

The Effects of Road Infrastructure on Poverty Reduction in Rural China

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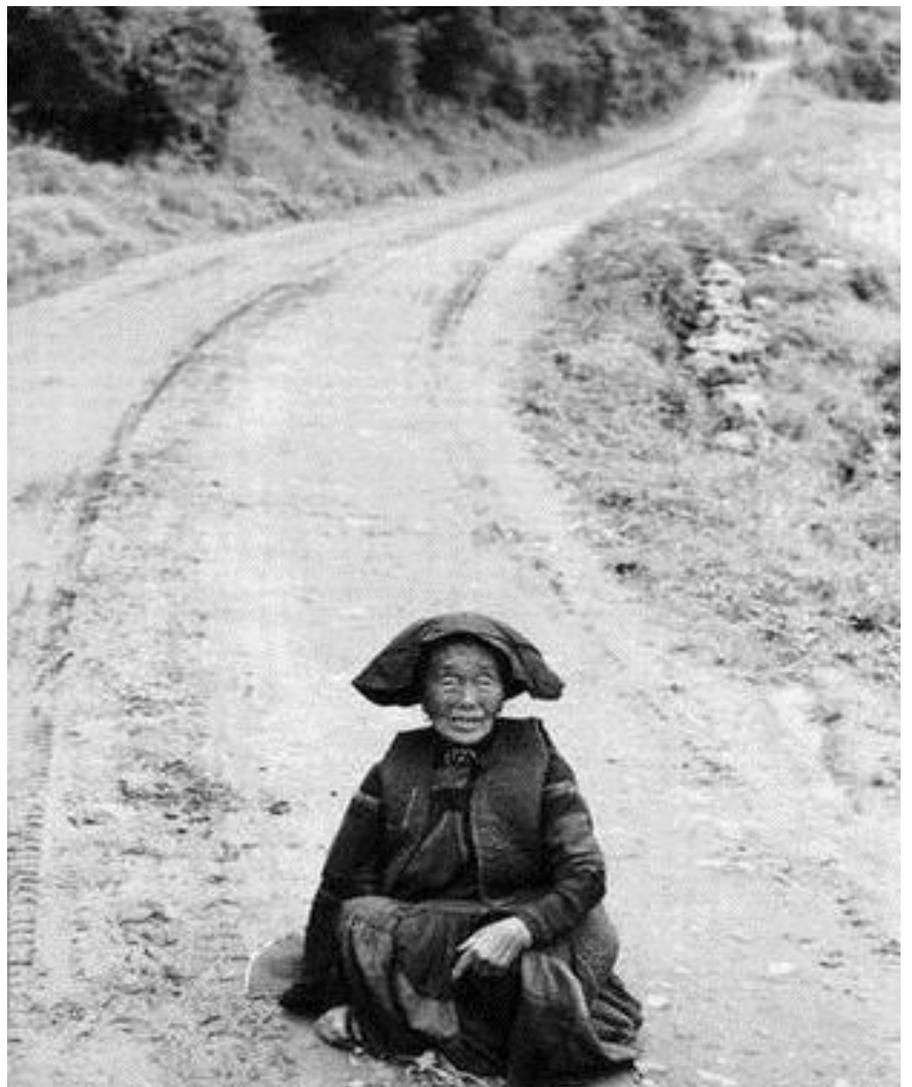


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Introduction

The World Bank (WB) reported in its September 2012 report that there are about 1.29 billion poor people who live below US\$1.25 dollars a day. Two-thirds of the total (855 million) lives in South and East Asia. In China alone, in the year of 2009, people living below the line accounted for 153 million, 11.8% of its whole population. This figure has been reduced due to the Chinese governments' long lasting poverty alleviation efforts during the past five years, but still hovered around 10% for now (Merrell and Viveros 2013).

Despite being the second-largest economy in the world, the country's per capita income is still par with countries like Angola, Jamaica and Tunisia.¹ As evidenced by the WB survey in 2012, China consist almost half of the total poor in the whole world. China's Government is presently taking strong measures to cascade growth and development in the poor peripheral areas through investment on infrastructure, education, health care and development programs.²

This research paper studies the effect of road infrastructure in reducing poverty in rural China. The study aims to provide further empirical evidence on the importance of building roads in poverty alleviation in China, in particular, Net per Capita Annual Income of poor villages in rural China being the dependent variable and road infrastructure as the key independent variable.

The research uses the 2002 World Bank data that conducted surveys in six provinces around China. Research findings conclude that transportation infrastructure has a positive impact on income of poor villages and serves as an important tool in poverty alleviation in rural China. Research suggests that road infrastructure projects merit higher priority complemented by other poverty alleviation reforms and

¹ The Worldbank. <http://data.worldbank.org/indicator/NY.GNP.PCAP.CD>

² International Fund for Agricultural Development. Rural Poverty in China. <http://www.ruralpovertyportal.org/country/home/tags/china>

mechanisms that provide basic public services to poor villages.

Research Question

Does road infrastructure development have significant influence on poverty reduction in rural China?

1 Literature Review and Research Objectives

The motivation of this study lies on two parts: finding a solution to the ongoing dispute over China's rural infrastructure projects and testing the real effect of road construction to poverty alleviation based on controversial academic findings.

Disputes over China's "Linking All Villages" Projects

Since the beginning of 2000s, Chinese government has significantly increased the budget for poverty reduction. Most of the poverty reducing investment was spent on transport infrastructure as part of the "Linking All Villages" projects. During the period of 11th Five-Year-Plan (2006-2010), China invested approximately 954 billion yuan (US\$157 billion) in construction and improvement of about 1.87 million km rural roads. Almost all the townships in China have accessible roads, about 97 percent of which are paved by asphalt or cement concrete; and 99.4 percent of the administrative villages have accessible roads, about 84% of which are paved.

However, some public intellectuals doubt the investment on road construction due to the lack of empirical evidence. They argue that many road projects were built just for the sake of political achievements, because among a big number of infrastructure projects such as electricity, telecommunication, water system, school and clinics, road construction requires the least time and most obvious outcome. This study aims to provide empirical results about the effect of transportation infrastructure to the annual net per capita income of villages in rural China.

Controversies in academic field

In the academe, continuous controversy ensues over the effect of enhancing transport infrastructure to alleviate poverty in rural China. Wang (2010) believes that investing on infrastructure will alleviate poverty and enhance economic growth (Wang 2010). Kanbura and Rauniyar (2010) conducted a more in-depth analysis on transport infrastructure development and suggest that policy should focus on (1) improving road connections within rural areas and (2) improving road connections between rural and urban areas (Ravi and Ganesh 2010).

However, many scholars argue that the relationship between infrastructure and economic growth is nuanced. The Department for International Development (DFID) in UK (2002) suspects the effectiveness of infrastructural assistance for two reasons. First, though important for economic growth, infrastructure investment had little relevance to poverty reduction. Second, actual benefits from infrastructure were significantly less than anticipated (DFID 2002). This research aims to test whether transportation infrastructure development has significant effects in rural China.

Other poverty reduction theories

According to a study of the World Bank, poverty in China is concentrated in the Western provinces of the country, of which townships are mostly remote and mountainous. Causes of poverty in rural China involve lack of access to natural resources, health care, infrastructure, credit and labor. The study then concludes that China's Government is urged to focus policy in providing improved access to basic education, health, credit, water, supply, **roads**, and other basic infrastructure (World Bank, 2000).

In another study, the Asian Development Bank (ADB) concluded the same that poor need greater access to education, health services, water, sanitation, employment, credit, and markets (ADB 1999; Ali and Pernia 2003), while McKague and Oliver

(2012) added that supplementary access in market practices are also key to engage a range of market-oriented organizations to improve the prosperity of the poor (McKague and Oliver 2012) .

Based on these researches, the study contributes to the literature by coming up with empirical results of whether transport infrastructure development has significant effect on increasing income of villages in rural China. In addition, the research tries to capture the pure effect of transport infrastructure development to alleviating poverty by including control variables like accessibility of villagers to education, health care, convenience in the collection of water, contribution of non-farm income and job opportunities in non-farm sectors.

2 Data and variables

Dataset

The data in the research was collected from the Poverty and Development: CCAP Village Survey in 2003, which was published in the China Survey Data Network.³ The survey was conducted by a team lead by Professor Linxiu Zhang of the Center for Chinese Agriculture Policy, Chinese Academy of Sciences, Professor Scott Rozelle of the University of California at Davis, and Professor Loren Brandt of the University of Toronto. They made a multi-stage stratified sampling, choosing 2459 villages in six provinces, namely, Jiangsu, Sichuan, Shaanxi, Gansu, Hebei and Jilin. The provinces and villages are typical in China in terms of geographical distribution and economic development. With self-enumerated questionnaires, the survey collected a great deal of information about basic characteristics of villages, public project investment and governance system. From the original dataset, we extracted the sub-dataset of basic village information to test the influence of road

³ China Survey Data Network. "Poverty and Development: CCAP Village Survey (2003)," accessed Nov 3, 2012, http://www.chinasurveycenter.org/CSDN_EN/DownloadChannel_new/detail.aspx?ClassID=4&DataID=19#.

infrastructure on the economic development of linked villages (See appendix I table 1). The observation unit in the research involves the villages, at which all data are collected at the village level.

With regard to the research objective, original data is further processed and converted for the analysis with Stata statistical software. In order to examine the effects of road infrastructure on poverty alleviation, the research only includes low-income villages with annual per capita income less than 2000 Chinese yuan (US\$320), which is roughly the median of annual per capita income of rural households in 2002.⁴ After excluding the missing data, the data included a total of 1450 villages of observation in the research. At the same time, the researchers opted to make some adjustments from the original data, such as rescaling some variables to make the data more comprehensible. In total, seven variables are generated and are included in the following analysis. The definition and summary of variables can be seen in Table 1.

Dependent variable

In the research, we access the poverty situation of poor villages in rural China by looking into the per capita net income of surveyed villages (*netinc*) in 2002. Although poverty is defined by scholars from different perspectives, income poverty measurement has been widely accepted and used in research and real work (Mowafi 2012). In low-income households, basic consumption such as foods and clothes account for a large percentage of total expenditure. Accordingly, per capita income is a better measurement of poverty severity than per household income. Furthermore, the dependent variable *netinc* is further converted into its logarithm form, which gives more direct information about income changes and income gaps. The range of *netinc*

⁴ National Bureau of Statistics of China, China statistical yearbook 2003 (Beijing: China Statistics Press, 2003), 367.

for the surveyed villages is from 100 yuan to 2000 yuan with a mean of 100.42 yuan.

Independent variables

The key interest variable labelled as *roadpass* is considered by the researchers which measures whether there is at least a paved road connected to the village. When the villages are connected to the road network, it is given by *roadpass* equal to 1; otherwise it is equal to 0. In the study, 37 percent of the surveyed villages are connected by at least a paved road.

Poverty is a complicated socio-economic problem with diverse causes. To examine the pure effect of road infrastructure, other control variables are included in the regression model (Table 3). According to the ADB study conducted in 2003, education, health care and water source are important factors affecting poverty reduction. To control the omitted variable bias, variables of *propilliter* (percentage of illiteracy), *ownclinic* (clinics locate in the village) and *distwat* (distance to the water source) are included in the regression model. To test whether the effects of *roadpass* differ according to different levels of marketization, *nonfarminc* (percentage of non-farm income) and *ownentpriz* (enterprises located in the village) are also included as control variables.

Collected by self-enumerated questionnaires, the data encountered missing values and limited quality. Fortunately, missing data only happened to few villages and it does not have significant influence on the analysis and interpretation of results after dropping the observations with missing data. With regard to data quality, we have conducted prudent examination to predict the data's potential influence on the research and kept this in mind while interpreting the regression models. The descriptive statistics of the variables are illustrated in Table 1.

Table 1: Definition and Summary of variables: Poverty Causes Data

Variables	Definition	Samples size	Mean	Std. Deviation	Min. values	Max. values
netinc	Net income per capital in 2002, unit: Chinese yuan	1540	1100.42	489.51	100	2000
roadpass	=1 if there is a tarred road passing through the village, =0 otherwise	1540	0.37	-	0	1
propilliter	Percentage of illiterates among total labor	1540	11.26	16.23	0	100
ownclinic	=1 if there is at least one clinic located in the village, =0 otherwise	1540	0.82	-	0	1
distwat	The distance to the most common water-source in 100 meter	1540	3.85	9.28	0	100
nonfarminc	Percentage of non-farm income in the net income per capital (%)	1540	32.76	23.29	0	100
ownentpriz	=1 if there is at least one enterprise located in the village, =0 otherwise	1540	0.23	-	0	1

3 Results

After testing the correlation between variables in table 2, researchers tried different regression models. We compared specifications 1 and 2 in table 3, and observed that the two models have similar adjusted R^2 . We decided to consider specification 2 as our basic regression model to examine the relationship between income of villages and available road infrastructure since it is more convenient to explain income changes and gaps. Accordingly, we added sequentially two blocks of variables to the equation which represented the accessibility to basic public service and local marketization level. This ordering provided a means to observe how accessibility of other basic public service and marketization changed the coefficient of transport infrastructure. Our particular interest is to test how significant is the

influence of road infrastructure on increasing income and reducing poverty.

Table 2: Coefficient between Variables

variables	netincome	roadpass	propilliter	ownclinic	distwat	nonfarminc	ownentpriz
netincome	1.0000						
roadpass	0.1366	1.0000					
propilliter	-0.2509	-0.0731	1.0000				
ownclinic	0.0990	0.1279	-0.1678	1.0000			
distwat	-0.1603	-0.0855	0.0723	-0.0342	1.0000		
nonfarminc	0.1756	0.1369	-0.0230	0.1123	-0.0185	1.0000	
ownentpriz	0.1595	0.2492	-0.0895	0.1273	-0.0664	0.1939	1.0000

Table 3 presents four hierarchical regression equations predicting average income in villages. The first equation examines the relationship between income and road infrastructure in a linear model. The second equation reveals the relationship between percentage change of income and road infrastructure. The third equation adds basic public service variables.

We find out that the coefficient of road infrastructure decreased from 0.1474 in specification 2 to 0.1069 in specification 3. This indicates that basic public services are also important determinants of rural poverty. The fourth equation adds two more variables about marketization, which also change the coefficient of road infrastructure significantly. Based on specification 4, the influence of road infrastructure is significant at the 5% significance level, while other variables except *ownclinic* have significant influence at the 1% significance level. Here we still include *ownclinic*, which is significant at 10% significance level as a control variable in the regression model. After comparing statistics such as adjusted R^2 , we choose specification 4 as our prediction model.

Table 3: Regression model of the impact of road infrastructure

Dependent variable (Y): Per capita net income of surveyed villages in 2002.				
Regressor	Y	Ln(Y)	Ln(Y)	Ln(Y)
	(1)	(2)	(3)	(4)
Roadpass (1=road passing, 0=otherwise)	138.4018** (25.6017)	0.1474** (0.0273)	0.1069** (0.0264)	0.0686* (0.0269)
Percentage of illiterates			-0.0076** (0.0009)	-0.0075** (0.0008)
Ownclinic (1=owning clinic, 0=otherwise)			0.0990* (0.0388)	0.0705 (0.0381)
Distance to water source (in 100m)			-0.0072** (0.0015)	-0.0070** (0.0014)
Percentage of non-farm income				0.0034** (0.0006)
Owmentpriz (1=owning enterprise, 0=otherwise)				0.0899** (0.0302)
Constant	1049.189** -15.5744	6.8265** -0.0176	6.8737** -0.0398	6.7776** -0.0423
Summary Statistics				
Adjusted R ²	0.0186	0.0177	0.0982	0.1260
SER	485.09	0.5301	0.5078	0.4999
No of observations	1540	1540	1540	1540

Note: Standard errors are given in parentheses under coefficients. Individual coefficients are statistically significant at the *5% level or **1% level.

The regression function is presented below:

$$\ln(\widehat{netinc}) = 6.7776 + 0.0686roadpass - 0.0075propilliter + 0.0705ownclinic - 0.0070distwat + 0.0034nonfarminc + 0.0899owmentpriz \quad (Adjusted \quad R^2 = 0.1260, \quad SER = 0.4999)$$

The coefficient of *roadpass* is 0.0686, which indicates that those villages connected to at least a paved road are expected to have average income 6.86 percent higher than other villages. More evidences and information is needed to judge the practical importance of the influence of road infrastructure, such as the specific income distribution in impoverished rural China and the difficulty to increase farmers'

income in surveyed villages.

4 Discussion

Findings

Inferences can be made from the regression analysis cited above:

First, road infrastructure has statistically significant influence on poverty reduction in underdeveloped rural China. The research presents empirical evidence for the project of “linking all villages”, that building road infrastructure could be an effective means for the Government to promote economic development and reduce poverty in rural villages. Road infrastructures according to this research mitigate “bottlenecks” to accessing development, education, health, water, among others.

Second, accessibility to basic public services also has significant influence on increasing income. Providing public service is accepted to be alternative means of reducing poverty.

Thirdly, on the issue of Governments facing budget limits, policy makers should consider the practical importance and costs of various projects to decide policy priority. Comparing the coefficients of *roadpass* (6.86%) to that of *ownclinic* (7.05%), both projects have similar influence on poverty reduction. Nonetheless, despite *roadpass* having a slightly less impact, it is reasonable for the Government to prioritize transport infrastructure first because it is much easier to implement, more welcomed by farmers, and provides better mobilization of incoming developments in health, education and water access in the long run. In addition, implementing better road infrastructure promotes marketization which contributes to the alleviation of rural poverty based on the significant coefficients of the variables *nonfarminc* and *ownentpriz*.

Internal Validity

- Omitted variable bias

The researchers acknowledge that there are some factors that may have been omitted as control variables to explain annual per capita rural income, in particular, labor force ratio. Villages with higher labor force ratio earn higher per capita income. In another, the ADB suggested the inclusion of the availability of the village to accessible credit in the regression equation. However, these two omitted variables have not been included as questions in the original survey.

- Errors-in-variables bias

There may be some ambiguous questions resulting in inaccurate answers of respondents to the questionnaire, for instance, questions like ‘what is the proportion of non-farm income in your village?’ These surveys are roughly completed by village officials, who may be less educated and having difficulties in understanding the meaning of non-farm income. Other issues also include the respondent’s intentional misreporting with some villagers understating their income due to the anticipation that policy makers provide more fiscal support to poorer villages.

- Reverse causality

In China, the government in certain areas asks villagers to donate some money to supplement the budget for constructing roads. In this case, richer villages have the higher likelihood of building more roads, which could bring reverse causality. However, donation only accounts for a limited percentage in the total cost of building roads, thus, the research is less likely to have significant reverse causality.

External Validity

The data is collected from 6 separately located provinces from west to east and north to south of China. The number of observations in the sample has good representativeness to estimate the true population. However, since the sample size is

limited within villages with net per capita income of 2000 yuan and below, the statistical study is only applicable to poor rural areas and may not explain effects of road infrastructure development in richer urban areas. Moreover, the survey was conducted in 2003 and may no longer be applicable to the current situation. In lieu of this, the research would need to be reevaluated.

5 Case Study: rural road development in Yuechi County

This section introduces a case study on the rural road development in Yuechi County, an agricultural county in Sichuan Province in western China, and analyzes its impact on improving the living of the local villagers. By reviewing the changes taking place before and after the paved-road construction project, we can have a clear idea of the benefits that villagers receive from rural road infrastructure.

Yuechi County profile

Yuechi is a county located in the east of Sichuan Basin, covering an area of 1457 square kilometers, and holding a population of 1.14 million. There are 46 townships and one management committee under its jurisdiction, with 861 villages and 75.8 acres of arable land in total. Yuechi is a famous agricultural county in Sichuan Province.

Located in northeastern Sichuan traffic arteries, Yuechi has the regional advantages as it is close to the "Two Rivers New District". However, with the advancement of urban-rural integration, the network of rural roads became lag behind the needs of local economic development. There was an urgent need to improve the quality of the road surface and the level of accessibility in the rural areas of Yuechi County. From 2007, the county has launched a massive rural road construction and rehabilitation project. The original muddy trails have been rehabilitated to wide and motorable paved roads. As of 2013, the county has basically achieved the "linking-all-

village" construction goal. It has now set up more than 40 regular buses that directly connect the county center to each township.

Rural road construction

In recent years, Yuechi has given the priority to develop rural transportation infrastructure as a tool for local economic development. It began a large-scale road construction from 2007. Especially after 2010, it further increased the construction fund. The length of newly-built road grew up to 300 kilometers each year. At the same time, the traffic order was much improved and the operational level of rural transportation was greatly upgraded.

- The increasing investment on rural road construction

Within the county district, Yuechi invested 7.9 million yuan on the rehabilitation of one of its main stems, covering a length of 13.8 kilometer, resulting in highly-promoted traffic smoothness. It invested 15 million yuan on a new tourist road connecting the surrounding tourism resources with first level quality according to national road construction standard. Another 20 million and 66 million yuan has been invested on the renovation of obsolete roads with bad surfaces and the rehabilitation and maintenance of 240 kilometers pitch road that connects more than 40 townships, which contributed to the achievement that every township is connected to the county center by a pitch road.

With the development of rural economy and the new countryside construction, Yuechi County continued to increase the construction fund for rural road. It invested 0.13 billion yuan to build village roads of more than 1800 kilometers, and achieved the goal of "linking all village with paved road". In 2011 alone, Yuechi received a fiscal transfer payment of 0.11 billion yuan from upper government which was specially utilized for the conversion of bad quality muddy trails into paved roads in

remote villages, which greatly improved the integration of the rural network in this county. In 2012, Yuechi further increased the construction fund and newly constructed 275 kilometer cement roads in 32 townships and 48 villages. By that year, the length of motorable road in the rural area has reached 1200 kilometers.

- The growing quality of rural transport operation

Yuechi County selected a bunch of roads of good surface quality for the pilot project of rural public transport. The county government invested 270 busses for the regular transport services, benefiting more than 40 townships. Meanwhile, to strengthen the safety awareness, Yuechi promoted a series of publicity and traffic violation handling. In 2011, Yuechi invested 0.3 million on setting up traffic signal light and warning board. It distributed 100 thousand pamphlets to the general public to raise their safety awareness.

Impact observation

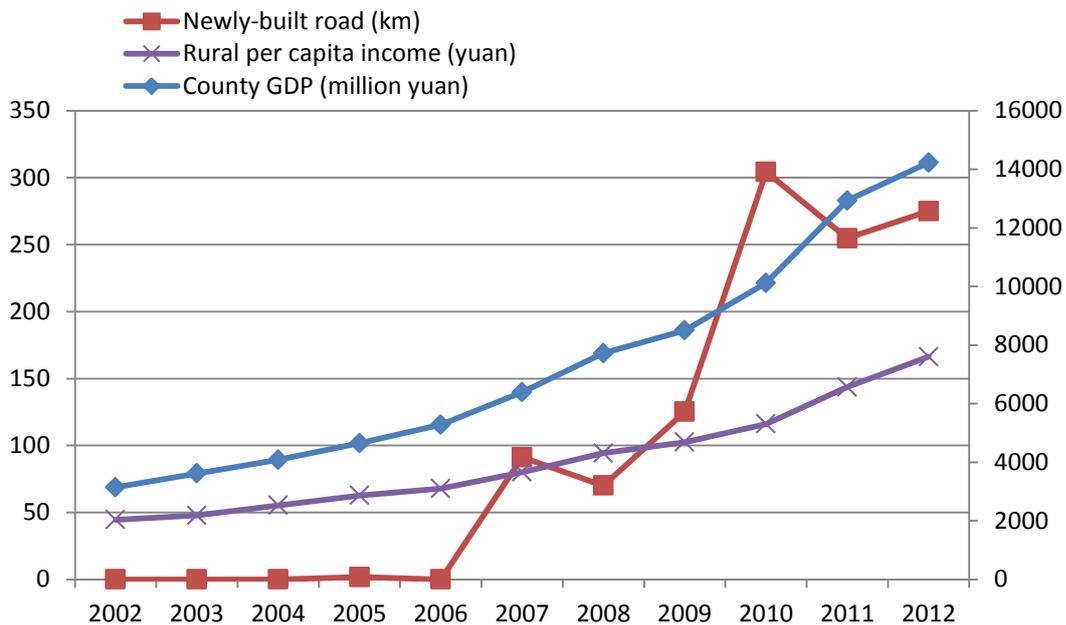
Yuechi is a typical agricultural county in the western part of China. In 2012, Yuechi's agricultural GDP (including farming, forestry, animal husbandry, side-line production and fishery) reached 5.57 billion yuan, accounting for almost 40% of regional total GDP. It was a 5.7 percent growth over last year. From 2007 onward, there have been a growing number of roads newly built each year, averaging at 186.75 kilometers per year. At the same time, the farmers' net per capita income has been increasing and more than doubled from 3611 yuan in 2007 to 7601 yuan by the end of 2012. The figures of regional GDP, the length of newly-built roads and rural per capita income in Yuechi County is as follows:

Table 4: rural road construction and economic development in Yuechi County from 2002-2012

Year	Newly-built road (km)	County GDP (million yuan)	GDP growth rate	Rural per capita income (yuan)	Amount of increase (yuan)
2002	0	3148	12.8%	2040	128
2003	0	3620	15.0%	2185	145
2004	0	4082	12.8%	2532	347
2005	1.84	4651	13.9%	2865	333
2006	0	5280	13.5%	3100	235
2007	91.2	6393	21.1%	3661	561
2008	70.1	7720	20.8%	4314	653
2009	125.2	8500	10.1%	4688	374
2010	304.3	10120	19.1%	5311	623
2011	254.7	12930	27.8%	6565	1254
2012	275	14226	10.0%	7601	1036

Source: Yuechi government website <http://www.scyc.gov.cn/>

It is clear from the table that the development of Yuechi's economy in the new century can be divided into two phases: Phase 1 is from 2002 to 2006 when there was merely no newly built road. During those years, the amount of rural income increase was less than 350 yuan, the county GDP annual growth rate was suppressed under 15 percent. Phase 2 begins with the massive rural road construction project in 2007; both the GDP growth rate and per capita income received remarkable increases. The year 2007 is a significant watershed, after the launch of the massive road construction, the GDP growth rate strikingly increased from 13.5 percent in the previous year to 21.1 percent, a nearly 8 percentage point increase, and rural per capita income for the first time climbed up to 560 yuan. The positive relationship between rural road construction, GDP growth and per capita income increase is further illustrated in graphic lines in Figure 1.

Figure 1: the trend of local economy with the development rural road network

The interviews with local residents reflect the impact of rural road construction on peoples' living. A farmer in Lizi village of Shiyazi town reported that the paved road built in 2010 has attracted many tourists from outside to a lake scenery spot near their village, which inspired his idea of doing business with these tourists by opening a grocery store and selling food and drinks to them.

Another villager described the inconvenient situation before the project. "When it rains, it is hard for me to send my children to school through the muddy way because I have to should the little one on my back with the elder one hand in hand. Though I wanted to start my own business, the marked access was very limited. Now things have changed, I have decided to plant more vegetables and develop scale breeding of pigs"⁵

Other villagers said the wide and unblocked cement road connected their small village to everywhere, thus the transport cost of their agricultural products has been

⁵ This villager was interviewed by journalist and the news is at <http://www.gazx.org/content/2014-7/9/2014791044915700.htm>

greatly reduced, which has provided them more opportunities to sell the farm products to outside markets.

At the same time, the establishment of rural public transport in Yuechi County saved the villagers' commute time to town and county centers. Villagers recalled the time when there were no busses; they had to ride motorbike on the bumpy country trails if they wanted to go to townships. Now the bus directly brings the villagers to the outside world. Every township and 44 percent of 861 villages now enjoy the transport service. The easier access to urban areas has widened the farmers' vision and instilled vigor to the remote villages, which promotes the urban-rural integration process. Today, the villages along the paved roads have experience significant change from mud-brick houses to two-storey mansions, from ox carts and vehicles drawn by man to cars and motorcycles.

Yuechi's local economy is shaped by the development of rural road. Four modern agricultural production bases with an area 10400 hectares have been set up for large scale fruit, cash crop and timber production, and the beautiful rural views have been utilized to establish new ecotourism. villagers believe that the wide roads will lead them to wealth and comfort.

Discussion

In 2012, Yuechi upgraded its agricultural industry by rebuilding several vegetable and dried fruit production bases and establishing seven modern agricultural demonstration zones, the reconstruction area reached up to 13000 hectares. With the support of the road networks, these agricultural products could be easily transported to vast market inside and outside Sichuan Province, which effectively contributed to local economy development. In 2012, Yuechi's agricultural GDP increased by 5.7 percent over last year. The villages with significant achievements in road construction

received highest growth rate.

The circulation of agricultural goods, rural human resources and lands has been escalated by the massive rural roads construction in Yuechi County. It promoted the commercialization of the elementary agricultural product and rural lands and activated rural economy. The integration of rural road network will not only specialize the production function and promote scale economy, which eventually raises the production efficiency, but also reduce the transport cost and expand the market reach, therefore increase the transaction efficiency.

The rural road construction has changed local agricultural economy from homegrown to commercialization. Now villages in Yuechi County have greater ability to attract capital, technology and human resources, which enhanced the planting and breeding industry and created new space for tourism. This remarkable change has upgraded farmers' living standard, expanded their employment chances and promoted the urbanization and marketization in the area.

6 Comparison with other poverty reduction alternatives

The case study on Yuechi County's rural road development reinforces the empirical findings in section 3 that road infrastructure has positive impact on poverty reduction and living standard improvement. However, building road is not the sole solution to poverty reduction. Other types of infrastructure projects such as irrigation, drinking water, electricity and telecommunications (especially cell phones) also have been shown to have positive effect on villages (World Bank, 1994; Songco 2002, Don, Ricardo & Moinul 2000). Besides, government services that would enhance human capital such as elementary education and basic healthcare are also proved to be effective both empirically and practically. (Lasker, Weiss & Miller, 2001; Gomes & Câmara, 2004; Hegtvedt Willson 1984). When it comes to practice, should the

policymaker prioritize road infrastructure over other infrastructure projects, or the other way around? This section compares the degree of impact of road with all rural infrastructures ranging from irrigation, drinking water, electricity, telecommunication to school and clinic, by running a multiple regression using ordinary least square (OLS) estimator. Therefore, a preliminary regression model would be:

$$\text{Poverty reduction indicator} = f(\text{policy initiative of interest; control variables})$$

Dependent variable

Poverty reduction can be estimated by various indicators such as income or expenditure per capita, inequality measures such as Gini index or other measurement such as literacy or infant mortality rate. For the sake of consistency, this section still uses the logarithm form of per capita net income ($\log(\text{netinc})$) as the dependent variable.

Independent variable

The independent variable contains all the police initiative of interest; in other words, it is the measurement of public projects such as road, irrigation, drinking water, electricity, telecommunication and school and clinic. In order to compare the impact of road with these policies at the same scale, we extracted another sub-dataset which describes the development projects that had been implemented since 1998 (See appendix I table 2). Per capita income was merged into this dataset by village ID. The dataset was further modified by setting dummy variables to record each project received by villages. If the village had received a particular project, school or irrigation for instance, it is marked as 1, otherwise it would be 0. There are 2453 observations in this sample cohort.

In this study, road is the key independent variable, and others are considered as supplementary independent variables. The bunch of independent variables are named as *HasRoad* (road project built after 1998), *HasIrri* (irrigation project built after 1998),

HasWater (domestic water project built after 1998), *HasElc* (electricity project built after 1998), *HasTlcm* (telecommunication project built after 1998), *HasSchool* (school built after 1998), and *HasClinic* (clinic built after 1998).

Control variables

Likewise, control variables are selected the same as the previous regressions, namely, *propilliter* (percentage of illiteracy), *ownclinic* (clinics locate in the village) and *distwat* (distance to the water source), *nonfarminc* (percentage of non-farm income) and *ownentpriz* (enterprises located in the village). However, as in this regression, we incorporate an independent variable *HasClinic*, which is highly correlated with *ownclinic*, hence *ownclinic* is dropped from control variables.

Regression model

After defining the dependent, independent and the control variables, the regression model is constructed as follows,

Specification 1:

$$\lognetinc = c + \alpha_1 * HasRoad$$

Specification 2:

$$\lognetinc = c + \alpha_1 * HasRoad + \beta_1 * propilliter + \beta_2 * distwat + \beta_3 * nonfarminc + \beta_4 * ownentpriz$$

And, Specification 3:

$$\lognetinc = c + \alpha_1 * HasRoad + \alpha_2 * HasIrri + \alpha_3 * HasWater + \alpha_4 * HasElc + \alpha_5 * HasTlcm + \alpha_6 * HasSchool + \alpha_7 * HasClinic + \beta_1 * propilliter + \beta_2 * distwat + \beta_3 * nonfarminc + \beta_4 * ownentpriz$$

The reason for constructing three specifications is we want to test the pure impact of road by incorporating all other public project, these project can be grouped as joint independent variable. By comparing the change in the coefficient of α_1 before

and after these variables, we can see the pure effect of road construction on increasing per capita income and compare it with other policy alternatives.

Results and discussion

The regression result is presented in Table 5. In specification 1, the coefficient of the key interest independent variable *HasRoad* is positive and significant at 1% level, meaning that if the village had received road project since 1998, the net per capita income would be expected to increase by 18.8% than those who had not. Control variables are needed to mitigate the omitted variable bias. By incorporating these variables in specification 2, we see a remarkable decrease in the coefficient from 0.1880 to 0.0455, suggesting that the villages with road built actually received only 4% higher per capita income than those without. Meanwhile, the significant level also decreases to 5% level. The adjusted R square increases obviously from 0.0167 to 0.2809, implying a better degree of fitting in regressions in specification 2.

To compare the impact of road with other public projects, we ran a third round of regression, and the result is illustrated in specification 3. The coefficient of *HasRoad* is still positive, however, it is not significant at 5% level any more⁶. Among the supplementary independent variables, only *HasIrri*, *HasElec*, *HasSchool* and *HasClinic* are statistically significant. As is summarised in Table 6, the clinic construction has the greatest impact on poverty reduction, villages with this project implemented would receive 25% higher income. It is understandable as village clinics provide healthcare services to the local villagers, whenever they get sick, they can be treated immediately and recover soon, which is beneficial to maintain productivity.

⁶ Though the coefficient of *HasRoad* is still significant at 1% level, in statistics, this level is primarily not accepted

Table 5: Regression Models of the impact of other public projects

Dependent variable (Y): Per capita net income of surveyed villages in 2002.			
Regressor	Ln(Y)	Ln(Y)	Ln(Y)
	Specification 1	Specification 2	Specification 3
HasRoad (1: has road project, 0:otherwise)	0.1880** (0.0287)	0.0455* (0.0253)	0.03422 (0.0254)
HasIrri (1: has irrigation project, 0: otherwise)			0.0601* (0.0270)
HasWater (1: has domestic water project, 0: otherwise)			-0.0367 (0.0262)
HasElec (1: has electricity project, 0: otherwise)			0.1071** (0.0312)
HasTlcm (1: has telecommunication project, 0: otherwise)			0.0113 (0.0243)
HasSchool (1: has school project, 0: otherwise)			-0.1364** 0.0243
HasClinic (1: has clinic project, 0: otherwise)			0.2554** 0.0404
propilliter (Percentage of illiterates)		-0.0139** (0.009)	-0.0135** (0.0008)
distwat (Distance to water source in 100m)		-0.0052** (0.0001)	-0.0045** (0.0016)
nonfarminc (Percentage of non-farm income)		0.0063** (0.0005)	0.0060** 0.0005
Owntentpriz (1:owning enterprise, 0:otherwise)		0.3764** (0.0273)	0.3570** (0.0274)
Constant	7.176** (0.0222)	7.0198** (0.0294)	6.9738** (0.0416)
Summary Statistics			
Adjusted R ²	0.0167	0.2809	0.3038
SER	0.6981	0.5974	0.5886
No of observations	2453	2453	2453

Note: Standard errors are given in parentheses under coefficients. Individual coefficients are statistically significant at the *5% level or **1% level.

The second comes to the electricity project with some 10% increase function on income. Electricity is a fundamental infrastructure for rural production. The

electricity network generates energy for farming and breeding as well as improve villagers' living standard. Irrigation also has a positive influence on local income, which is consistent with Songco (2002)'s finding.

Table 6: Summary of the impacts of other public projects

Project	Coefficient	Significance	Explanation
Road	0.03422	insignificant	-
Irrigation	0.0601	5% level	6.01% increase in net per capita income if the project was implemented
Domestic water	-0.0367	insignificant	
Electricity	0.1071	1% level	10.88% increase in net per capita income if the project was implemented
Telecommunication	0.0113	insignificant	-
School	-0.1364	1% level	13.64% decrease in net per capita income if the project was implemented
Clinic	0.2554	1% level	25.03% increase in net per capita income if the project was implemented

It is confusing in this test that School has a negative impact on poverty reduction. It can be explained by a reverse causality. In fact, the village school construction project was launched very early in the 1960s, and by 1990s, most villages had primary schools in or nearby. Those who received the construction school project are considered to be really remote and poor. In addition, rather than clinic, electricity and irrigation, education is a long term project which cannot receive immediate utilization. Resultantly, those who were originally poor were selected to have school project implemented, and the income of these villages cannot be increased in short term from the construction year 1998 to the survey year 2003, hence the negative coefficient of

HasSchool is comprehensible.

7 Policy Implications and scope of future research

Based on the results of the research, the following are the proposed implications for evaluation of policy makers:

First, Given that the coefficient of *roadpass* is positive in the first regression equation, and a strong evidence from the case study of Yuechi County's rural road development, China should **continue the "Linking All Villages" project**. Taking into account the comparative costs and the villagers' participation, building infrastructure merits priority because it is easier to implement and more acceptable by the villagers.

Second, besides road construction, other infrastructure projects such as electricity networks and irrigation system should be upgraded, as these projects exert immediate and effective influence on improving the living standard and income level of rural people. However, considering the cost of designing and implementation the complicated power and irrigation system, policy makers need to conduct a careful cost-and benefit-analysis. Whether to prioritize road construction over the other infrastructure is subject to the context of specific projects in different development phases. It should be cautiously examined case by case.

Third, with the provision of road connections to villages, the government should also enhance **basic public services** of the following:

- Provide free education to poor households to reduce illiteracy and conduct teacher training programs to enhance education quality;
- Establish clinics to safeguard villagers' health and enable them to engage more in livelihood projects to augment income; and
- Create water supply systems along accessible roads to reduce villagers' time and effort in obtaining water, a critical resource for both production

and living.

Last but not least, Government should promote **marketization** in impoverished rural areas. For instance, the local government can formulate preferential policies to stimulate non-farm economy, and provide specialized training and privileges to local income-generating enterprises.

For future research, the regression model could include additional control variables that measure access to credit, labor workforce ratios, among others. The research could also involve looking on other benefits of building road infrastructures such as the benefits of interconnecting villages that synergize output and economic growth in poor villages in rural China. The research can further the study by comparing between the effects of building road infrastructure in urban areas and rural areas in China. Future researchers can also replace the dependent variable and suggest variables that measure the social impact of building road infrastructures in the poorer areas in China.

Conclusion

The study concludes that indeed, building road infrastructures have a positive and significant effect on the annual net income per capita of villagers in rural China. Projects that enhance road construction connecting rural areas of China deserve Government's attention and need priority. Other public projects, especially village clinic, electricity and irrigation system also deserves policy makers' consideration. With limited budget, the prioritization of different public projects needs cautious investigation and examination.

Although road is not the sole solution for poverty reduction, an integrated rural road network would enable higher economic growth by reducing transport cost and activating local economy as villagers have more chances to see the outside world.

Poverty reduction needs synergistic effect from various policy initiatives, road infrastructure projects can be complemented with other poverty alleviation reforms such as education, health, access to water systems, and access to market economy.

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Appendix I (see next page)

2003 Rural Survey on World Bank Project Evaluation

Province: _____ County: _____ Township: _____ Village: _____

Name of respondent: _____ Tel.: _____

Table 1: Social and Economic Indicators of the Village

	Unit	2002	1997
Basic information			
1. How many "small groups (xiao zu)" in your village?			
2. Total households	Household		
3. Of which : Full-time farming household	Household		
4. Households who don't farm at all	Household		
5. Households with family business	Household		
6. Total population	Person		
7. Of which: Han people	Person		
8. Net per capita income per year	Yuan		
9. Of which: proportion of off-farm income	%		
10. Distance between the two most further away small groups (xiao zu)	Km		
Land information			
11. Total arable land	Mu		
12. Of which 1: flat land	Mu		
13. terraced land	Mu		
14. Of which 2: irrigated land	Mu		
15. Sown area of crops	Mu		
16. Of which: Grain crops	Mu		
17. Area of orchard, tea, mulberry	Mu		
18. Forest	Mu		
19. Of which: economic forest, excluding orchard in forest	Mu		
20. Grassland (including Grain for Green)	Mu		
21. Water area (including fish pond)	Mu		
Labor force information			
22. Total labor force	Person		
23. Of which 1: Working off-farm inside the village	Person		
24. Daily commuters	Person		
25. Out migrant	Person		
26. During the SARS epidemic in 2003, how many people returned?	Person		
27. Of which 2: Illiterate	Person		
28. Senior high and above graduates	Person		

Infrastructure	Unit	2002	1997
31. How many schools in your village?			
32. When was the most recently built school built?	Year		
33. How many clinics in your village?	Entries		
34. Of which: How many clinics were built by the village/xiaozu(s)?	Entries		
35. When was the most recently built clinic built by the village/xiaozu(s)?	Year		
36. How many households have access to electricity?	Household		
37. How many households have access to tap water?	Household		
38. How many households have telephone or cell-phone?	Households		
Geographic information and Environment			
39. Any tarred road passing thru your village? 1=yes; 2=no			
40. The distance from the village committee seat to the nearest tarred road	Km		
41. Type of tarred road 1=national; 2=provincial; 3=county; 4=town; 5=other (please specify)			
42. Distance from village committee seat to township seat	Km		
43. Main vehicle to township seat by average villagers 1=on foot; 2=bicycle; 3=tricycle; 4=motorbike; 5=passenger bus; 6=passenger ship; 7=other (specify)			
44. Time to township seat by the main vehicle?	Hour		
45. Of total arable land : Proportion of flatland	%		
46. Proportion of land steeper than 25 degrees	%		
47. Extent of soil erosion 1=very serious; 2=serious; 3=slight; 4=none			
48. Grassland quality 1=very good; 2=good; 3=fair; 4=poor; 5=very bad			
49. Type of drinking water 1=tap water; 2=water cellar; 3=well; 4=spring; 5=river, lake, reservoir; 6=other (specify)			
50. Distance from village committee seat to the major drinking water source	Km		
Other			
51. How many fellow villagers working at township government?	Person		
52. How many fellow villagers working at county government or above?	Person		
53. How many secondary technical school and above graduates produced since 1982?	Person		
54. Is the village committee in debt? 1=yes 2=no			
55. If yes, how much debt in your village?	10000yuan		
28. Number of enterprises			
29. Of which: village/xiaozu-run enterprises, excluding enterprises jointly run by several households			

Table 2 : Public Project

Since 1998 (including 1998), has/does your village had/have any of the following public projects?

Project Code*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Brief description	Primary purpose of this project	Start year	Start month	Finish year	Finish month	Total investment (including cash and material)	Of total investment: Loan	Of total investment: Village matching fund	Labor days contributed by village (excluding paid time contribution)	How many Xiaozu benefit?	How many households benefit?	Project coverage	Source(s) of fund	Who actually carried out the project?
	1=have 2=have not		1=increase farmers' income 2=improve farmers' living status 3=improve/protect environment 4=generate job opportunities 5=increase village revenue 6=others (specify)					10,000 yuan	10,000 yuan	10,000 yuan		Xiaozu	Household		1=world bank 2=other international agency(specify) 3=poverty alleviation office 4=development office 5=ministrial channel 6=food for work 7=village 8=others (specify)	1=village committee 2=township government 3=county level government agency 4=project office 5=others (specify)

Project code*: 11=Build road or bridge; 12=Build school; 13=Build clinic; 14=Drinking water; 15=Irrigation system; 16=Drainage system; 17= Electricity; 18= Telephone line; 19=Radio/TV cable; 20= Land improvement; 21=Watershed management; 22=Terracing; 23=Downtown planning and improvement; 24=Logging ban and foresting; 25= Eco-forest; 26=Grain for green; 27=Building pasture; 28=Activity and recreation room

Table 3: Development Project

Since 1998 (including 1998), has/does your village had/have any of the following development projects?

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project Code*		Brief description	Primary purpose of this project	Start year	Start month	Finish year	Finish month	Total investment (including cash and material)	Of total investment: Loan	Of total investment: Village matching fund	Labor days contributed by village (excluding paid time contribution)	How many Xiaozu benefit?	How many households benefit?	Project coverage	Source(s) of fund	Who actually carried out the project?
	1=have 2=have not		1=increase farmers' income 2=improve farmers' living status 3=improve/protect environment 4=generate job opportunities 5=increase village revenue 6=others (specify)					10,000 yuan	10,000 yuan	10,000 yuan		Xiaozu	Household		1=world bank 2=other international agency (specify) 3=poverty alleviation office 4=development office 5=ministerial channel 6=food for work 7=village 8=others (specify)	1=village committee 2=township government 3=county level government agency 4=project office 5=others (specify)

Project code*: 29=Grain crop; 30=Cash crop (including commercial vegetable); 31=Orchard; 32=Green house; 33=Economic forest; 34=Livestock; 35=Fishpond; 36=Family business; 37= Computer; 38= Micro credit

Table 4: Information on Village leaders since 1998

1. When was the latest village election in your village? _____year 2. When was the Second latest village election in your village? _____year

Title	Term	3	4	5	6	7	8	9	10	11	12
		Name	Tenure from		Tenure to		Gender	Age now	Education	Occupation before taking the position	How did he/she get the position?
			year	month	year	month	1=male 2=female	years	1=illiterate 2=primary 3=junior high 4=senior high 5=secondary technical and above	1=full-time farmer 2=wage earner 3=self-employed 4=village/small group cadres 5=retired serviceman 6=other (specify)	1=General villagers election 2=village committee election 3=appointed by township or above 4=party branch election 5=other (specify)
Village leader	First										
	Second										
	Third										
	Fourth										
	Fifth										
Party secretary	First										
	Second										
	Third										
	Fourth										
	Fifth										

Table 5: Farmer special technical association

1、 Are there any villagers in your villages who are members of any farmers associations? 1=yes; 2=no (skip to 23)

2、 If yes, is the association run by your village, jointly by several villages? 1=this village; 2=multi-villages; 3=both

3、 How many households in your village are members of any associations? (unit: h)

带格式的: 项目符号和编号

4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Name of the association	Establishing year	Is the association run by your village only or jointly by several villages?	Coverage of the association	With whom did this association register?	Which sector is the association mainly involved?	Who initiated this association?	How many households from your village are formal members of this association?	How many households from your village are informal members of this association?	Do formal members of this association need to pay membership fee?	Does this association have any constitution?	Does this association hold member meetings every year?	How are the major decisions made in the association?	Does it vote in the association?	Does it share profit with other members of the association?	Does the head of the association have an official village committee member?	Does the association have its own enterprise?	Does the association earn profit?
	year	1=your village (>>8) 2=multi-villages	1=Some villages of this township; 2=All across this township; 3=All across this county; 4=Some counties in this province; 5=Across provinces	1=Not registered; 2=Science and technology commission; 3=civil affairs bureau; 4=agricultural bureau; 5=commerce bureau; 6=other(specify)	1=livestock and plant industry 2=plant industry 3=handicraft industry 4=finance 5=other service sector 6=other (specify)	1=village committee; 2=township or above government 3=social groups; 4=enterprise, including leading enterprises; 5=specialized households; 6=jointly by some farmers; 7=others (specify)	household	household	1=yes 2=no 3=don't know	1=yes 2=no 3=don't know	1=yes 2=no	1=joint decision by all members 2=decision by board members of the association 3=the backbone of the association 4=government 5=other (specify)	1=yes 2=no 3=don't know	1=yes 2=no	1=yes 2=no	1=yes 2=no	1=yes 2=no, it's non-profit 3=no, the management is not good 4=other (specify)

22. If there is any association in your village, are there any associations in other villages that predate the association in your village? 1=yes; 2=no; 3= don't know
23. Has county or township government sent out any red title documents to your village specifically for the purpose of promoting the development of association? 1=yes; 2=no; 3= don't know
24. Has county or township government held any meetings (including experience sharing) specifically for the purpose of promoting the development of association? 1=yes; 2=no; 3= don't know
25. If there is no association in your village now, do other villages in this county have any association? 1=yes; 2=no; 3= don't know

Table 6: village affair management

- 1、 If a villager wants to convert his/her arable land into fishing pond, is it necessary for him/her to get a permit from the township government?
1= yes, he/she must get a permit; 2=only notify; 3=no
- 2、 If villager wants to establish a small-scale, say a cloth factory, how many days does it take to apply for a business license? (unit: day)
- 3、 How much money does it take a villager want to apply and get an private business license? (unit: yuan)
- 4、 If the village wants to have major land reallocation in the village, is it necessary to get approval from the township government?
1= yes, must; 2=only notify ; 3=no
- 5、 In 2002, how many obligation labor days did your village provide as required by the upper level government?
- 6、 In 2002, how many village cadre meetings were organized by the county and township governments? (not including meeting about election) (unit: time)
- 7、 In the recent village election, how many village cadre meetings were organized by the county and township government. (unit: time)
- 8、 In 2002, how many red title documents did your village get from the township government?
- 9、 In the process of village election, do candidates need to be approved by the township government?
1=yes; 2=only report; 3=no
- 10、 What's the attitude of upper level governments toward violation of the family planning policy?
1=absolutely not allowed; 2=fine payment or other penalty; 3=no measure
- 11、 Can newly married-in women get arable land?
1. Yes, immediately; 2. yes, if there is land in the village; 3.Not until next adjustment;
4. No; 5.other (specify)
- 12、 Can newly born child get arable land?
1. Yes, immediately; 2. yes, if there is land in the village; 3.Not until next adjustment;
4. No; 5.other (specify)

13、 Can divorced women can keep her land?

1= yes; 2= it's up to the family; 3= no, land will be taken back by the village; 4= other(specify)

14、 In 2002, how many technical trainings was organized in your village? (unit: time)

15、 In 2002, how many persons participate in those technical trainings? (unit: person times)