsymbol{\mu}_c$:

$$I_{jtk} = \alpha + \mathbf{Y}_t\boldsymbol{\beta} + \mathbf{F}_{jt}\boldsymbol{\delta} + \mathbf{Z}_{jt}\boldsymbol{\gamma} + \boldsymbol{\mu}_c + \varepsilon_{jtk} \tag{1a}$$

The term $\boldsymbol{\mu}_c$ captures county-level characteristics that are *time-invariant*, including all observable and unobservable factors. Lagging equation (1a) by one time period generates equation (1b):

$$I_{jk,t-1} = \alpha + \mathbf{Y}_{t-1}\boldsymbol{\beta} + \mathbf{F}_{j,t-1}\boldsymbol{\delta} + \mathbf{Z}_{j,t-1}\boldsymbol{\gamma} + \boldsymbol{\mu}_c + \varepsilon_{jk,t-1} \tag{1b}$$

Notice the lagged term of $\boldsymbol{\mu}_c$ is still itself because it is time-invariant. Subtracting equation (1b) from (1a) generates equation (1c):

$$(I_{jtk} - I_{jk,t-1}) = (\mathbf{Y}_t - \mathbf{Y}_{t-1})\boldsymbol{\beta} + (\mathbf{F}_{jt} - \mathbf{F}_{j,t-1})\boldsymbol{\delta} + (\mathbf{Z}_{jt} - \mathbf{Z}_{j,t-1})\boldsymbol{\gamma} + (\varepsilon_{jtk} - \varepsilon_{jk,t-1}) \tag{1c}$$

The term $\boldsymbol{\mu}_c$ disappears in equation (1c). Estimating equation (1c) thus generates consistent estimates of all parameters in equation (1) such as $\boldsymbol{\beta}, \boldsymbol{\delta}$ and $\boldsymbol{\gamma}$ without the need to include all possible observed and unobserved factors at the county level.

In addition to estimating the equation for levels of investments, we also estimate villages' irrigation investment portfolios using the following estimating equation:

$$IS_{jtk} = \alpha + \mathbf{Y}_t\boldsymbol{\beta} + \mathbf{F}_{jt}\boldsymbol{\delta} + \mathbf{Z}_{jt}\boldsymbol{\gamma} + \boldsymbol{\mu}_c + \varepsilon_{jtk} \tag{2}$$

where IS_{jtk} represents the share of investment from source k in village j during period t. The specification of equation (2) is similar to that of equation (1a). The same set of explanatory variables is included. The county fixed-effects estimator is also used. In addition, because the dependent variables of the three versions of equation (2), share of investment by farmers, by the village collective, and by the upper level government, add up to 100%, the seemingly unrelated regression is used to estimate all three equations jointly. Cross-equation restrictions are imposed so that the estimated coefficients on the same variable from the three equations add up to zero. In all regressions, standard errors are clustered at the county level.

6. Results

The regression analyses perform well overall. The R^2 statistics of most regressions exceed 0.15, a level that can be considered as adequate for panel data regressions (Tables 4–8). Since the base period is 1996–2001, the estimated coefficient on the 2002–2004 period dummy measures the difference in investment levels between the 2002–2004 period and the 1996–2001 period. The estimated coefficient on the 2005–2007 period dummy is interpreted in the same fashion. Table 4 shows that the level of total investment made in the 2002–2004 period is lower than that in the 1996–2001 base period, and the difference is statistically significant (columns I and III). The level of investment in the 2005–2007 period bounced back. It is not statistically different from that in the 1996–2001 period and is larger than the level in the 2002–2004 period, as indicated by the t test. This is consistent with the trend observed in Figure 1. One important observation across Tables (4–7) (columns I and III) is that although village collective investments declined in the 2005–2007 period, the increase in investment by the upper level government is enough to take the level of total investment back to the 1996–2001 level. So our study does provide some evidence that the upper level

Table 4. Factors That Influence Total Investment in Village-Level Irrigation Projects (USD/Hectare/Period, County Fixed Effects)[a]

	I	II	III
Policy Shifts			
Dummy = 1 if 2002–2004 period	−60.87**		−66.02***
	(20.69)		(20.33)
Dummy = 1 if 2005–2007 period	−15.01		−24.16
	(21.87)		(26.54)
Fiscal Autonomy			
Share of irrigation fees retained by village (MRR, lagged)	95.64	103.8	
	(63.05)	(64.27)	
Decision-making authority index, lagged	16.45	16.53	
	(13.43)	(13.68)	
Irrigation Conditions			
Log of total canal length in meters, lagged	19.75*	19.39**	16.98*
	(9.055)	(8.070)	(8.627)
% of lined canal in length (meters), lagged	63.57*	62.11	49.76*
	(32.76)	(35.23)	(27.28)
Ratio of irrigated to maximum irrigable area	12.56	29.34	28.47
	(30.38)	(36.95)	(35.11)
Socio-Economic Conditions of Users and Villages			
Dummy = 1 if village relies exclusively on surface water for irrigation, lagged	−23.27	−21.63	−18.86
	(35.16)	(34.46)	(29.13)
Annual income per capita in USD 1000[b]	−0.023	−0.011	−0.005
	(0.034)	(0.036)	(0.027)
Share of villagers working outside village	−28.99	−52.68**	−12.38
	(19.32)	(21.95)	(23.27)
Share of villagers graduated from middle school	0.165	0.238	0.227
	(0.546)	(0.608)	(0.550)
Years of water management experience of Party Secretary	2.431	3.080	2.058
	(1.707)	(1.753)	(1.302)
Annual revenue from village enterprise in USD 1000[b]	−0.839	−0.322	1.578
	(2.007)	(2.050)	(2.234)
Governance System			
Noncollective irrigation management (WUA or contract)	−30.72	−47.68	−16.02
	(27.32)	(27.88)	(23.04)
Constant	−107.4*	−139.8*	−89.36
	(57.59)	(72.78)	(58.70)
Observations	138	138	138
R^2	0.16	0.12	0.12

[a]Note: robust standard errors reported in parentheses; levels of significance reported as *, **, and *** significant at 10%, 5%, and 1%, respectively. To allow for cross-period comparison, the investment amount for the 1996–2001 time period is divided by 2 because it is a 6 year period, while 2002–2004 and 2005–2007 are 3 year periods.

[b]Monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate.

government is stepping up to fill the gap in public investment left by the diminishing role of village collectives.

Estimated coefficients on the period dummies can be used to examine the effects of the fiscal policy shifts on irrigation investments. Table 5 examines factors that influence irrigation investment made by village collectives. The estimated coefficient on the 2002–2004 period dummy is negative but not statistically significant (columns I and III). This indicates the tax-for-fee reform did not have a significant impact on the investment activities of village collectives. The estimated coefficient on the 2005–2007 period dummy is negative and statistically significant (columns I and III), indicating a strong and negative impact of the elimination of agricultural tax. Both the tax-for-fee reform and the elimination of agricultural tax shrank the budgets of village collectives. The elimination of agricultural tax also reduced the benefit of irrigation investment because village collectives could no longer generate fiscal revenues from agricultural production. The empirical results show that the fiscal policy shifts affected investment by village collectives mostly by changing the benefit of investment, not through tightening the budget constraint.

Results in Table 6 show that there is a statistically significant drop in upper level government investment during the posttax-for-fee period. The estimated coefficient on the 2002–2004 period dummy is negative and statistically significant (columns I and III). This is probably because investment in village-level irrigation

Table 5. Factors That Influence Village Collective Irrigation Investment (USD/Hectare/Period, County Fixed Effects)[a]

	I	II	III
Policy Shifts			
Dummy = 1 if 2002–2004 period	−11.54		−11.61
	(7.694)		(7.766)
Dummy = 1 if 2005–2007 period	−16.98**		−17.26**
	(6.045)		(6.434)
Fiscal Autonomy			
Share of irrigation fees retained by village (MRR, lagged)	−0.562	0.729	
	(5.919)	(6.280)	
Decision-making authority index, lagged	0.656	1.465	
	(1.661)	(1.928)	
Irrigation Conditions			
Log of total canal length in meters, lagged	1.532	−0.0796	1.521
	(3.509)	(3.243)	(3.358)
% of lined canal in length, lagged	13.77	14.19	13.68
	(14.85)	(14.03)	(14.26)
Ratio of irrigated to maximum irrigable area	−0.675	4.917	−0.490
	(7.871)	(8.944)	(8.328)
Socio-Economic Conditions of Users and Villagers			
Dummy = 1 if village relies exclusively on surface water for irrigation, lagged	0.400	−5.990	−4.559
	(0.604)	(4.330)	(3.092)
Annual income per capita in USD 1000[b]	−4.759	0.000	0.017
	(3.574)	(0.016)	(0.011)
Share of villagers working outside village	0.0162	−2.529	1.654
	(0.011)	(4.699)	(4.065)
Share of villagers graduated from middle school	1.450	−0.038	−0.024
	(3.917)	(0.166)	(0.163)
Years of water management experience of Party Secretary	−0.0242	0.447	0.405
	(0.167)	(0.714)	(0.576)
Annual revenue from village enterprise in USD 1000[b]	0.624	0.333	0.645
	(0.966)	(1.021)	(0.893)
Governance System			
Noncollective irrigation management (WUA or contract)	−3.804	−9.381	−3.568
	(5.683)	(6.751)	(5.760)
Constant	1.841	12.14	1.388
	(32.05)	(30.12)	(31.42)
Observations	138	138	138
R^2	0.15	0.08	0.15

[a]Note: robust standard errors reported in parentheses; levels of significance reported as *, **, and *** significant at 10%, 5%, and 1%, respectively. To allow for cross-period comparison, the investment amount for the 1996–2001 time period is divided by 2 because it is a 6 year period, while 2002–2004 and 2005–2007 are 3 year periods.

[b]Monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate.

projects is a lower priority for county or township WRBs or IDs, whose main duties are regional-level irrigation affairs. As a result, the smaller budget created by the tax-for-fee reform had a large and significant effect on the investment of upper level government into village-level projects, although this reform does not seem to affect the investment of village collectives. The estimated coefficient on the 2005–2007 period dummy is not statistically different from zero (columns I and III), indicating the investment of upper level government bounced back to a level that is not statistically different from the level in the pretax-for-fee period. This is confirmed by the result of a *t* test that the estimated coefficients on the 2005–2007 and the 2002–2004 period dummies are statistically different. This suggests that upper level agencies are responding to the call for a larger irrigation budget from the central government.

Results in Table 7 show that fiscal policy shifts had the least impact on farmers' investment (columns I and III). The estimated coefficients on the 2002–2004 and the 2005–2007 period dummies are not statistically significant. The *t* test also indicates the two coefficients are not statistically different. These results show that the levels of investment by farmers did not change much over time. Although the fiscal reforms have alleviated farmers' financial burdens to a large extent, farmers did not change their investment behavior. These results may indicate that in rural China higher income levels do not necessarily increase private contributions to the provision of public goods. The lack of impact may also be driven by the cap national policies impose on the cash contribution from farmers.

Table 6. Factors That Influence Upper Level Government Irrigation Investment (USD/Hectare/Period, County Fixed Effects)[a]

	I	II	III
Policy Shifts			
Dummy = 1 if 2002–2004 period	−45.36**		−50.22***
	(15.69)		(15.07)
Dummy = 1 if 2005–2007 period	−6.523		−13.45
	(21.12)		(23.31)
Fiscal Autonomy			
Share of irrigation fees retained by village (MRR, lagged)	112.1*	118.3*	
	(56.28)	(57.63)	
Decision-making authority index, lagged	10.61	10.40	
	(14.41)	(14.49)	
Irrigation Conditions			
Log of total canal length in meters, lagged	23.27***	23.51***	20.34**
	(6.989)	(6.340)	(6.792)
% of lined canal in length (meters), lagged	51.24*	49.92*	37.06*
	(23.49)	(25.42)	(19.77)
Ratio of irrigated to maximum irrigable area	−24.51	−12.80	−9.075
	(17.65)	(23.14)	(18.07)
Socio-Economic Conditions of Users and Villagers			
Dummy = 1 if village relies exclusively on surface water for irrigation, lagged	−27.69	−25.96	−25.13
	(31.78)	(31.41)	(26.10)
Annual income per capita in USD 1000[b]	−0.065	−0.051	−0.050
	(0.046)	(0.039)	(0.035)
Share of villagers working outside village	−18.03	−35.85**	−2.038
	(12.54)	(15.95)	(19.12)
Share of villagers graduated from middle school	0.434	0.498	0.496
	(0.449)	(0.493)	(0.451)
Years of water management experience of Party Secretary	2.633*	3.141*	2.165*
	(1.414)	(1.415)	(1.173)
Annual revenue from village enterprise in USD 1000[b]	−1.835	−1.321	0.601
	(1.407)	(1.424)	(0.824)
Governance System			
Noncollective irrigation management (WUA or contract)	−33.35	−45.20	−19.82
	(26.78)	(26.44)	(21.73)
Constant	−134.2**	−163.8***	−109.0**
	(45.65)	(49.20)	(41.23)
Observations	138	138	138
R^2	0.17	0.13	0.12

[a]Note: robust standard errors reported in parentheses; levels of significance reported as *, **, and *** significant at 10%, 5%, and 1%, respectively. To allow for cross-period comparison, the investment amount for the 1996–2001 time period is divided by 2 because it is a 6 year period, while 2002–2004 and 2005–2007 are 3 year periods.

[b]Monetary values are first inflation adjusted using the rural consumer price index to 2000 CNY and then converted to USD using the respective year's exchange rate.

Estimation results also reveal that fiscal autonomy factors affect investment decisions, although the effects differ across sources of investment. One surprising result is that neither MRR nor decision-making authority seems to influence investment by village collectives (Table 5, columns I and II). One possible explanation is that a high MRR does not necessarily mean there are more fiscal resources for village collectives to make irrigation investments. Similar to the general under-pricing of irrigation water, irrigation fees are generally set at a low level. Even if a village could retain a large share of irrigation fees (a high MRR), there may not be much left for investment after operation and maintenance expenses are taken out. The limited fiscal resources generated from irrigation fees combined with the shrinking general budget caused by the fiscal policy shifts may also explain why decision-making authority does not affect the investment decisions of village collectives. Higher fiscal autonomy provides incentives but does not provide means (fiscal resources) for village collectives to make irrigation investments.

Fiscal autonomy at the village level, however, seems to influence upper level government's investment decision. The estimated coefficient on MRR is positive and statistically significant (Table 6, columns I and II). This indicates that when upper level government makes investment decisions, the amount of fiscal resource villages have (as indicated by MRR) matters. This may be because upper level government likes to invest in villages where their investment may be matched by village-level funds.

Table 7. Factors That Influence Farmer Irrigation Investment (USD/Hectare/Period, County Fixed Effects)[a]

	I	II	III
Policy Shifts			
Dummy = 1 if 2002–2004 period	−3.977		−4.196
	(3.716)		(3.546)
Dummy = 1 if 2005–2007 period	8.500		6.553
	(10.85)		(10.76)
Fiscal Autonomy			
Share of irrigation fees retained by village (MRR, lagged)	−15.92	−15.21	
	(9.498)	(9.172)	
Decision-making authority index, lagged	5.184*	4.656*	
	(2.330)	(2.532)	
Irrigation Conditions			
Log of total canal length in meters, lagged	−5.051	−4.040	−4.878
	(5.462)	(4.903)	(5.118)
% of lined canal in length (meters), lagged	−1.439	−1.998	−0.978
	(16.28)	(16.05)	(15.37)
Ratio of irrigated to maximum irrigable area	37.75**	37.23**	38.04**
	(15.37)	(15.53)	(14.95)
Socio-Economic Conditions of Users and Villagers			
Dummy = 1 if village relies exclusively on surface water for irrigation, lagged	9.177**	10.32***	10.82***
	(3.335)	(2.257)	(2.827)
Annual income per capita in USD 1000[b]	0.026	0.039	0.029
	(0.024)	(0.025)	(0.021)
Share of villagers working outside village	−12.41	−14.30*	−12.00
	(8.161)	(7.679)	(9.904)
Share of villagers graduated from middle school	−0.245	−0.221	−0.245
	(0.181)	(0.178)	(0.175)
Years of water management experience of Party Secretary	−0.602	−0.509	−0.512
	(0.452)	(0.488)	(0.469)
Annual revenue from village enterprise in USD 1000[b]	0.371	0.666	0.332
	(0.687)	(0.670)	(0.766)
Governance System			
Noncollective irrigation management (WUA or contract)	6.431	6.908	7.374
	(5.273)	(5.748)	(4.562)
Constant	24.96	11.82	18.30
	(52.86)	(49.03)	(49.85)
Observations	138	138	138
R^2	0.21	0.19	0.18

[a]Note: robust standard errors reported in parentheses; levels of significance reported as *, **, and *** significant at 10%, 5%, and 1%, respectively. Corvée labor contribution is not included. To allow for cross-period comparison, the investment amount for the 1996–2001 time period is divided by 2 because it is a 6 year period, while 2002–2004 and 2005–2007 are 3 year periods.

[b]Monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate.

However, the estimated coefficient on village-level decision-making authority is not statistically significant (columns I and II). So having less control over village decisions is not an important factor in upper level government's selection of villages for investment. This may be because irrigation funds from upper level government are often designated for specific projects (e.g., canal lining). Other management decisions such as who will carry out the project and where to purchase construction materials are not important to upper level government because its performance will not be evaluated (by higher-level government) based on those aspects.

One important finding is that the decision-making authority of villages is positively associated with the levels of investment made by farmers. The estimated coefficient on the lagged decision-making authority index is positive and statistically significant (Table 7, columns I and II). With greater autonomy in the village to make decisions regarding irrigation matters, farmers have more control of how their own investments will be used, which probably improves their expected rate of return because they are more confident that they will be able to capture the benefits of their investments. This in turn increases the likelihood that farmers will invest their private money to improve irrigation infrastructure. MRR, by contrast, does not affect farmers' investment decisions (columns I and II). This may also be because farmers recognize that irrigation fees at most provide meager fiscal resources for investment.

Table 8. Factors That Influence the Share of Irrigation Investment by Source (Seemingly Unrelated Regression With County Fixed Effects)[a]

	Share of Investment by Village Collective			Share of Investment by Upper Level Government			Share of Investment by Farmers		
Dependent Variables	I	II	III	IV	V	VI	VII	VIII	IX
Policy Shifts									
Dummy = 1 if 2002–2004 period	0.106*	0.102*		−0.235***	−0.227***		0.129**	0.125**	
	(0.056)	(0.056)		(0.064)	(0.062)		(0.063)	(0.062)	
Dummy = 1 if 2005–2007 period	0.017	0.011		−0.239***	−0.240***		0.222***	0.229***	
	(0.066)	(0.066)		(0.074)	(0.073)		(0.074)	(0.073)	
Fiscal Autonomy									
Share of irrigation fees retained by village (MRR, lagged)		−0.104	−0.119		0.368***	0.396***		−0.264**	−0.277**
		(0.121)	(0.123)		(0.134)	(0.141)		(0.134)	(0.139)
Decision-making authority index, lagged		−0.009	−0.008		−0.020	−0.009		0.029	0.017
		(0.023)	(0.023)		(0.025)	(0.026)		(0.025)	(0.026)
Irrigation Conditions									
Log of total canal length in meters, lagged	−0.022	−0.025	−0.026	0.074**	0.081***	0.060*	−0.052*	−0.057*	−0.035
	(0.028)	(0.028)	(0.027)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
% of lined canal in length, lagged	0.086	0.073	0.075	−0.035	−0.001	0.004	−0.051	−0.072	−0.080
	(0.080)	(0.081)	(0.082)	(0.091)	(0.089)	(0.094)	(0.090)	(0.089)	(0.093)
Ratio of irrigated to maximum irrigable area	0.078	0.092	0.068	−0.191	−0.222	−0.131	0.113	0.130	0.063
	(0.135)	(0.135)	(0.135)	(0.153)	(0.149)	(0.156)	(0.151)	(0.149)	(0.153)
Socio-Economic Conditions of Users and Villagers									
Dummy = 1 if village relies exclusively on surface water for irrigation, lagged	−0.034	−0.031	−0.035	−0.145*	−0.138*	−0.153*	0.179**	0.169**	0.188**
	(0.067)	(0.067)	(0.068)	(0.076)	(0.074)	(0.078)	(0.071)	(0.074)	(0.077)
Annual income per capita in USD 1000[b]	0.000	0.000	0.000	−0.000	−0.000	−0.000***	0.0005	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Share of villagers working outside village	0.143*	0.158**	0.197***	0.072	0.0417	−0.0379	−0.215***	−0.199**	−0.159*
	(0.074)	(0.076)	(0.074)	(0.084)	(0.084)	(0.0847)	(0.083)	(0.084)	(0.083)
Share of villagers graduated from middle school	0.001	0.001	0.001	0.002*	0.002	0.002	−0.003***	−0.003***	−0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Years of water management experience of Party Secretary	−0.003	−0.004	−0.005	0.011***	0.013***	0.014***	−0.008*	−0.009**	−0.009**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Annual revenue from village enterprise in USD 1000[b]	0.006	0.008	0.007	−0.000	−0.006	−0.009	−0.006	−0.002	0.002
	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.0103)
Governance System									
Noncollective irrigation management (WUA or contract)	−0.059	−0.047	−0.020	−0.012	−0.03	−0.127**	0.071	0.080	0.148**
	(0.056)	(0.058)	(0.054)	(0.064)	(0.064)	(0.062)	(0.063)	(0.064)	(0.061)
Constant	−0.298	−0.242	−0.143	0.0262	−0.205	−0.200	0.272	0.447	0.343
	(0.307)	(0.315)	(0.313)	(0.348)	(0.348)	(0.360)	(0.344)	(0.348)	(0.353)
Observations	133	133	133	133	133	133	133	133	133
Chi^2	62.37***	68.08***	66.68***	73.32***	98.35***	85.72***	69.32***	84.59***	77.2***

[a]Note: robust standard errors reported in parentheses; levels of significance reported as *, **, and *** significant at 10%, 5%, and 1%, respectively.
[b]Monetary values are first inflation adjusted to 2000 CNY using the rural consumer price index and then converted to USD using the respective year's exchange rate.

Results on other explanatory variables show that different factors are considered when different agents make their investment decisions. Village collectives' investment levels are not responsive to the irrigation conditions or the social-economic conditions of the village. None of the estimated coefficients are statistically significant (Table 5). Although this is a surprising and worrisome finding, it is consistent with the observations that the fiscal policy shifts have significantly shrunk the budget of village collectives and removed some of the incentives for irrigation investment. Irrigation fees are not likely to be sufficient for irrigation projects either. With limited fiscal resources to mobilize, there is not much village collectives can do. Upper level government and farmers do seem to respond to local conditions, but they seem to consider different factors. Investments of upper level government are responsive to the status of irrigation infrastructure. The estimated coefficients on canal length are positive and statistically significant (Table 6), indicating that villages with longer canals are likely to see higher levels of upper level government investment. Since upper level government prefers projects such as lining canals, the positive coefficient may reflect the higher cost of lining longer canals. The estimated coefficient on the percent of lined canal variable is also positive and statistically significant (Table 6). This indicates upper level government may have a preference for villages with more lined canals for its investment. In such villages, it costs less to get the canal network to be completely lined and thus achieve minimum conveyance loss, which is cost-effective for the upper level government. Another possible explanation is that it costs more to renovate deteriorated canals in villages with

more lined canals. Investments of farmers are responsive to factors that reflect the importance of irrigation. Farmers invest more if a greater portion of their land is irrigated (Table 7). Farmers in villages that rely exclusively on surface water for irrigation also invest more (Table 7). Results on several other explanatory variables are also consistent with expectations. More years of water management experience by the party sectary in the village translate into increased investment by upper level government (Table 6). This indicates that relationships remain important. The long-standing relationships more experienced managers often enjoy can be leveraged to bring in upper level government investment. The opportunity of working off-farm reduces private contributions to irrigation projects as a typical type of public good [*Meinzen-Dick et al.*, 2002]. The estimated coefficient on the share of villagers working outside village variable is negative and statistically significant (Table 7).

Results on the shares of investment by the three sources indicate that the investment portions have changed significantly over time. The estimated coefficients and *t* tests for the difference between coefficients on the two period dummies show that shares of investment contributed by village collectives increased about 10 percentage points from the period 1996–2001 to the 2002–2004 period but dropped by 10 points after 2004 (Table 8, columns I and II). Shares contributed by upper level government dropped by about 23 percentage points from the period 1996–2001 to 2002–2004 and stayed about the same after 2004 (columns IV and V). By contrast, shares contributed by farmers increased by about 13 points from the period 1996–2001 to 2002–2004 and continued to increase by another 9 percentage points after 2004 (columns VII and VIII). The results are largely consistent with the results on investment levels reported in Tables (5–7). Both sets of results show that village collectives are playing a smaller role in irrigation investment. Upper level government is starting to fill in the void in irrigation investment caused by the national fiscal policy changes. Farmers, although contributing a minority share to irrigation investment, have been a stable source of irrigation funding.

7. Conclusions

This paper investigates investment trends into irrigation infrastructure between 1996 and 2007 and assesses the impacts of macro-fiscal policies on the sources and levels of investment in rural villages in northern China. Village leaders, water user associations, farmers, and upper level government have all invested in village-level irrigation projects. Both descriptive and multivariate analyses suggest that fiscal reforms have significantly reduced village collectives' capacity to fund irrigation infrastructure in the village by taking away the fiscal resources as well as weakening the incentive for irrigation investment. There was a significant drop in upper level government investment during the posttax-for-fee period (2002–2004 in the sample areas). Since 2005, upper level government has increased its investment to prereform levels and partly filled the public investment void in irrigation infrastructure. Fiscal reforms had the least impact on farmers' investment, which has been the most stable source of funding for village-level irrigation projects.

The trends identified in this paper suggest that farmers and upper level government agencies are emerging as the main investors of villages' irrigation infrastructure. The question remains as to whether they can form a partnership to invest in irrigation infrastructure. Whether public-private partnership improves the provision of public goods and how it is practiced have been well studied in the literature [e.g., *de Bettignies and Ross*, 2004]. It may present a viable model for China, as envisioned in the mechanism of "run by local people with assistance from the state" promoted by China's central government. Our data do not provide sufficient details to evaluate whether such a partnership has developed in rural China and whether it works. This is an important topic for future research.

Another important policy question is how to increase farmers' role in irrigation investment. Although farmers are a more stable source of investment than upper level government and village collectives, their investment levels did not increase over time. The small-plot nature of China's farms (most farms are smaller than 1 acre) and changes in the rural landscape (e.g., the declining importance of agricultural income to rural households and the loss of on-farm labor to off-farm employment) are not conducive to farmers investing in their local irrigation systems either. We do see that higher village-level autonomy over fiscal decision-making creates a hospitable environment for farmers to invest. Greater control over grassroots irrigation-related matters may provide farmers with more confidence in securing returns to their investments and therefore increase their willingness to put their money on the table for irrigation-related works. Identifying such factors and designing corresponding policies are important tasks for researchers and policy makers.

Although the overall trend is one of increased attention and investment by upper level government into irrigation, on-the-ground facts reveal a starkly poor irrigation landscape. Levels of investment in irrigation infrastructure remain small. Even in the most recent study period (2005–2007), the average total investment was only about US$78/ha over a 3 year period. This may explain why irrigation efficiency in China remains very low and points to room for potential efficiency increases through greater investment in water-saving technologies and other irrigation modernization. Other reforms such as reforming the property rights of village irrigation infrastructure and reforming water pricing need to be implemented to stimulate irrigation investments.

Acknowledgments
The authors acknowledge the financial support of Ministry of Science and Technology (2012CB955700 and 2010CB428406), National Natural Sciences Foundation of China (70925001 and 71161140351), International Development Research Center (107093-001), Australian Center for International Agriculture (ADP/2010/070), the Fulbright Commission, World Bank, and the CAS Strategic Priority Research Program (XDA01020304). Contact the authors to learn about access to the data.

References

Bergstrom, T. C., L. E. Blume, and H. R. Varian (1986), On the private provision of public goods, *J. Public Econ.*, *29*, 25–49.
Cai, X. M. (2008), Water stress, water transfer and social equity in Northern China—Implications for policy reforms, *J. Environ. Manage.*, *87*, 14–25.
Central Committee of the Communist Party of China (CCCPC) and General Office of the State Council of China (2005), 2005 No. 1 Policy Document, Beijing.
Central Committee of the Communist Party of China (CCCPC) and General Office of the State Council of China (2012), 2012 No. 1 Policy Document, Beijing.
Chan, K. S., S. Mestelman, R. Moir, and R. A. Muller (1996), The voluntary provision of public goods under varying income distributions, *Can. J. Econ.*, *29*(1), 54–69.
Chang, X. (2003), Report on "Tax-for-fee" reform in rural areas [In Chinese], *Newsl. Work Rural Areas*, *0032*(7), 5–7.
de Bettignies, J. E., and T. W. Ross (2004), The economics of public-private partnerships, *Can. Public Policy Anal. Polit.*, *30*(2), 135–154.
ESCAP (2010), *Statistical Yearbook for Asia and the Pacific 2009*, U. N. Publ., Bangkok.
Faguet, J. P. (2004), Does decentralization increase responsiveness to local needs? Evidence from Bolivia, *J. Public Econ.*, *88*(4), 867–894.
Fan, S., L. Zhang, and X. Zhang (2002), *Growth, Inequality, and Poverty in Rural China: The Role of Public Investments*, Int. Food Policy Res. Inst., Washington, D. C.
Fan, S., L. Zhang, and X. Zhang (2004), Reforms, investment, and poverty in rural China, *Econ. Dev. Cult. Change*, *52*, 395–421.
Food and Agriculture Organization of the United Nations (FAO) (2013), AQUASTAT data, Food and Agric. Organ., Rome, Italy.
Fujiie, M., Y. Hayami, and M. Kikuchi (2005), The conditions of collective action for local commons management: The case of irrigation in the Philippines, *Agric. Econ.*, *33*(2), 179–189.
General Office of the State Council of China (2004), No. 36: Notice on pushing forward the reform of water prices to promote water conservation to conserve water resources, Beijing.
Henan Bureau of Hydrology and Water Resources (2007), *Henan Province 2007 Water Resources Bulletin*, Zhengzhou, China.
Hiroshi, S. (2008), Public goods provision and rural governance in China, *China Int. J.*, *6*, 281–298.
Huang, Q. (2014), Impact evaluation of the irrigation management reform in northern China, *Water Resour. Res.*, *50*, 4323–4340, doi: 10.1002/2013WR015192.
Huang, Q., S. Rozelle, B. Lohmar, J. Huang, and J. Wang (2006), Irrigation, agricultural performance and poverty reduction in China, *Food Policy*, *31*(1), 30–52.
Huang, Q., S. Rozelle, J. Wang, and J. Huang (2009), Water management institutional reform: A representative look at northern China, *Agric. Water Manage.*, *96*, 215–225.
Huang, Q., J. Wang, K. W. Easter, and S. Rozelle (2010), Empirical assessment of water management institutions in northern China, *Agric. Water Manage.*, *98*(2), 361–369.
Jin, H., Y. Qian, and B. Weingast (2005), Regional decentralization and fiscal incentives: Federalism, Chinese style, *J. Public Econ.*, *89*, 1719–1742.
Lam, W.-F. (1998), *Governing Irrigation Systems in Nepal: Institutions, Infrastructure, and Collective Action*. Inst. for Contemporary Stud., San Francisco, Calif.
Lei, X. (2005), Agricultural tax becomes history in Henan Province [in Chinese], *Farmers Ref.*, 2005(2), 5.
Li, Y. (2009), The status and direction of the development of water user associations in China [in Chinese], *China Water*, *21*, 15–16.
Lin, J. Y. (1992), Rural reforms and agricultural growth in China, *Am. Econ. Rev.*, *82*, 34–51.
Lin, J. Y., and Z. Liu (2000), Fiscal decentralization and economic growth in China, *Econ. Dev. Cult. Change*, *0002*, 1–21.
Lin, W.-L., and T. P. Chan (2004), China's widening economic disparities and its "Go West Program," *J. Contemporary China*, *13*, 663–686.
Liu, Q. (2004), Building irrigation infrastructure after tax-for-fee reform [in Chinese], *Agric. Technol.*, *24*, 17–22.
Lohmar, B., J. Wang, S. Rozelle, J. Huang, and D. Dawe (2003), *China's Agricultural Water Policy Reforms: Increasing Investment, Resolving Conflicts, and Revising Incentives, Agric. Inf. Bull., 782*, Market and Trade Econ. Div., Econ. Res. Serv., U.S. Dep. of Agric., Washington, D. C.
Meinzen-Dick, R. (2007), Beyond panaceas in water institutions, *Proc. Natl. Acad. Sci. U. S. A.*, *104*(39), 15,200–15,205.
Meinzen-Dick, R., K. V. Raju, and A. Gulati (2002), What affects organization and collective action for managing resources? Evidence from canal irrigation systems in India, *World Dev.*, *30*, 649–666.
Ministry of Finance of China (MFC) and Ministry of Water Resources of China (MWR) (2005), Notice on the methods of implementing special funds for small-scale irrigation infrastructure construction grants, Beijing.
Ministry of Water Resources of China (MWR) (2006), *Water Resources Development Statistics Bulletin 2006*, Beijing.
Ministry of Water Resources of China (MWR) (2011), *Water Resources Bulletin 2011*, Beijing.
Ministry of Water Resources of China (MWR), National Development and Reform Commission (NDRC), and Ministry of Civil Affairs of China (MCAC) (2005), Opinions on strengthening the development of Water User Association, Document 502, Beijing.
Mushtaq, S., S. Khan, D. Dawe, M. A. Hanjra, M. Hafeez, and M. N. Asghar (2008), Evaluating the impact of tax-for-fee reform (Fei Gai Shui) on water resources and agriculture production in the Zhanghe Irrigation System, China, *Food Policy*, *33*, 576–586.
Ningxia Daily News (NDN) (2005), Agricultural tax is eliminated province wide starting 2005, January 12, 2005. [Available at http://szb.nxnet.cn/index1.aspx, last accessed 25 May. 2014.]
Ningxia Water Resources Bureau (2002), *Ningxia 2002 Water Resources Bulletin*, Yinchuan, China.
Ningxia Water Resources Bureau (2007), *Ningxia 2007 Water Resources Bulletin*, Yinchuan, China.
Oi, J. C. (1992), Fiscal reform and the economic foundations of local state corporatism in China, *World Polit.*, *45*, 99–126.

Oi, J. C., K. S. Babiarz, L. Zhang, R. Luo, and S. Rozelle (2012), Shifting fiscal control to limit cadre power in China's townships and villages, *China Q.*, *211*, 649–675.
Oksenberg, M., and J. Tong (1991), The evolution of central-provincial relations in China, 1971–1984 the formal system, *China Q.*, *125*, 1–32.
Ostrom, E. (2007), A diagnostic approach for going beyond panaceas, *Proc. Natl. Acad. Sci. U. S. A.*, *104*(39), 15181–15187.
Shalizi, Z. (2006), Addressing China's growing water shortages and associated social and environmental consequences, *Policy Res. Working Pap. WPS3895*, World Bank, Washington, D. C.
Wang, S. (1997), China's 1994 fiscal reform: An initial assessment, *Asian Surv.*, *37*, 801–817.
West, L. A. (1997), Provision of public services in Rural PRC, in *Financing Local Government in the People's Republic of China*, edited by C. Wong, pp. 214–280, Oxford Univ. Press, Hong Kong, China.
Wong, C. P. W. (1997), Rural public finance, in *Financing Local Government in the People's Republic of China*, edited by C. P. W. Wong, pp. 167–209, Oxford Univ. Press, Hong Kong, China.
World Bank (2001), China: Overcoming rural poverty, in *World Bank Country Study*, pp. 1–14, World Bank, Washington, D. C.
Zhang, L. X., R. F. Luo, C. F. Liu, and S. Rozelle (2006), Investing in rural China: Tracking China's commitment to modernization, *Chin. Econ.*, *39*(4), 57–84.