INFRASTRUCTURE INVESTMENT IN RURAL CHINA: Is Quality Being Compromised during Quantity Expansion?

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Abstract

Good public infrastructure management means more than increasing the *quantity* of infrastructure stocks; it also involves improving the *quality* of infrastructure. This study seeks to document the quality of infrastructure projects in China's villages and to measure whether or not quality has suffered as China's investment effort has risen. Using data from 100 villages in China, we have found, using descriptive results, that in recent years *both* the quantity *and* the quality of infrastructure investments have increased over time. We also demonstrate that across space quantity and quality are positively correlated. We conclude that—at least in our sample villages—the quality of infrastructure is not being compromised for its quantity expansion during the entire sample period.

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By any measure, China has achieved impressive gains in the expansion of its rural infrastructure in recent years. Rural roads registered a rapid rate of increase in investment between 2001 and 2004, from 35.8 billion yuan to 124.2 billion yuan, an annual growth rate of 51 per cent (Ministry of Communications, 2005). By 2006 61 per cent of villages became connected into their town's road network by a paved road. Investments in irrigation systems and drinking water facilities also rose sharply (Ministry of Water Resources, 2005). From 2001 to 2004, the share of villages with access to tap water increased by 15 per cent. Since the late 1990s, more than 100 million people have enjoyed upgrades in their electrical and telecommunications infrastructure (*China Agricultural Statistics Yearbook*, 2005).

Despite the gains of recent years, national leaders are designing even more ambitious plans. One of the main policy initiatives of the current administration is the "Building a New Socialist Countryside" movement. Continued improvement in rural infrastructure is among the main goals. According to the recently created Rural Road Development Plan, during the 11^{th} five-year period (2006–10), the national government will invest a total of 100 billion yuan in rural roads (Ministry of Communications, 2006). During this same period, the leadership will allocate more than 40 billion yuan to drinking water facilities for rural communities (Ministry of Water Resources, 2005).

While few observers dispute that vast new funds are flowing into rural China and that the absolute *quantity* of infrastructure investment is rising, a number of researchers have expressed their concerns about the *quality* of the infrastructure projects that are being built. For example, Zhao (2005) states that the rural infrastructure in China is at best characterized as being of "poor quality". Several scholars have cautioned that, despite the fact that many villages in rural China have been linked with the outside world through the new road expansion movement, the quality of these roads is poor (Yang *et al.*, 2005; Huang and Xia, 2006). Their assessment is that many road projects have built roads that are too narrow. The pavement is too thin. Many of the new roads lack drainage systems. Even after only a few years, some roads are full of cracks. An assessment team from the Henan Provincial Bureau of Statistics (2005) characterizes the irrigation systems in part of the province's rural areas as seriously flawed. In many villages in Sichuan and Chongqing where drinking water facilities are failing, rural residents and their animals have been reported to be suffering from drought (People's Daily, 2006). In short, no matter how many projects are built, if their quality is poor, the benefits to rural communities will be lower and the quality of life may not rise at all.

International experience also shows that good infrastructure management means more than increasing the *quantity* of infrastructure stocks; it also involves improving the *quality* of infrastructure (World Bank, 1994). Failures in producing quality infrastructure can reduce the quality of life and productivity in rural communities. Bell *et al.* (1993) argue that, when drinking water facilities are of poor quality, they can reduce labor productivity and household income and undermine poverty alleviation efforts. According to a survey of power generation projects in a number of developing countries, an average of 40 per cent of the power-generating capacity is unavailable at any given time because of the poor quality of projects (World Bank, 1994). According to the World Bank (1994), costly investments into road construction are often wasted because of poor quality.

Despite the obvious importance of the subject, there is almost a complete absence of literature in China about the quality of rural infrastructure. Earlier studies focus almost exclusively on the benefits of investing in increasingly greater volumes of roads, irrigation systems and other physical infrastructure projects (for example, Fan *et al.*, 2002). More recently, there have been several papers that center on documenting the expanding quantity of infrastructure in rural China as well as explaining why some villages invest a lot and others invest a little (for example, Zhang *et al*., 2005, 2006a, 2006b; Luo *et al*., 2006). To date, however, beyond anecdotal reports (Zhao, 2005; Yang *et al*., 2005; Huang and Xia, 2006), little systematic empirical work has addressed the quality of infrastructure in rural China.

The overall goal of this paper is to understand whether or not *quality* has suffered as the *quantity* of investment into rural China has risen. To achieve this modest goal, we will strive to meet three specific objectives. First, we use a new dataset to describe the trends in the quantity of infrastructure investment in rural China. The purpose of this part of the paper is to see if the investments that have been reported at the macro-level are penetrating to China's villages. Second, we use special blocks of our dataset to document the quality of infrastructure in rural China. After constructing several measures of quality, we examine the nature of the heterogeneity in the quality of infrastructure over time and across space. Finally, we measure whether or not there is an inverse relationship between quantity and quality. As China's infrastructure has expanded over time and across space, we want to answer the question: Has the quality of China's infrastructure been adversely affected?

The remainder of the paper is organized as follows. Section 2 presents the data we will use in this study. Section 3 documents that, in fact, during the past several years, there has been a marked rise in the quantity of infrastructure in rural China and that this investment has reached the villages. The main question of the paper, then, is to understand whether or not, during this same time period, the quality of infrastructure in communities which have experienced these large rises in infrastructure investment has suffered or not. To do this, in Section 4 we first describe special blocks of the data that our survey team collected specifically for measuring quality. Second, we introduce our measures of quality. Using the measures, we trace the contours of the quality of infrastructure projects in rural China, describing the patterns inside and across the villages in our sample and across time. Section 6 uses multivariate approaches to examine whether or not the quality of infrastructure is being compromised during the quantity expansion of infrastructure in rural China. The final section presents our conclusions.

Data

Our main empirical analysis draws information mainly from the 2005 China Rural Governance Survey (2005 CRG Survey) which we undertook in collaboration with colleagues at the Center for Chinese Agricultural Policy, Chinese Academy of Sciences (CCAP-CAS). In this survey, 100 villages were randomly selected from 50 towns in 25 counties from 5 provinces. The fieldwork team, made up of two of our long-time collaborators at CCAP and 30 graduate students and research fellows, chose the sample and implemented the survey. The sample villages were selected as follows. First, five provinces were each randomly selected to represent five of China's major agro–ecological zones: Jiangsu in the eastern coastal region; Sichuan in the southwest; Shaanxi in the northwest; Hebei in the central region; and Jilin in the northeast. Next, five counties were selected from each province, one from each quintile from a list of counties arranged in descending order of per capita gross value of industrial output (GVIO). GVIO was used on the basis of the conclusions of Rozelle (1996) which shows that GVIO is one of the best predictors of standard of living and development potential and is often more reliable than net rural per capita income. Within each county, the survey team chose two townships, one from each half of a list of townships arranged in descending order of per capita GVIO. Finally, within each township, they chose two villages, following the same procedure as the township selection.

The 2005 CRG Survey form had a block that measures the quantity of investment in our 100 sample villages. Enumerators interviewed village leaders, using a survey form designed to elicit information about the size and scope of investments. Enumerators asked questions about each infrastructure investment project that was undertaken in the village between 1998 and 2004. The survey also included questions on the year of project initiation and completion, its cost and sources of funding. This part of the survey (which was also administered to a larger set of 2,459 villages that the authors collected in 2003—described below) was the basis for the analysis on the quantity of infrastructure investments. The main part of the survey that we use to examine quality is described later in the paper.

To analyze the changes in the quantity of infrastructure in rural China, we use a survey that preceded the 2005 CRG Survey, namely, the 2004 China Public Investment Survey (2004 CPI Survey) which we also undertook in collaboration with CCAP-CAS. The 2004 CPI Survey covered 2,459 villages in 6 provinces randomly selected from around China.[1] The 100 villages covered in the 2005 CRG Survey are a subset of villages randomly selected from the 2,459 sample villages from the 2004 CPI Survey. Similar to the section described above, enumerators in the 2004 CPI Survey collected information about the size and scope of each infrastructure investment undertaken in the village between 1998 and 2003, their timing and sources of funding and implementation. In addition, a variety of background information was also collected on the economic, political and demographic conditions of each village in 1997 and 2003.

[1] The sample villages come from six representative provinces. Jiangsu represents the eastern coastal areas (Jiangsu, Shandong, Shanghai, Zhejiang, Fujian and Guangdong); Sichuan represents the southwestern provinces (Sichuan, Guizhou and Yunnan) plus Guangxi; Shaanxi represents the provinces on the Loess Plateau (Shaanxi and Shanxi) and neighboring Inner Mongolia; Gansu represents the rest of the provinces in the northwest (Gansu, Ningxia, Qinghai and Xinjiang); Hebei represents the north and central provinces (Hebei, Henan, Anhui, Hubei, Jiangxi and Hunan); and Jilin represents the northeastern provinces (Jilin, Liaoning and Heilongjiang). While we recognize that we have deviated from the standard definition of China's agro–ecological zones, the realities of survey work justified our compromises. Pretests in Guangdong demonstrated that data collection was extraordinarily expensive and the attrition rate high. One of our funding agencies demanded that we choose at least two provinces in the northwest. Our budget did not allow us to add another central province (for example, Hunan or Hubei) to the sample.

Quantity of Investment in Rural Infrastructure

Despite the suggestion by some that China's rural villages are being neglected (Zhao, 2005; Ma and Fang, 2005), our surveys show a high and growing volume of investment in China's rural infrastructure. They also show that the investment initiatives that are being reported in macro statistics are being funded in rural communities. In this way our data are consistent with many of the government reports on the expansion of the volume of investment into public infrastructure (for example, State Statistics Bureau, 2006). During the five years of our study, enumerators working on the CPI Survey recorded that there were 9,138 investment projects in the 2,459 sample villages. On average this means that during the 5-year sample period, each village had 3.75 projects, nearly 1 per year. Nearly 90 per cent of villages in the sample had more than one investment project between 1998 and 2003.

While it is hard to say if this level of investment is high enough to facilitate China's modernization, compared to other developing countries, it appears that China in recent years is generating a relatively high degree of investment. For example, in a study by Khwaja (2002), after canvassing several hundred villages in Northern Pakistan, enumerators found that only 99 villages had at least one development project during the previous decade or more. Only 33 villages had more than one project.

In addition, China's investment targets are increasingly focusing on investment into public goods. In the 1980s local leaders put a lot of their effort into managing village-run development projects (Rozelle, 1990). For example, during the 1980s and 1990s local leaders often took an active role in starting and running local enterprises instead of taking on more traditional regulatory and public goods management roles. In some parts of China the vast tracts of commercial timber forests, citrus and apple orchards and large-scale livestock projects testify to the efforts of entrepreneurial village and township leaders who were trying to improve and diversify the economic bases of their communities. After 1998, however, our data show that leaders centered most of their energy on public goods-oriented investment projects (87 per cent).[2] In value terms, more than 80 per cent of rural investment was spent on public goods.

Leaders also invested in wide variety of infrastructure projects. Specifically, of the 5,975 public goods projects (not including the 3,163 electricity and communication projects), sample villages invested in fifteen different types of public goods investment projects (Table 1, column 1). The average size of

[2] In calculating *all* public goods projects, we include investments made in electrical grid and telephone line upgrades. There were nearly 2000 of these projects in our sample villages between 1998 and 2003. In some sense, however, these projects are not run like the rest of the projects, either public goods investments or development projects. For example, In a vast majority of the electrical grid upgrading projects, the electrical company made all of the investment and did not include the village in any of the decision making process. The cost of the project, according to our interviewees, would be captured by higher electricity fees or increased electricity use. Given the different nature of these types of projects, in the rest of the paper we do not include them in the analysis of public goods projects. Hence, this reduces the number of public goods projects from 7950 to 5975.

each type of project was fairly small—108 thousand yuan (Table 1, column 2)—although these vary from project to project (from a high for watershed management projects—298 thousand yuan—to projects such as clinics and village beautification that were only around 25 thousand yuan).

Table 1. Number and size of public goods projects (regional population weighted), 1998–2003

Project	Number of projects	Average size (1000 yuan)	Accumulated distribution of projects
Road/Bridge	1266	112	21.2
Grain for Green	892	67	36.1
School	850	99	50.3
Irrigation/Drainage	819	65	64.1
Drinking water	636	75	74.7
Loudspeaker for village committee	379	60	81.0
Activity/Recreation center	262	50	85.4
Clinic	163	25	88.2
Beautify environment	157	24	90.8
Watershed management	151	298	93.3
Forest closure	140	34	95.6
Land Leveling	124	136	97.7
Eco-forest	55	34	98.6
Soil improvement	52	110	99.5
Building grazing pasture	19	134	99.8
Other infrastructure projects	10	244	100.0
N / mean	***5,975***	***108***	**--**

Source: Authors' survey.

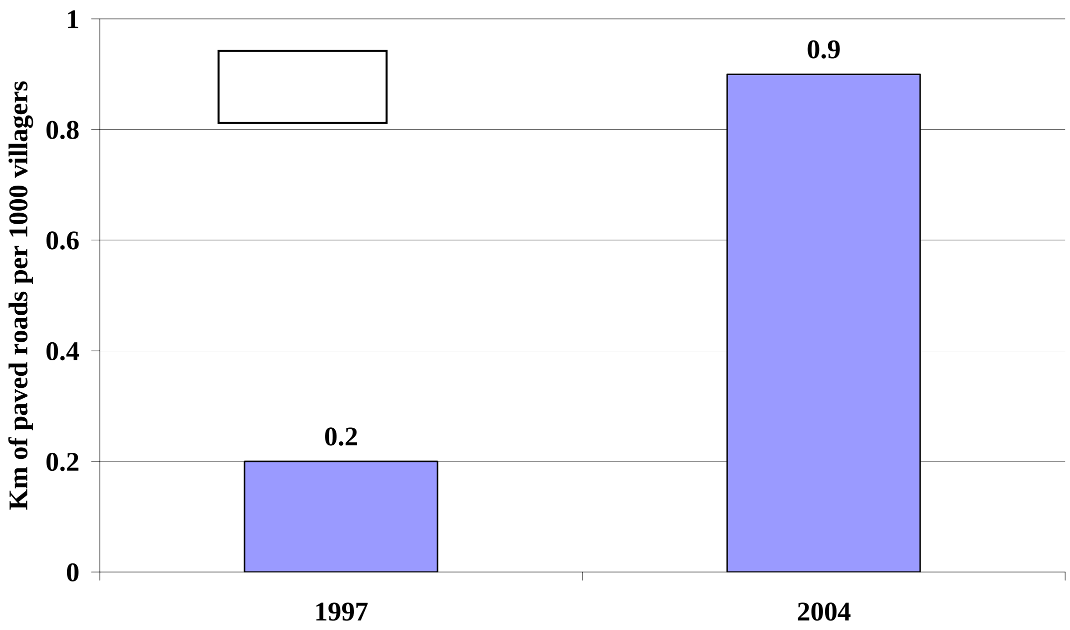
Some types of investment projects, however, were much more popular than others and, in fact, a large majority of all public goods investment projects were made in one of five categories (Table 1, columns 1 and 3). For example, over half of the villages (1,266) invested in roads or bridges. Roads and bridges accounted for 21.2 per cent of all of public goods projects. Between 800 and 900 villages invested in Grain for Green, school construction or irrigation and drainage projects.[3] More than 600 villages invested in drinking water projects. In total, 75 per cent of all public goods projects were

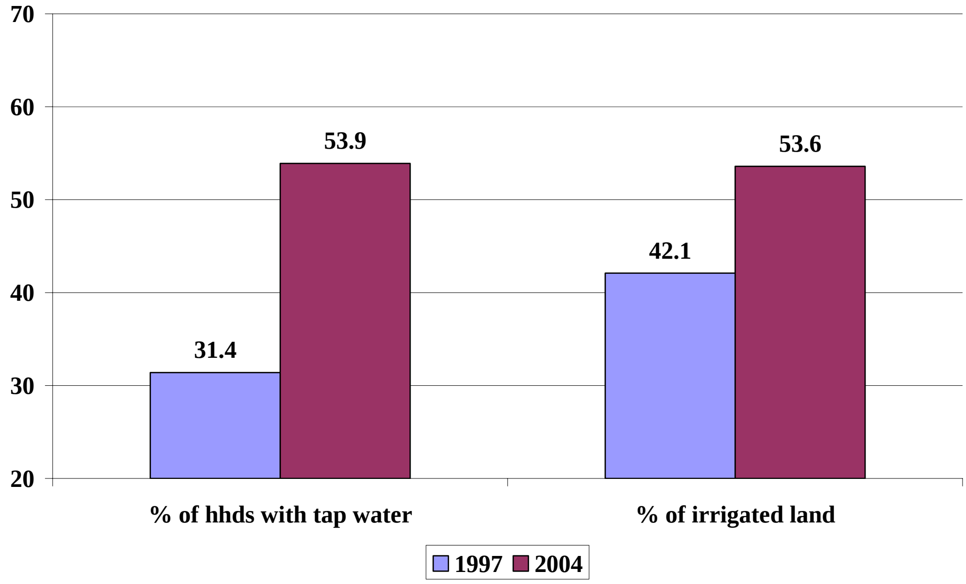
[3] Grain for Green is a large national forestry program begun in 1999 that was designed to pay farmers to set aside cultivated land and plant forest or grasslands. In total between 1999 and 2003, more than 5 million hectares nationally were converted from cultivated land to forests and grasslands (Xu and Cao, 2002).

accounted for by investment into these five investment activities. The top five projects—roads and bridges, Grain for Green, irrigation, school construction and drinking water—also commanded a large share of total investment. Of all investment in value terms, leaders invested 81 per cent of their funds in the top five projects. The fact that roads/bridges, irrigation and drinking water accounted for 43 per cent of all projects and 46 per cent of investment justifies our putting these three types of infrastructure projects at the center of the quality analysis. In the rest of the paper we refer to these three types of projects as *core infrastructure projects*.

Most importantly, when we look at trends in the expansion of the volume (or quantity) of infrastructure investment in rural China over time, our data show contours that are consistent with the quantity expansion reported by the government in their macro-level data (which was referred to in the introduction). Rural roads registered the highest growth rates. For example, the length of paved roads within villages increased by 29.7 per cent per year. Between 1997 and 2004, the length of paved rural roads increased from 0.2 kilometers per thousand people to 0.9 (Figure 1, Panel A). The fraction of households with access to tap water also increased during this period from less than one third (31 per cent) to more than half (54 per cent). The share of effectively irrigated land in the typical village also rose (from 42 per cent to 54 per cent—Figure 1, Panel B). Clearly, our data, which are measuring investment into villages within the boundaries of villages, are consistent with the story of quantity expansion that is found in the secondary data.

Figure 1. Expansion in the Quantity of Infrastructure in Rural China





Source: Authors' survey.

Quality of Investment in Rural Infrastructure

Although it is clear that there has been a large rise in the total volume of investment into China's rural infrastructure, these figures do not tell us anything about their quality since the *quantity* of rural infrastructure is not necessarily equal to *quality*. To explore shifts in the quality of rural China's infrastructure, in this section we first describe special blocks of the data that were collected specifically for measuring quality. Second, we describe the various measures of quality that we use. Finally, we trace the contours of the quality of infrastructure projects in rural China and explore whether quality is suffering when quantity is expanding.

Data for Measuring Quality

In total there are three blocks of the survey concerned with issues of the quality of investment that are used in the study. In collaboration with our colleagues at CCAP-CAS, we designed two of the blocks to focus exclusively on the quality of the investment. The first of these blocks asked village leaders a series of questions about the core infrastructure investment projects in the village. During the survey, enumerators asked detailed questions about each of the three types of core infrastructure projects, including who initiated the project, the application process, the design of the project and project implementation. With such detailed information about each project, we are able to understand a lot about the entire "life" of the project from its inception through its completion.

In another block of the survey, two of the enumeration team members utilized a survey instrument that was designed by us and our colleagues at CCAP-CAS in consultation with professional civil engineers to come up with a quality index for each project. Each evaluation form assesses two dimensions of each infrastructure project: an engineering dimension and a performance dimension. In attempting to describe each of these dimensions, we created a long list of project attributes. Specifically, there are 40 attributes used on the form for each road project, 42 attributes for each irrigation project and 37 attributes for each drinking water project.

The form that we used to evaluate the quality of each core infrastructure project was created to look like a score sheet. A number of points was assigned to each attribute. The number of points assigned to each attribute was supposed to reflect the importance of the contribution of the attribute to the project's overall quality. For example, the depth of the road surface and the material used to construct the road surface was assigned 12.5 points (accounting for more than 10 per cent of a road's quality). In contrast, the "line of the road", which was measured by the enumerator based on a visual inspection of "how straight" a road looks (or how symmetric the curves are), was only assigned 4 points. The number of points (or weights) was assigned this way because it was the opinion of our engineering consultants that the road surface was a much more important factor in the quality of a road than whether or not the line of the road was perfectly straight or nicely curved. If project's attributes all received full score, the score would add to 100. English translations of the forms for roads, irrigation and drinking water projects are included in the appendix.

We were quite concerned that, despite the effort put into creating the detailed evaluation form, there could possibly be a great deal of enumerator-specific subjectiveness in the assigning of scores to each attribute. To overcome this, our colleagues and we trained the enumerators intensively as a group, playing many "comparison games" that were designed to get every enumerator assigning the same (or nearly the same) number of points to the same types of attributes. We also created a detailed scoring manual that was used by each of the enumeration teams. Finally, the survey team took literally thousands of photographs of the projects. Hence, after the survey was completed we were able to look at the pictures of the projects and compare them against their scores. In this way, we were able to make adjustments to projects *ex post* when they looked to be out of line with the projects that ranked immediately ahead and behind them.

The information about the performance dimension of the quality measure was also enumerated by the evaluation team. Households were randomly selected and asked about the performance and reliability of the roads, irrigation networks and drinking water systems. For example, in the case of roads we asked the villagers how many days per year a road was not usable (due to rain or mud or some other factor). Enumerators also asked if the flow of traffic was ever impeded because the road was too narrow or the surface impassable. In the case of the drinking water systems, enumerators used litmus test paper to test for acidity and glass test tubes to check for the clarity of water. As in the case of roads, enumerators also asked about reliability (for example, how many months per year, days per month and hours per day did the drinking water system deliver water?). Enumerators also asked farmers about their perception of the irrigation system's reliability.

A third block of the survey was designed to ask farmers about their perceptions about the quality of projects and their satisfaction with the outcome of the investment activities. The purpose of the survey was to come up with a measure that would allow us to see if there was any correlation between farmer satisfaction and project quality. In other words, we were trying to elicit information that would allow us to understand if the measures of quality are correlated with the perceptions of farmers about whether or not the projects were successful.

To collect the information on farmer satisfaction, eight farm households were randomly selected from each sample village. Enumerators interviewed each household inside their homes. For each infrastructure project undertaken in the village between 1998 and 2004, enumerators asked farmers whether they thought the project was successful or not. In addition, enumerators also asked farmers to rank the projects in their village on the basis of their benefits to the villagers.

Constructing the Measures

The most straightforward measure of quality that we use, the *standard raw score*, is the simple sum of the scores of each of the project attributes. Therefore, the standard raw score ranges from 0 to 100. In some projects, however, the scope of work only involved a subset of the attributes of a project. In this case the project's score was standardized so it too ranged between 0 and 100 points. The standardization was accomplished by dividing the sum of the score given by the enumerators by the total number of points available for the attributes that were relevant to the project. For example, if an irrigation project only involved replacing the pump (worth 15 points if the attribute was judged to meet the criteria for a full score), intake gates (2 points) and main head-works (8 points), the total possible points would be 25. Such a project would have nothing to do with the rest of the irrigation system (for example, the tertiary canals, outlet gates to farmer fields and/or the drainage system—worth 75 points). Because of this partial nature, there was no way that points could be assigned for these other attributes. It is for this reason that we standardized the score by dividing the sum of the points assigned to each of the relevant attributes by the total maximum number of points for the attributes (had they been given a full score). For example, in the case of the partial irrigation project, if the enumerator decided that the scores assigned to the 3 relevant attributes added to 20, the standard raw score would be 20/25*100, or 80 points.

Accounting for the "Degree of Difficulty"

For a number of reasons, we believe the standard raw score measures may not always account for the complete context within which a project is designed and implemented. In other words, in some places projects are difficult to implement; in other places they are relatively easy. Some projects are simple in design; others are relatively complicated. In some places villagers and their leaders have to work hard to implement a project; in others they are given a "turn-key" operation and the villagers benefit from a project without any effort on their own collective account. As a consequence, it is possible that the standard raw score measure of quality is a function of either the environment of a village's infrastructure project and/or the complexity of the project.[4] In such a case the

[4] A simple example can illustrate the importance of accounting of the difficulty factors. If we merely use the standard raw score, then a village might be penalized for attempting a complex

standard raw scores would not be comparable among all villages in our sample (in terms of being able to compare the ability of villages to implement quality projects).

Because of these concerns, we developed a new measure of quality. To create this measure, we began with the standard raw score of a project, and in the same way as an Olympic diving score is adjusted for the difficulty of the dive, we adjusted the investment project's quality measure for three elements: a) the degree of physical or geographical difficulty facing those charged with project construction; b) the complexity of the project; and c) the degree to which local residents participated in the design and implementation of the project. In other words, we sought to make our measures of quality more sensitive to the context within which each project was designed and implemented by adjusting the standard raw score for each project's physical difficulty, its complexity and the degree of local participation. The new measure is called the *adjusted score*.[5] Compared to standard raw scores, adjusted scores have the advantage of being more comparable across villages and projects that are designed and implemented in different environments and with different inputs from outside the village.

Also in the same way that Olympic diving scores are created, the adjusted measure is created by applying additive weights to the standard raw score. Each of the three adjustment elements— one for physical/geographical difficulty; one for complexity; and one for local participation—ranged from 1 to 1.5. The higher the additive weight, the more physically challenging the terrain (or the more complex was the project or the more autonomous was the village's effort). Enumerators assigned weights on the basis of a criteria sheet that was also designed in consultations with our engineering consultants. Because standard raw scores (SRS) ranged between 0 and 100, adjusted scores (AS) of quality ranged from 0 to 450 (AS=SRS*(1.5+1.5+1.5), if the project was built on physically demanding terrain, was complex, and was built entirely at the initiative and with the resources of the village leadership. A summary of these adjustment factors by province, project inception year and project type is provided in Appendix Table 1.

The Quality of Rural China's Infrastructure Projects

Regardless of our measure of quality, the 2005 CRG Survey data show that as the overall volume of infrastructure investment rose, quality (in the aggregate) did not suffer (at least when we look at simple trends). In fact, the quality of infrastructure projects in rural China increases slightly during the sample period. From 1998 to 2003, the standard raw scores of infrastructure projects in rural China increased from 70 to 75 (Figure 2, Panel A). Similar results are

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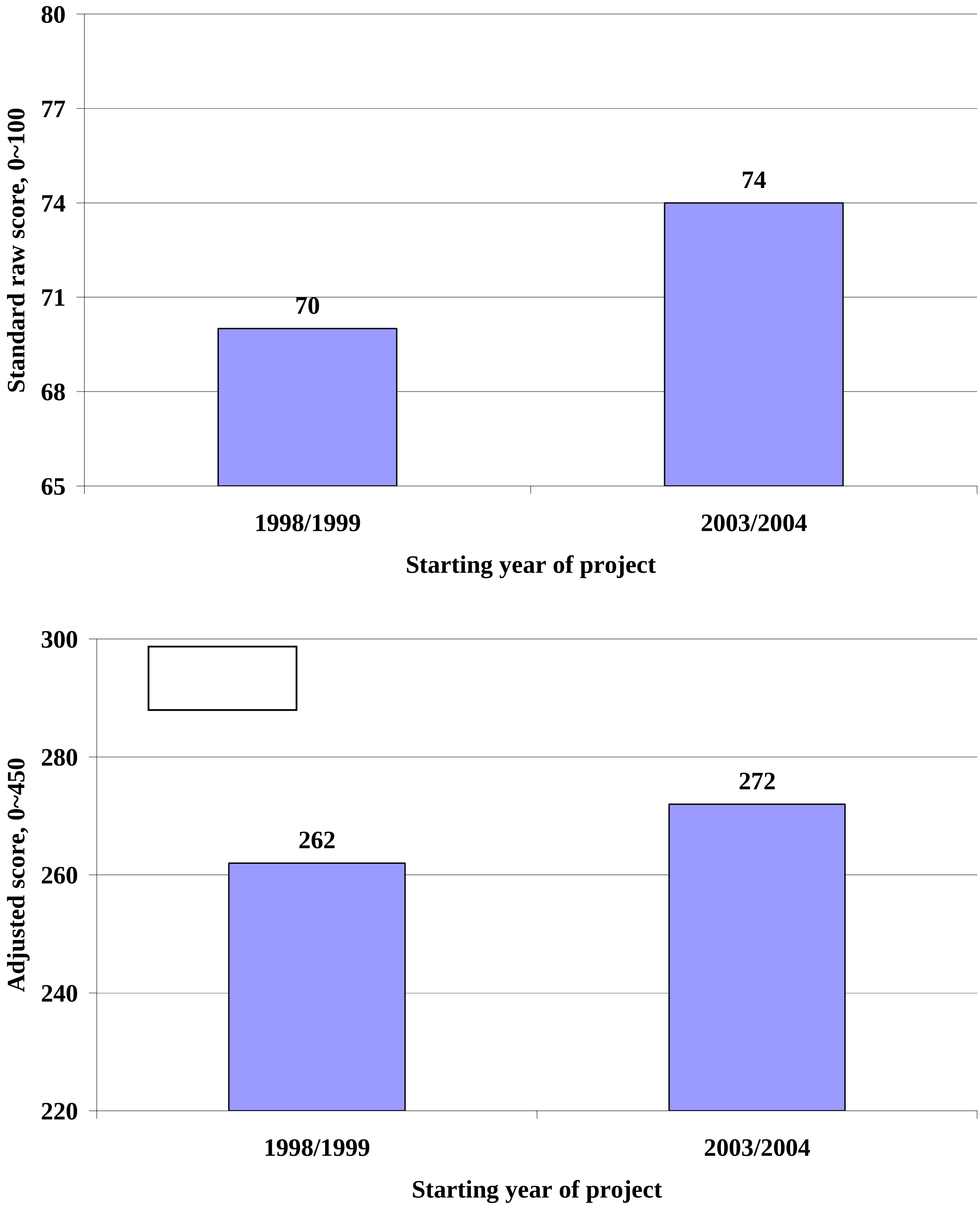
project (for example, a road network linking all small groups in the village together). The penalty would be even more severe if the village were located in a physically challenging environment (for example, in a mountainous area). In contrast, a village implementing a simple project (for example, a short segment of a feeder road linking a nearby county road to the village office) in a village that was located on a plain would have an easier time achieving a higher score.

[5] Each of the three adjustment elements ranges from 0 to 1.5. Recall that standard raw score ranges between 0 and 100. Therefore, adjusted score ranges from 0 to 450.

found when using the adjusted scores. During the same time period, the adjusted scores increased from 258 to 272 (Figure 2, Panel B). Hence, using either the standard raw or adjusted score measures, our approach to measuring quality does not support the conclusions of others (Zhao, 2005; Yang *et al.*, 2005; Huang and Xia, 2006) who claim that quality was suffering during the recent period of investment expansion.

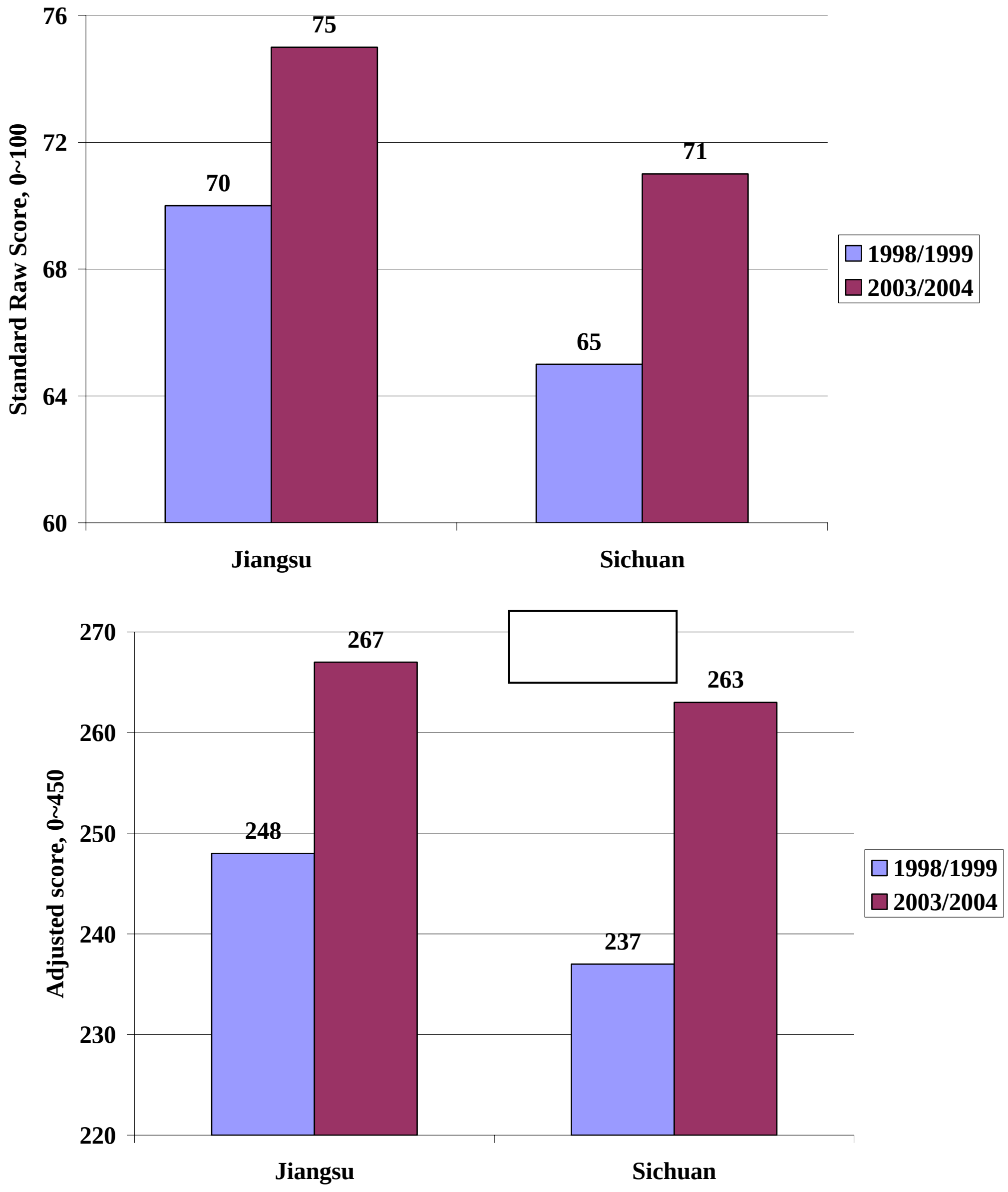
Figure 2. Increase in the Quality of Infrastructure over Time, China



Source: Authors' survey.

The positive relationship between rising quantity and quality can also be seen when we examine the quality of infrastructure projects by province. The scores rose in all provinces—although at different rates in different provinces. For example, in Sichuan province, one of the poor provinces in China, the standard raw score of infrastructure projects increased from 65 in 1998 to 71 in 2003. A similar pattern appears in Jiangsu, one of the better-off provinces in China. The standard raw score of infrastructure projects in Jiangsu increased from 70 in 1998 to 75 in 2003 (Figure 3, Panel A).The rising pattern of infrastructure projects across provinces of our sample also holds when using the adjusted scores. During the same time period, the adjusted raw score of infrastructure projects province increased from 237 to 263 in Sichuan. In Jiangsu the adjusted raw score rose from 248 to 267 (Figure 3, Panel B).

Figure 3. Increase in the Quality of Infrastructure over Time, Jiangsu and Sichuan



Source: Authors' survey.

Correlations between Measures of Infrastructure Quality and Farmer Satisfaction

One question arises when looking at project quality. Is the quality of projects something that farmers observe and/or demand? To answer this question, we take advantage of the information that enumerators collected in the household part of the survey to create two measures of farmer satisfaction with the project. The first satisfaction measure, SM_i, is the average of a binary evaluation of project quality by eight sample farmers in each village. The question that enumerators asked was: Do you believe that <such and such project> could be called "successful"? We then took the answer from each of the j=8 households (SMij=1, if household j believed project i was successful and SMij=0 if they believe the project was not) and created SMi as the sum of SMij/8.

The other satisfaction measure is a subjective project benefit ranking index that was constructed by a normalization procedure used by McPeak *et al*. (2006). To explain how this measure was created, let i denote project (i=1,…,N) where N denotes the total number of projects undertaken in this village during sample period. We then define a new variable, R_i, which represents the rank order of each individual project among all of the projects that were implemented in the village during the study period. Based on these definitions, we can produce a measure of the *benefit ranking index* of project i, denoted as RI_i, as $RI_i = [1-(R_i-1)/N]*100$.[6]

To illustrate how this measure works, suppose that there is a village in which a total of 8 projects were undertaken during 1998-2004. Also suppose that a farmer from this village ranked a particular road project 3rd among all of the village's 8 projects. From the farmer's point of view, the benefit ranking index (RI_i) of this road project would be 75 [=$(1-\frac{3-1}{8})$*100]. This means the farmer believed that this road project in his/her village brought local residents more benefits than 75 per cent of all other projects undertaken in this village during the sample period.

Using the first measure of farmer satisfaction, SM_i, our data demonstrate that farmers are largely satisfied with the infrastructure projects that were constructed in their villages between 1998 and 2004. During the sample period SMi=0.91. This means that, on average, 91 per cent of farmers stated that they believed that the infrastructure projects in their villages were "successful". Across China's provinces, SMi ranges from 0.82 in Sichuan and Shaanxi (the two lowest provinces) to 0.97 in Jilin.

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[6] It can be shown quite easily that, by definition, the benefit ranking index of an average project would be greater than 50 per cent (or 0.5).

$$RI_i = [1-(R_i-1)/N]$$

$$\Rightarrow \sum_{i=1}^{N} RI_i = \sum_{i=1}^{N} [1-(R_i-1)/N] = N - \sum_{i=1}^{N} \frac{R_i-1}{N}$$

$$= N + 1 - \frac{N(N+1)}{2N} = \frac{(N+1)}{2}$$

$$\therefore \text{The average of RI} = 0.5 + \tfrac{1}{2N} > 0.5 \quad \text{QED}$$

According to our other measure of farmer satisfaction, RIi, farmers appear to be somewhat more satisfied with the core projects when comparing them to the non-core projects. On average, the core projects are in the 69th percentile. In other words, the typical core infrastructure project in our sample is better than 69 per cent of all of the projects undertaken in the village in terms of benefits that farmers believed the projects brought to the village.

Importantly, for our analysis, our data also show that farmer satisfaction and project quality are positively correlated. For example, the correlation coefficient between the ranking of a project's benefit (RIi) and its standard raw score (SRSi) is 0.21; it is 0.23 between RIi and the adjusted score (ASi). The correlation coefficients are both significantly different than zero at the 10 per cent level. Since our data show that the quality of a project is correlated with farmer satisfaction, we believe it is possible to infer from this that quality is at least somewhat related to the welfare that rural households derived from the infrastructure project.

We find similar results when we examine the relationship between our other measure of farmer satisfaction (SMi) and project quality. To examine this relationship we divide our core projects into two types and compare their quality: those in which all eight farmers believe that the project is successful (or SMi = 1.00). We call this type of project a *unanimously successful project*). The other type of project is one in which less than eight farmers believe that the project is successful (or SMi<1.00). We call this type of project a *not-unanimously successful* one. According to our data, unanimously successful projects tend to have higher quality (in terms of the SRS and AS measures). Specifically, on average, the standard raw score of the unanimously successfully projects is 73. The standard raw score of the not-unanimously successful projects is 68. This difference is significant at the five per cent level.

From examining the simple descriptive correlation analyses between farmer satisfaction and project quality, it is clear that we need to keep several issues in mind when we are interpreting our results. Although significant, the correlations between farmer satisfaction and project quality, while positive, are still relatively low. Why is this? Of course one possibility is that our indices of quality are measured with substantial error. It could also be that, while farmers equate the success of a project with its quality, there are other factors that they also value (such as the size of the project). It is possible that while farmers value quality, they do not want a project in which the quality standard was set too high (assuming that quality comes at a cost). Although there is little we can do in this paper to correct for these shortcomings and uncertainties, at the very least this needs to be remembered when interpreting the results.

Is Quality Being Compromised During Quantity Expansion?

In this section, our primary purpose is to examine whether or not there is a negative relationship between the *quality* and the *quantity* of infrastructure in rural China's villages and to do so in a way that is more rigorous than above. We will address this question on two different levels. First, we test whether or not there is a negative quality–quantity relationship at the project level within village. In other words, we want to see if a village invests in two projects, whether or not the larger one is higher or lower quality than the smaller one, *ceteris paribus*. We will call this the *within village quantity–quality tradeoff* or for short the *within village* measure. Second, we then examine whether or not when one village invests more in quantity terms the average quality of the investments is hurt or enhanced compared to a village that invests less. We will call this the inter-village measure of the quantity-quality tradeoff.

Within village quality–quantity tradeoff

To examine the within village quality–quantity tradeoff we do a series of multivariate analyses. We start simply, by regressing the standard raw scores of an infrastructure project on the investment volume of this project, controlling for village effects with village dummies.[7] Then we control for an additional set of project-specific factors, including project age, the sources of their funding as well as a number of other variables that measures the ways that projects within a village differ in terms of their initiation, the application process, design and implementation. In both models, we also included project type dummies to capture the differences in different types of projects as well as in the ways that different types of projects are scored.

The results of the multivariate analysis of the quality–quantity relationship at the project level demonstrate that the models perform fairly well. The goodness of fit measures (R-square ranges from 0.72 to 0.79) are relatively high. The F-test of the joint significant test that the village dummies are needed to explain inter-village differences in quality (the focus of the analysis below) show that as a set the village dummies are highly significant. Interestingly, none of the project characteristics come up as significant.[8]

When examining our coefficient of interest (on the project quantity variable), it is clear that the within village analysis leads us to a conclusion in which we reject the hypothesis that quality is being compromised when the quantity of infrastructure is expanding. In none of the two models is the coefficient on project investment variable negative (Table 2, row 1). In fact, in both regressions, the coefficients are positive and significant at least at the 10 per cent level (columns 1 and 2). This means that on average the bigger project in each village is of somewhat higher quality.

[7] Because of the nature of the way we constructed our variables, it can be shown that standard raw scores and adjusted scores are highly correlated and can both be used in our analysis as measures of infrastructure quality. Our data show that the correlation coefficient between the standard raw scores and adjusted scores is 0.92 (and significant at one per cent level). By this, we can have confidence that both standard raw scores and adjusted are related to each other. We also perform a sensitivity exercise to see how robust our findings are. Specifically, we used the adjusted scores instead of standard raw scores. In such a case we could not find any substantive difference in our basic findings that we got from using the quality measure of standard raw scores.

[8] More detailed discussion and interpretations of these results are given in a companion essay titled "Can Good Projects Succeed in Bad Communities". In that paper, we seek to identify the determinants of quality, with a focus on examining which factors affect project quality more, project characteristics or village characteristics.

Table 2. Multivariate Results Examining the Relationship between the Quality and Quantity of Infrastructure at the PROJECT Level in Rural China

	Dependent variable: Project Quality in Standard Raw Score	
	(1)	(2)
Project Quantity		
Project size in 1,000 Yuan	0.022	0.016
	(3.43)***	(1.77)*
Project characteristics		
project proposed by villagers, 1=yes, 0=no		16.719
		(1.68)
project proposed by villager committees, 1=yes, 0=no		11.345
		(1.65)
village committee applied the project, 1=yes, 0=no		-4.231
		(0.68)
Township or above government officials applied the project, 1=yes, 0=no		12.386
		(1.24)
contractor designed the project, 1=yes, 0=no		-0.748
		(0.08)
Villagers implemented the project, 1=yes, 0=no		-2.717
		(0.25)
villager leaders implemented the project, 1=yes, 0=no		-20.521
		(1.56)
Township or above government implemented the project, 1=yes, 0=no		-13.919
		(1.28)
contractors implemented the project, 1=yes, 0=no		0.025
		(0.00)
project funded by above only, 1=yes, 0=no		1.928
		(0.23)
project funded by village/farmers only, 1=yes, 0=no		-6.293
		(0.99)
Project age in month		0.107
		(1.19)
Project type dummies		
Road project, 1=yes, 0=no	3.359	3.129
	(0.75)	(0.56)
Drinking water project, 1=yes, 0=no	10.782	10.164
	(1.77)*	(1.45)
Village dummies	YES	YES
Constant	59.773	54.434
	(8.80)***	(3.12)***
Observations	154	153
R-squared	0.72	0.79

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Between village quality–quantity tradeoff

Although we do not find any evidence that quality is being compromised at the project level, we still do not know whether this is so when examining between village differences. Before we proceed to test whether there is a negative quality–quantity relationship at the village level, however, we need to get measures for the quality and the quantity of infrastructure at the village level. For the quantity of infrastructure, it is relatively straightforward. Total (or average per year) village-level investment can be generated by adding up the total quantity of investment effort in value terms.

In contrast, it is relatively more complicated for two reasons to produce a measure of the total (or average) level of infrastructure quality in a village. First, in most of our villages (more than two-thirds of them) there were at least two infrastructure projects in which the measured level of quality varied significantly. For example, the quality of infrastructure projects in one village ranged from 28 to 80 out of 100 in terms of the standard raw score. In fact, in 10 per cent of our villages, there was at least a 40 percentage point gap between the project that scored the highest quality and the project that scored the lowest.

Second, one must also consider how to weight each of the projects when producing a measure of the average level of quality. The basic problem is that infrastructure projects are denominated in different units (for example, kilometers of roads, hectares of irrigated area, the number of households getting access to drinking water). Therefore, unlike the case of investment quantity, there is no natural way of weighting the quality of infrastructure projects since the units in which they are denominated are not addable. Consequently, the fundamental challenge that we face is how to weight the quality of each infrastructure project to produce an average level of infrastructure quality for each sample village.

Given these two considerations, there are two alternative weighting schemes that we use to produce a measure of the average level of infrastructure quality for each village. The first one, which is the least sophisticated one, is created by computing the simple average of the quality of infrastructure projects in the village. In other words, each infrastructure project—no matter what size or degree of complexity—is given a weight of 1. We call this type of measure the *simple average*.

While this is one approach, in many cases it is easy to understand why a measure based on a simple average may not account for the fact that "not all projects are created equal". In our sample, some infrastructure projects were big while others small. The average within village standard deviation of the project size for villages with more than two projects is 151 thousand yuan. Sometimes, the differences can be extreme. For example, the size of an infrastructure project in one village was 25 thousand yuan; the size of another project was 510 thousand yuan. In this case, if we used a simple average the weight of the quality of the 25 thousand yuan project would be the same as the weight of the 510 thousand yuan project. Hence, in cases in which there are large differences in the sizes of infrastructure projects within a village, we could also give more weight to the larger projects. Therefore, in addition to the simple average, we also produce an alternative measure that weights the quality of each infrastructure project in a village by its investment share. In the rest of the paper this is called the *weighted-average measure*.

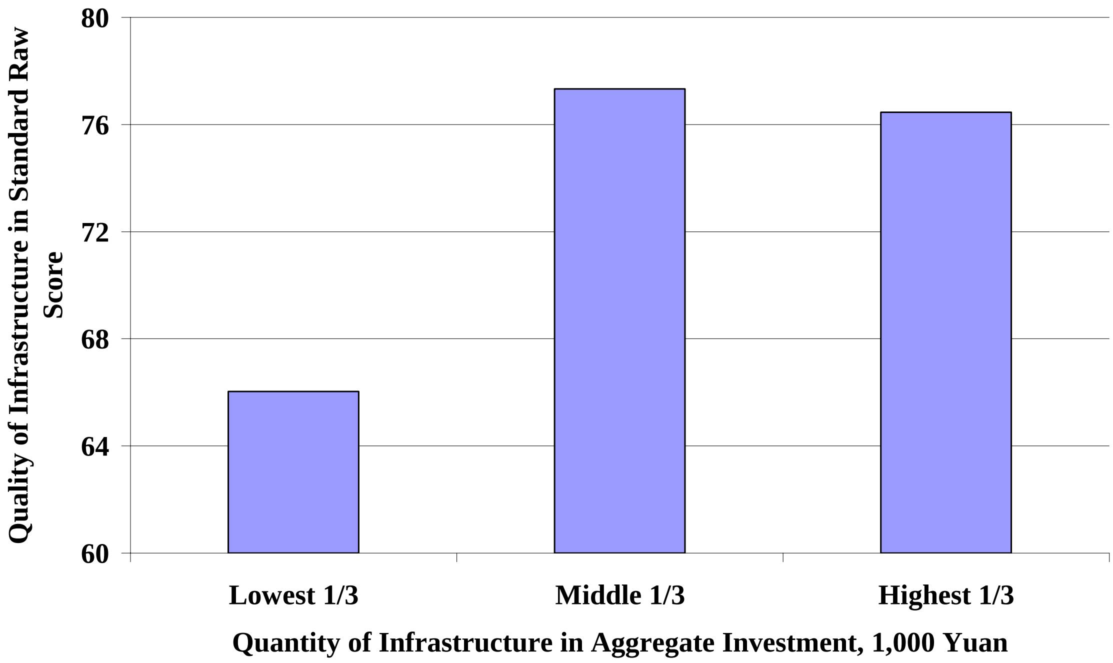
Using the different measures of the average *quality* and total *quantity* of infrastructure investment at the village level, we take two steps to examine whether quality is being compromised for quantity. First, we begin with a relatively simple, but transparent examination of descriptive statistics. We generate a simple bar chart comparing *quality* and *quantity*. We also use nonparametric analysis to examine whether or not there is a negative or positive correlation between quality and quantity.

Second, and importantly, we also conduct multivariate analysis to examine in greater depth the relationship between quantity and quality by holding other things constant and looking at the net relationship between quantity and quality. In our analysis, we focus on the standard raw score of infrastructure project as it is the variable that is most highly correlated with farmer satisfaction.[9] Because of the uncertainty over which weighting scheme we should be using for creating the measures of the average project quality in a village, we present the results from our analyses using both measures.

Results of Descriptive Analysis

Despite the concerns of some that the *quality* of infrastructure in rural China is being compromised for *quantity* (Yang *et al*., 2005; Huang and Xia, 2006), results from our descriptive analysis show at least a neutral relationship between the quality and quantity of infrastructure. As villages move from the lowest tercile when ranked in terms of volume of investment (that is, those villages that have received the lowest volume of investments) to the highest tercile, the standard raw score of infrastructure projects in a village increases from 66 to 76. This pattern suggests that there is a positive rather than negative relationship (Figure 4).

Figure 4. Quality and Quantity of Infrastructure Projects at the Village Level



Source: Authors' survey.

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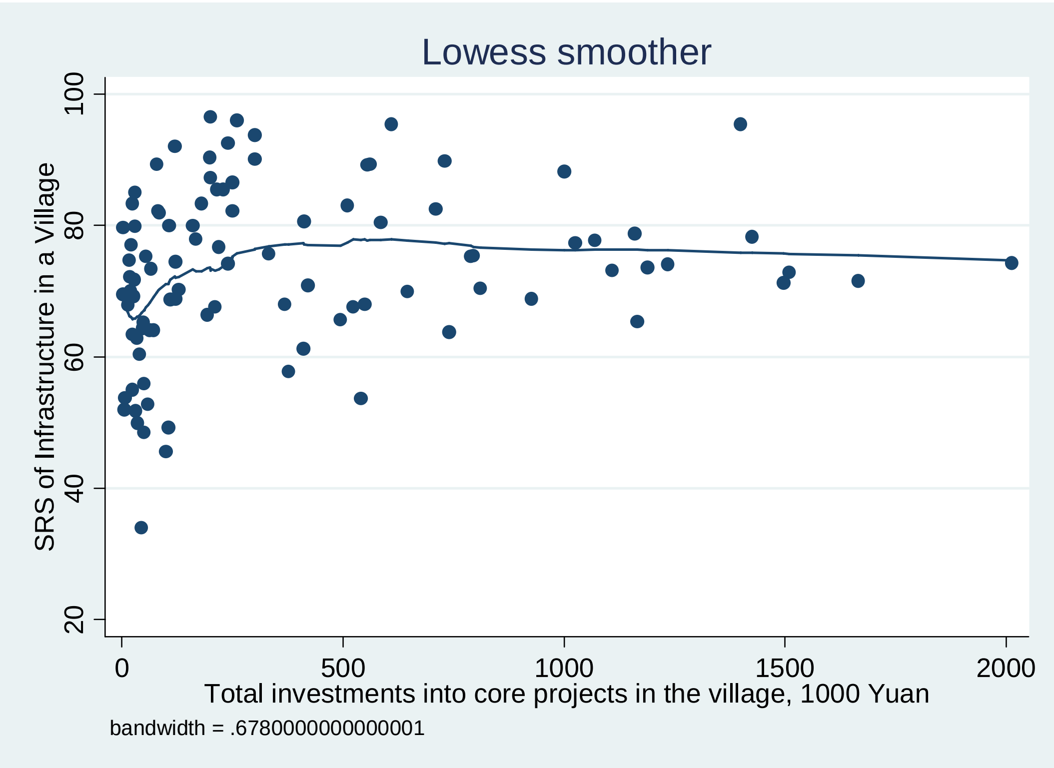
[9] The analysis could easily be done with adjusted scores and the fundamental findings are identical. Moreover, the adjusted scores are not needed in the multivariate analysis since we can control for the adjustment factors by including them as right hand side variables in our regression equations. Results using adjusted scores are available from the authors upon request.

If the relationship between quality and quantity of infrastructure is non-linear across quantity space, it would be important to identify the full range of the quality–quantity relationship. Hence, rather than aggregating measures into a comparison of two point estimates (as the bar chart does) nonparametric regression can be used. In this analysis we use a locally weighted regression or LOWESS estimator. Like other nonparametric analysis, LOWESS estimator has the benefit that it makes no assumptions about functional form, allowing the data to "speak for themselves" (Delgado and Robinson, 1992).

Results from our non-parametric analysis suggest that there is no evidence that quality falls when the quantity of investment rises in a village. The smoothed scatter plot does not trace out a downward sloping curve (Figure 5). In fact, the plot seems to show that the relationship between quality and quantity of infrastructure, if anything, rises gradually at lower volumes of infrastructure investment. After 500 thousand yuan (which would mean for only the largest eight per cent of the projects in our sample villages), the smoothed curve flattens gradually.

Figure 5. Correlation between Quality and Quantity of Infrastructure in Rural China, All Sample



Source: Authors' survey.

Multivariate Analyses

To examine further the relationship between the quality and quantity of infrastructure in rural China, we do a series of multivariate analyses. We start simply, by regressing the mean standard raw scores of infrastructure projects in a village on the aggregate investment volume in the village, controlling for the presence of different types of infrastructure projects in the village (Specification 1). Next, we control for an additional factor, the age of infrastructure projects, since it could be that quality deteriorates over time as part of the normal rate of depreciation (Specification 2). In Specification (3) we add a number of other variables that can explicitly control for the environment in which a project was constructed. In Specification (3), we add a number of other variables that should explicitly control for the environment in which a project was constructed. Finally, we replace the project environment variables used in specification (3) with the three additional control variables to account for the three adjustment factors (those that turn the standard raw score into the adjusted score and captures the complexity of the environment in which the project was designed and implemented), namely, physical difficulty, complexity and local participation factors. Finally, we replace the project environment variables used in specification (3) with the three additional control variables to account for the three adjustment factors (those that turn the standard raw score into the adjusted score and captures the complexity of the environment in which the project was designed and implemented), namely, physical difficulty, complexity and local participation factors. In summary, we are going to estimate the following four empirical specifications:

Specification (1): $QL_i = \alpha_0 + \delta QT_i + \gamma_1 Z_{1i} + \varepsilon_i$

Specification (2): $QL_i = \alpha_0 + \delta QT_i + \gamma_1 Z_{1i} + \alpha_1 Age_i + \varepsilon_i$

Specification (3): $QL_i = \alpha_0 + \delta QT_i + \gamma_1 Z_{1i} + \alpha_1 Age_i + \gamma_2 Z_{2i} + \varepsilon_i$

Specification (4): $QL_i = \alpha_0 + \delta QT_i + \gamma_1 Z_{1i} + \alpha_1 Age_i + \gamma_3 Z_{3i} + \varepsilon_i$

where, i is an index for the village; QL_i is a measure of the average quality of the three types of core infrastructure projects in village i; Age and Z_1, Z_2 and Z_3 are control variables that are measured as described in the next paragraph.

To estimate empirically specifications (1) to (4) we need to define the exact variables used in each specification. As we noted earlier in this section, we actually have two alternative measures of infrastructure quality at the village level: the simple average quality, and weighted-average quality. The main explanatory variable of interest, QT_i, is the variable that measures the aggregate volume of investment into the three types of core infrastructure projects in each village (which makes δ the parameter of interest). Age_i is included to capture the average age of each infrastructure projects in months. The variable Z_{1i} is a vector of dummy variables which help define the mix of the type of projects in each village. Specifically, the dummy variables indicate whether village i has road projects only, drinking water projects only, irrigation projects only, or some mix of core projects (that is, any two of the three types of projects or all three types of projects—in total there are seven variables in Z_1).

In addition, the specifications (3) and (4) contain a number of other control variables. The variable Z_{2i} is a vector composed of the three adjustment factors: the degree of physical or geographical difficulty; the complexity of the project; and the degree to which local residents participated in the design and implementation of the project. The term Z_{3i} is a vector of covariates that are included to capture village characteristics, including the percentage of village land that has a slope greater than 25 degrees; the distance in kilometers between the two furthest small groups in the village; the distance in kilometers from the village committee to the township seat; the distance in kilometers from the village committee to the nearest road; two dummy variables indicating whether an infrastructure project was funded either by funds coming from above only or from funds coming from the village only. Summary statistics of the variables used in the multivariate analyses are reported in Appendix Table 2.

Results of Multivariate Analysis Using the Simple Average Measure of Quality

The results of the multivariate analysis of the quality–quantity relationship that uses the simple average quality as the dependent variable demonstrate that the models perform fairly well and produce results that are mostly consistent with the descriptive analysis. The goodness of fit measures (R-square ranges from 0.12 to 0.41) appear to be sufficiently high and rise as more covariates are controlled for. Some of the results also are consistent with our expectations. For example, in villages where a higher fraction of infrastructure projects is solely funded by villages themselves the quality index of the infrastructure projects tends to be lower (Table 3, Column 4). Similarly, the more autonomous was the village's effort in the design and implementation of infrastructure projects, the poorer is the quality of infrastructure projects in their village. Both of these results are consistent with the finding of Khwaja (2002) who finds that quality suffers when villagers (who are not experts) get involved in technical matters. Another result that is consistent with our intuition is that the more physically challenging the terrain, the poorer the quality of the infrastructure (Column 3). Throughout our analysis, the results of Specifications (3) and (4) have a much higher goodness of fit (or R-square) statistic than Specifications (1) and (2), in part reflecting the importance of capturing the environment in which projects were constructed.

When examining our coefficient of interest (on the investment quantity variable), the analysis leads us to a conclusion in which we reject the hypothesis that quality is being compromised when the quantity of infrastructure is expanding. In none of the four models is the coefficient on the investment quantity variable negative (Table 3, row 1). When we either use the simple regression model (specification 1) or control for the age the project (specification 2), the coefficient of interest is positive and significant at the 5 per cent level (columns 1 and 2). The coefficient remains positive, albeit they are insignificant, when we for the difficulty factors (column 3) or control for other project environment variables (column 4).[10]

[10] While there is a positive measured relationship between quality and quantity (at least in models 1 and 2, using simple average measure of quality), the magnitude of the rise in quality is small at the margin as quantity rises. This can be seen by examining the magnitudes of the coefficients. Across the four models the size of δ ranges from 0.003 to 0.006. This means that, everything else held constant, when the infrastructure investment in a village increases, the overall quality of infrastructure in that village actually improves slightly. According to the magnitude of the

Table 3. Multivariate Results Examining the Relationship between the Quality and Quantity of Infrastructure at the Village Level in Rural China, WHOLE Sample

	Dependent variable: Unweighted Quality of Infrastructure in a Village			
	(1)	(2)	(3)	(4)
Aggregate investment in core infrastructure projects, 1,000 Yuan	0.006	0.006	0.003	0.004
	(2.18)**	(2.15)**	(1.35)	(1.11)
Attributes of an average core project				
Age in month of core projects		0.001	-0.020	-0.070
		(0.02)	(0.36)	(0.95)
Were core projects funded by above only?				-8.167
				(1.54)
Were core projects funded by village only?				-9.372
				(2.57)**
Were core projects implemented by above?				-1.515
				(0.34)
Adjustment factors:				
Geographical factor of core projects			-25.083	
			(3.99)***	
Completeness factor of core projects			10.914	
			(1.28)	
Participation factor of core projects			-24.321	
			(3.56)***	
Village characteristics				
% of hilly land over 25 degree in total land area in the village				-0.004
				(0.07)
the farest distance between two small groups within this village, km				-0.123
				(0.23)
the distance between village committee and township seat, km				-0.280
				(0.82)
the distance of the nearest road from the village seat, km				-0.017
				(0.14)
Dummy variables indicating presence of certain types of projects	YES	YES	YES	YES
Constant	71.923	71.904	113.857	82.252
	(13.77)***	(13.48)***	(6.71)***	(11.96)***
Observations	94	94	93	94
R-squared	0.12	0.12	0.41	0.23

Note: Absolute value of t statistics in parentheses,* significant at 10%; ** significant at 5%; *** significant at 1%

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coefficients for the models using the investment share-weighted standard raw score as the dependent variables, in a village in which there is an increase of 100 thousand yuan of infrastructure investment (the average size of project in rural China is about 170 thousand yuan), the overall quality of infrastructure in a village rises by 0 (in the cases where the coefficients are insignificantly different from zero) to 0.6 point. This is equivalent to a rise in quality which is equal to four per cent of one standard deviation. In summary, at the very least we can say that, when we use the simple average of the quality of the projects in each village, quantity is not being expanded at the cost of quality; in fact, when we use some of the models, it is rising, albeit only fractionally.

The same basic results hold when we redo the same regressions that use the simple average measure of quality on a sub-sample of the villages that implemented at least one road infrastructure project. In this analysis we only include road projects (a homogeneous set of project types) in order to eliminate any problem that might be arising from our use of a more heterogeneous set of projects. Even when using only road projects, as above, we find that the measured relationship between quantity and quality is not negative. In all of the models, the coefficients on the road investment variable are all positive (Table 4, row 1). When we control for the physical difficulty, complexity and local participation factors, the coefficient is positive and significant at the 5 per cent level (column 3). This means that, everything else held constant, when the investment into the road network of a village increases, the overall quality of the road infrastructure in that village actually improves slightly.

Table 4. Multivariate Results Examining the Relationship between the Quality and Quantity of Infrastructure at the Village Level in Rural China, ROAD Sub-Sample

	Dependent variable: Unweighted Quality of ROAD Infrastructure a Village			
	(1)	(2)	(3)	(4)
Aggregate investment in road projects, 1,000 Yuan	0.005	0.005	0.007	0.005
	(1.40)	(1.32)	(2.46)**	(1.45)
Observations	81	81	82	80
R-squared	0.59	0.59	0.72	0.67

Note: Absolute value of t statistics in parentheses,* significant at 10%; ** significant at 5%; *** significant at 1%

Results of Multivariate Analysis Using the Weighted Average Measure of Quality

In contrast to the descriptive findings and to the findings reported in Tables 3 and 4 (which use the simple average quality measure), the results of the multivariate analysis that uses weighted average quality show that there is a negative relationship between quality and quantity of infrastructure in rural China (Table 5).[11] The coefficient of interest, δ, is negative in all eight cases. In six out of the eight cases, the coefficient is statistically significant. The negative coefficient suggests that the quality of China's rural infrastructure projects have fallen over time and that they are lower in places that have higher levels of spending on infrastructure investment.

Hence, the differences between the regressions that use simple average quality and weighted average quality measures of the dependent variable (aggregate quality) suggest that how the measures of quality are created matters. While we are not sure exactly why it is that the results differ, one explanation is consistent with the interpretation that in villages in which there are small *and* large projects, the quality of the larger projects are low enough

[11] In this section we report the results for eight regressions (for each of the four models—Specifications 1 to 4—we run regressions using the whole sample and on the sample of those villages with road infrastructure projects).

(in relative terms) to eliminate, and even reverse, the positive relationship that is found in the simple average quality regressions. To test empirically whether such an explanation is valid in this analysis, we divided villages into 2 types: those with projects that are all of similar size (type 1 villages), and villages with projects that vary in size (type 2 villages). In doing this, by "vary in size" we mean that the coefficient of variation of investment size of projects in a village is more than 0.4.[12] With this classification system, we reran the version of specifications (1) to (4) that uses weighted quality measures as the dependent variable for type 1 and type 2 villages separately. Results from regressions using sub-samples of villages show that the coefficients on investment quantity variable remains negative in each of these regressions using the sub-sample of type 1 villages. Moreover, the coefficients are statistically different from zero in specifications (3) and (4). In contrast, the coefficients on investment quantity variable become positive in each of these regressions using the sub-sample of type 2 villages, and the coefficients are statistically significant from zero in specifications (1) and (2).[13]

Table 5. Multivariate Results Examining the Relationship between the Quality and Quantity of Infrastructure at the Village Level in Rural China

	Dependent variable: Investment Share weighted Quality of Infrastructure a Village			
	(1)	(2)	(3)	(4)
WHOLE sample				
Aggregate investment in infrastructure projects, 1,000 Yuan	-0.004	-0.006	-0.010	-0.012
	(1.02)	(1.32)	(2.70)***	(2.63)**
Observations	95	94	93	92
R-squared	0.54	0.56	0.72	0.63
ROAD Sub-Sample				
Aggregate investment in road projects, 1,000 Yuan	-0.034	-0.035	-0.032	-0.037
	(4.46)***	(4.57)***	(4.30)***	(4.45)***
Observations	79	79	78	78
R-squared	0.54	0.55	0.63	0.60

Note: Absolute value of t statistics in parentheses,* significant at 10%; ** significant at 5%; *** significant at 1%

Perhaps most importantly, it should be noted that, although the coefficients are negative, their magnitudes are small in all of the regressions using the weighted measures of quality. Specifically, the coefficients from the regressions using all of the core projects (and using the entire sample of

[12] The coefficient of variation is simply the standard deviation of a variable divided by the mean. The coefficient of variation on investment quantity variable ranges from 0 to 1.88. One thing that needs to be considered in classifying sample villages in this way is to make sure that we have enough sample villages to run regressions using these two types of villages separately.

[13] We also tried other cut-off values of coefficient of variation to classify our sample villages into type 1 and type 2. Regardless of the cutoff values, the coefficients on investment quantity variable remains negative in each of these regressions that uses the sub-sample of type-1 villages. However, for the regressions that uses the sub-sample of type-2 villages, the coefficient on investment quantity variable become positive in three out of four cases when the cutoff is set at 0.5; positive in tow out of four cases when the cutoff is set at 0.6, 0.7, 1.0, and 1.3, respectively.

villages) range from -0.006 to -0.012. For a typical village in our sample, the aggregate infrastructure investment is 464 thousand yuan, with a standard deviation of 473 (Appendix Table 2). In the typical village, the average investment share-weighted quality is 73 (out of 100 points). The standard deviation of the quality variable is 13 points. According to the magnitude of the coefficients for the models using the weighted average models, in a village in which there is an increase of 100 thousand yuan of infrastructure investment, the overall quality of infrastructure in a village would fall by 0.6–1.2 points. This is equivalent to fall in quality which is equal to less than 10 per cent (or, more exactly, 5 to 9 per cent) of one standard deviation. With coefficients of this size, the magnitude of the quantity-quality tradeoff is almost negligible.

The pictures of the projects can also be used to illustrate the nature of the difference in projects that large and small using a bit naïve (but perhaps revealing) way. We do so by lining up all of photos of all of projects and ranking them by their quality scores. After doing so, it is virtually impossible to detect a difference in quality of projects that are 3 to 5 points apart, not to mention those that are much less than 1 point apart. In other words, when looking at our results from the descriptive analysis, when looking at our results from the multivariate analysis using the simple average quality as the dependent variable, and when looking at the results of the multivariate analysis using the weighted average quality as the dependent variable, quality in any real sense is not being compromised.

Summary and Conclusions

In this paper, we have used data that our collaborators in China have collected to create profiles of the quantity and the quality of infrastructure in rural China. The main question that we are interested in exploring is whether or not investment quality is being compromised when the quantity of infrastructure is expanding in rural China. Our short answer to this question is that quality is not being compromised—at least not in any material way. In fact, using descriptive results, we have discovered that in recent years both the quantity and the quality of infrastructure in rural China increase over time and vary across space. Moreover, contrary to the concern expressed by some (Zhao, 2005; Ma and Fang, 2005), the quality of infrastructure in rural China is not being compromised for its quantity expansion during the entire sample period.

So why is it that quality is rising over time? According to our data the average quality of China's projects went up by 2 points between 1998 and 2003 when using the standard raw score measure of quality (10 points when using the adjusted score measure). We have concluded that quality is not rising with the expansion of quantity, so what is causing it? Looking to the other factors in Specification 4, we find that the main coefficient that is significant is the one that is associated with the village-funded only variable. Moreover, the coefficient is negative and significant, meaning that the quality of projects is lower in villages with more village-funded-only projects. Since the share of village-funded only projects have fallen over time (from 49 per cent in 1998 to 40 per cent in 2004) and the share of projects that are funded by the government above only have risen (from 10 per cent to 24 per cent during the same period), at least in part this is accounting for some of the observed rise in quality. From this point of view, far from criticizing the leadership for pushing too many projects too fast (as some have), leaders should be praised for being able to increase quality while they have expanded infrastructure investment.

However, there are two points that we think worthy of noting here. One point is that, although our data show that most farmers in sample villages are satisfied with infrastructure delivered to their villages, our field survey shows that farmers said they still need more infrastructure, and they still want better-quality infrastructure. The other point is that, although our data show that both the quantity and the quality of infrastructure in rural China are rising during the sample period, if we compare China with its neighboring nations in East Asia (empirically, Japan and South Korea) at certain points of their development path, we see that China still faces challenges in improving its rural infrastructure. Therefore, while there has been progress, from a comparative perspective the process in China is just beginning and needs to be followed up by a long-term commitment to make massive and sustained investments in rural areas to provide more and better-quality infrastructure.

If this is true, at the same time that praise is being given to China's leaders for their efforts, they should also be encouraged to continue along the same path and expand future investment in rural infrastructure—while trying to maintain or even improve quality. In fact, it appears that this is exactly where this country is heading. According to the new 11th five-year plan (NDRC, 2006), China is committing itself and is actually in the process of making massive additional new investments in rural infrastructure. Leaders should make every effort to meet and exceed the plan in volume and continue its efforts to improve project quality.

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Appendix Table 1. Mean of Adjustment Factors by Category

Category	Geographical difficulty	Complexity	Local participation	Adjustment weight
	(1)	(2)	(3)	(4)=(1)+(2) +(2)
Section A: Province				
Jiangsu	1.08	1.24	1.26	3.58
Sichuan	1.18	1.16	1.32	3.67
Shaanxi	1.39	1.39	1.37	4.14
Jilin	1.07	1.27	1.14	3.48
Hebei	1.03	1.35	1.26	3.64
Section B: Project inception year				
1998/99	1.20	1.26	1.29	3.76
2003/04	1.15	1.26	1.29	3.71
Section C: Project type				
Roads	1.17	1.28	1.26	3.71
Drinking water	1.24	1.30	1.36	3.90
Irrigation	1.10	1.23	1.30	3.63
All Sample	1.16	1.27	1.29	3.72

Source: Authors' survey.

Appendix Table 2. Summary Statistics of Variables Used in Multivariate Analyses

Variable	Mean	Std. Dev.
Average standard raw score of infrastructure projects	73.3	12.7
Aggregate investment in infrastructure projects, 1,000 Yuan	463.7	473.4
Average project age in month	26.5	19.1
Fraction of infrastructure projects funded by above only	0.1	0.3
Fraction of infrastructure projects funded by village only	0.5	0.4
Fraction of infrastructure projects implemented by village only	0.7	0.3
Geographical factor of core projects	1.1	0.2
Completeness factor of core projects	1.3	0.1
Participation factor of core projects	1.3	0.2
% of hilly land over 25 degree in total land area in the village	23.6	27.5
the farest distance between two small groups within this village, km	2.4	2.6
the distance between village committee and township seat	5.0	3.9
the distance of the nearest road from the village seat	5.5	10.8
Village has road project, 1=yes	0.34	0.48
Village has drinking water project, 1=yes	0.07	0.26
Village has irrigation project, 1=yes	0.05	0.22
Village has road + drinking water project, 1=yes	0.10	0.31
Village has road + irrigation project, 1=yes	0.31	0.47
Village has drinking water + irrigation project, 1=yes	0.01	0.10
Village has road + drinking water + irrigation project, 1=yes	0.10	0.31