INFRASTRUCTURE INVESTMENT IN RURAL CHINA: IS QUALITY BEING COMPROMISED DURING QUANTITY EXPANSION?

Chengfang Liu, Linxiu Zhang, Renfu Luo and Scott Rozelle

By any measure, China has achieved impressive gains in the expansion of its rural infrastructure in recent years. Investment in rural roads increased rapidly between 2001 and 2004, from 35.8 billion yuan to 124.2 billion yuan, an annual growth rate of 51 per cent.[1] By 2006, 61 per cent of villages were connected to their town's road network by a paved road. Investments in irrigation systems and drinking water facilities also rose sharply.[2] 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.[3]

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 "Building a New Socialist Countryside". Continued improvement in rural infrastructure is among the main goals. According to the recently created Rural Road Development Plan, during the 11th five-year period (2006–10) the national government will invest a total of 100 billion yuan in rural roads.[4] During this same period, the leadership will allocate more than 40 billion yuan to providing drinking water facilities for rural communities.[5]

While few observers dispute that a vast quantity of new funding is flowing into rural China and that the absolute quantity of infrastructure investment is rising, a number of researchers have expressed concerns about the *quality* of the infrastructure

1 Ministry of Communications, *China Statistics Bulletin of Highway and Waterway Development* (Beijing: Ministry of Communications, 2005).

2 Ministry of Water Resources, *China Water Statistics Yearbook* (Beijing: Ministry of Water Resources, 2005).

3 National Bureau of Statistics, *China Agricultural Statistics Yearbook* (Beijing: National Bureau of Statistics, 2005).

4 Ministry of Communications, *China Rural Road Development Plan* (Beijing: Ministry of Communications, 2006).

5 Ministry of Water Resources, *China Water Statistics Yearbook.*

projects being undertaken. For example, Zhao states that rural infrastructure in China is at best characterized as being of "poor quality".[6] Several scholars have cautioned that although 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.[7] The roads are too narrow and the pavement is too thin. Many 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 characterizes the irrigation systems in part of the province's rural areas as seriously flawed.[8] In many villages in Sichuan and Chongqing, drinking water facilities are failing, and rural residents are consequently suffering from drought.[9] In short, no matter how many projects are built, if their quality is poor, the benefits to rural communities will be low.

International experience also shows that quality is as important as quantity for good infrastructure management.[10] Poor quality infrastructure reduces the quality of life and productivity in rural communities. When drinking water facilities are poor, health problems reduce labor productivity and household income, undermining poverty alleviation efforts.[11] A survey of power utilities in 51 developing countries around the world revealed that poor quality led to an average 40 per cent of the power-generating capacity being unavailable at any given time.[12] According to the World Bank, costly investments in road construction are often wasted because of poor quality.[13]

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6 Yu Zhao, "Baozhang woguo nongcun gonggong chanping youxiao gongji de jidian jianyi" (Some Suggestions on Ensuring the Efficient Provision of Public Goods in Rural China), *Nongye jingji* (Agricultural Economy), No. 8 (2005), pp. 14-15.

7 Lin Yang, Yanping Han and Zhimin Sun, "Gonggong caizheng kuangjia xia nongcun jichu sheshi de youxiao gongji" (Efficient Provision of Rural Infrastructure under a Public Finance Framework), *Hongguan jingji yanjiu* (Macro-Economy Study), No. 10 (2005), pp. 56-59; Jianqiang Huang and Bisheng Xia, "Pianyuan shanqu nongcun gonglu jianshe cunzai de wenti ji duice" (Problems and Countermeasures in Constructing Rural Roads in Remote Mountainous Areas), *Nongcun jingyi yu keji* (Rural Economy and Technology), No. 9 (2006), pp. 50-51.

8 Henan Provincial Bureau of Statistics, "Henan nongcun wenti xilie diaocha baogao zhi wu: guanyu tanghe xian nongye zonghe shengchan nengli de diaocha yu sikao" (Investigation Report Series on Problems in Rural Henan No. 5: An Investigation of the Comprehensive Production Capacity of Agriculture in Tanghe County, Henan Province) (Zhengzhou: Henan Provincial Bureau of Statistics, 6 September 2005).

9 "Residents Face Difficulty Getting Drinking Water, Extreme Drought Tortures Local Irrigation Works", *People's Daily* (30 August 2006).

10 World Bank, *World Development Report 1994: Infrastructure for Development* (Washington: World Bank, 1994).

11 Asian Development Bank, *Social and Poverty Impact Assessments* (2000), accessed at http://www.adb.org/Documents/IPSAs/NEP/SPIA-NEP-R206-01/SPIA-NEP-R206-01.pdf, last accessed 27 November 2008.

12 World Bank, *World Development Report 1994.*

13 World Bank, *World Development Report 1994.*

Despite the obvious importance of these subjects, there is little literature in China about the quality of rural infrastructure. Earlier studies focus almost exclusively on the benefits of investing in more and more roads, irrigation systems and other physical infrastructure projects.[14] More recently, there have been several papers focusing 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.[15] To date, however, beyond anecdotal reports, little systematic empirical work has addressed the quality of infrastructure in rural China.[16]

A related question is the extent to which China's rural population is satisfied with the recent investments. This question is raised in some papers, but mainly in anecdotal ways. There is no systematic work examining how satisfied China's rural population is with its infrastructural investment, or relating this satisfaction to objective measures of quality.

This paper examines whether *quality* has suffered as the *quantity* of investment into rural China has risen and whether the rural population's satisfaction has increased with either the quantity or quality of infrastructure investments. To do so, we analyze a new dataset in three ways. First, we describe the trends in the quantity of infrastructure investment in rural China. The purpose of this part of the paper is to see whether the investments that have been reported at the macro-level are penetrating to China's villages. (This part of the paper, while of interest, is really to provide background for the rest of the paper, which focuses on quality.) 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. In addition, 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, has the quality of China's infrastructure been adversely affected? Finally, we examine the

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[14] Shenggen Fan, Linxiu Zhang and Xiaobo Zhang, *Growth, Regional Disparity, and Poverty* (Beijing: China Agricultural Press, 2002).

[15] Linxiu Zhang, Qiang Li, Renfu Luo, Chengfang Liu and Scott Rozelle, "Zhongguo nongcun gonggong wupin touzi qingkuang ji quyu fengbu" (Regional Investment in Public Goods in Rural China), *Zhongguo nongcun jingji* (Chinese Rural Economy), Vol. 11 (2005), pp. 18-25; Linxiu Zhang, Renfu Luo, Chengfang Liu and Scott Rozelle, "Investing in Rural China: Tracking China's Commitment to Modernization", *The Chinese Economy*, Vol. 39, No. 4 (2006), pp. 57-84; Linxiu Zhang, Renfu Luo, Chengfang Liu and Scott Rozelle, "Zhongguo nongcun shequ gonggong wupin touzi de jueding yingsu fenxi" (An Analysis of the Determinants of Public Good Investment in Rural China's Communities), *Jingji yanjiu* (Economic Research), Vol. 11 (2005), pp. 76-86; Renfu Luo, Linxiu Zhang, Jikun Huang, Scott Rozelle and Chengfang Liu, "Cunmin zizhi, nongcun shuifei gaige yu nongcun gonggong touzi" (Direct Election, Rural Tax Reform and Public Goods Provision in Rural China), *Jingji xue* (The Economics Quarterly), Vol. 5, No. 4 (2006), pp. 1295-310.

[16] Yu Zhao, "Baozhang woguo nongcun"; Lin Yang, Yanping Han and Zhimin Sun, "Gonggong caizheng"; Jianqiang Huang and Bisheng Xia, "Pianyuan shanqu".

relationship between the quantity and quality of investments and the satisfaction of the rural population.

Data

Our main data source is the 2005 China Rural Governance Survey (henceforth, 2005 CRG Survey), which we undertook in collaboration with colleagues at the Center for Chinese Agricultural Policy, Chinese Academy of Sciences (henceforth, CCAP-CAS). In this survey, 100 villages were randomly selected from 50 towns in 25 counties located in 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 because Rozelle shows that it is one of the best predictors of standard of living and development potential and is often more reliable than net rural per capita income.[17] 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 each of the 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 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.

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.[18] The 100 villages covered in the 2005 CRG Survey are a subset of

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17 Scott Rozelle, "Stagnation without Equity: Patterns of Growth and Inequality in China's Rural Economy", *The China Journal*, No. 35 (January 1996), pp. 63-96.

18 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; 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

villages randomly selected from the 2,459 sample villages in 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.

Quantity of Investment in Rural Infrastructure

Despite the suggestion by some that China's rural villages are being neglected, our surveys show a high and growing volume of investment in rural infrastructure.[19] 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 government reports on the expansion of the volume of investment into public infrastructure.[20] 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. This means that, on average, during the 5-year sample period each village had 3.75 projects. 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 whether this level of investment is high enough to facilitate China's modernization, compared to other developing countries, it appears that China is generating a relatively high degree of investment. For example, a study by Khwaja of several hundred villages in Northern Pakistan found that only 99 villages had at least one infrastructure project during the previous decade or more. Only 33 villages had more than one infrastructure project.[21]

In addition, China's investment targets are increasingly focused on investment in public goods. During the 1980s, local leaders put much effort into managing village-run development projects.[22] 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, 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

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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.

19 Yu Zhao, "Baozhang woguo nongcun"; Xiaohe Ma and Songhai Fang, "Woguo nongcun gonggong chanpin de gongji xianzhuang wenti yu duice" (Public Goods Provision in Rural China: Current Status, Problems and Countermeasures), *Nongye jingji wenti* (Agricultural Economy Issues) (April 2005).

20 For example, National Bureau of Statistics, *China Agricultural Statistics Yearbook*.

21 Asim Ijaz Khwaja, "Can Good Projects Succeed in Bad Communities? Collective Action in Public Goods Provision", Working Paper, Department of Economics, Harvard University, 2002.

22 Scott Rozelle, *Economics of Village Leaders in Rural China*, Unpublished PhD dissertation, Department of Agricultural Economics, Cornell University, 1990.

trying to improve and diversify the economic bases of their communities. After 1998, however, our data show that leaders put most of their energy into public-goods-oriented investment projects (87 per cent).[23] In value terms, more than 80 per cent of rural investment was spent on public goods.

Leaders also invested in a wide variety of infrastructure projects. Specifically, of the 5,975 public goods projects, sample villages invested in fifteen different types of public goods investment projects (Table 1, column 1). The average size of each type of project was fairly small—108,000 yuan (Table 1, column 2)—although these vary from project to project (from a high for watershed management projects—298,000 yuan—to projects such as clinics and village beautification that were only around 25,000 yuan).

Some types of investment projects, however, were much more popular than others and, in fact, a large majority of all public goods investment projects fell into one of five categories (Table 1, columns 1 and 3). For example, over half of the villages (1,266) invested in roads or bridges, which 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.[24] More than 600 villages invested in drinking-water projects. In total, 75 per cent of all public goods projects were 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.

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[23] In calculating *all* public goods projects, we include investments made in electrical grid and telephone line upgrades. There were nearly 2,000 of these projects in our sample village between 1998 and 2003. In some sense, however, these 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 7,950 to 5,975.

[24] "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, see Jintao Xu and Yiying Cao, "Efficiency and Sustainability of Converting Cropland to Forest and Grassland in the Western Region", Draft report to the China Council for International Cooperation on Environment and Development, Forest and Grassland Task Force (2002).

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

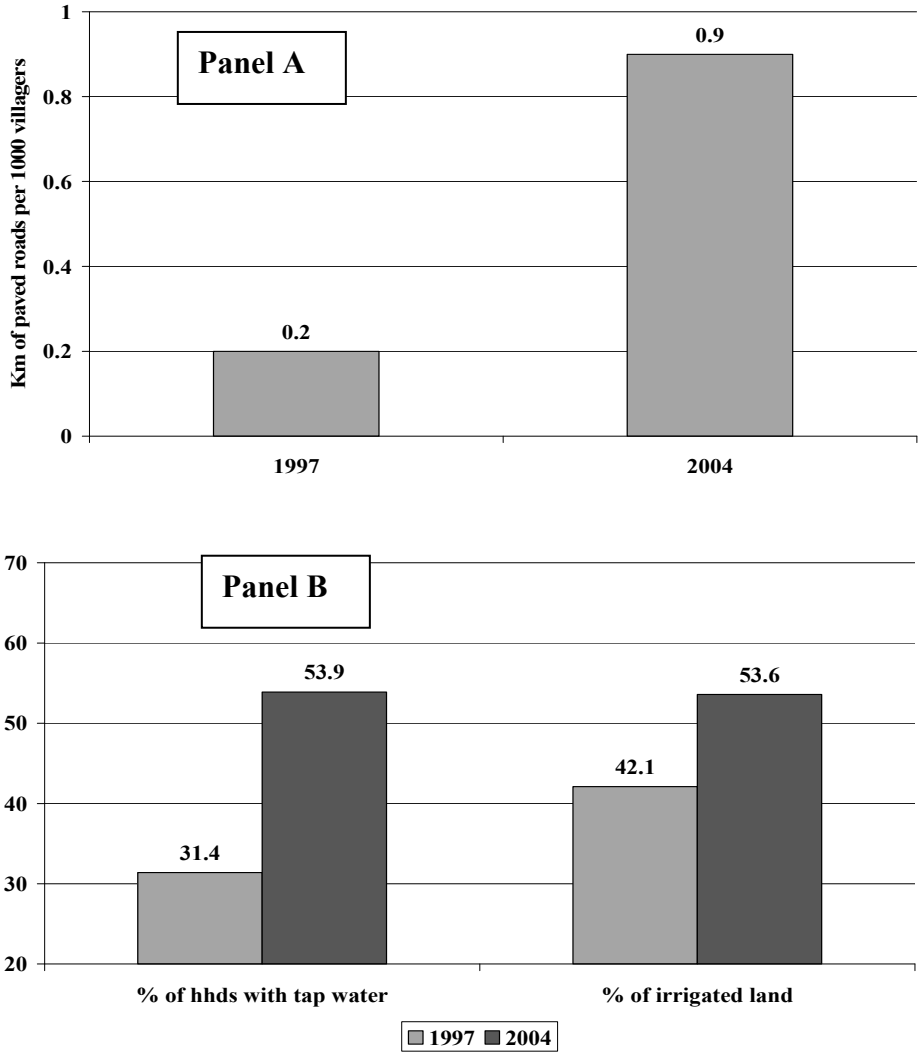
Project	Number of projects	Average size (1000 yuan)	Accumulated distribution of projects
Road/Bridge	1266	112	21.2
Grain for Green	892	67	36.1
School	850	99	50.3
Irrigation/Drainage	819	65	64.1
Drinking water	636	75	74.7
Loudspeaker for village committee	379	60	81.0
Activity/Recreation center	262	50	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.

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 (cited 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 proportion 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 in villages within village boundaries (and does not count infrastructure investments outside the boundaries of villages—such as interprovincial freeways, reservoirs in state forest lands, and projects such as schools and hospitals within the boundaries of county-seat urban districts), 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

Two blocks of the survey were designed to examine issues of investment quality. In the first we asked village leaders about the core infrastructure investment projects in their villages, including detailed questions about each of the three types of such projects: who initiated it, the application process, its design and project implementation. Through this information we are able to understand the entire "life" of a given project from its inception through its completion.

In the second block we utilized a survey instrument that was designed in consultation with professional civil engineers to produce a quality index for each project. Each evaluation form assessed 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: 40 attributes for each road project, 42 attributes for each irrigation project and 37 attributes for each drinking water project.[25]

To analyze the data, a number of points were assigned to each attribute. The number of points reflected 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 allocation of points reflects the opinion of our engineering consultants. If a project's attributes all received the full score, it would add to 100. English translations of the forms for roads, irrigation and drinking water projects are available upon request.

We were concerned that, despite the effort put into creating the evaluation form, there could be a great deal of enumerator-specific subjectivity in assigning scores. To overcome this potential bias, we trained the enumerators intensively as a group, playing many "comparison games" designed to get each of them to assign the same number of points to the same types of attributes. We also created a detailed scoring manual for use by each of the enumeration teams. Finally, the survey team took 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 the evaluations *ex post facto* if they appeared to be out of line with the projects that were ranked immediately ahead of and behind them.

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[25] We think that our measure of quality is comparable to those used in the literature. Lin Yang, Yanping Han and Zhimin Sun ("Gonggong caizheng") discuss the width of road surface and whether the side ditch drains well. We also discuss the width of road surface and whether the side ditch drains well. Jianqiang Huang and Bisheng Xia ("Pianyuan shanqu") discuss the building material and the thickness of road surface; we also discuss the building material and the thickness of road surface.

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. In the case of roads, for example, 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 paper to test for acidity and glass test tubes to check for clarity. As with roads, enumerators 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.

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. 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 that 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 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). So, 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 x 100, or 80 points.

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 the environment of a village's infrastructure project and/or the complexity of the project.[26] In such a case the standard raw scores would not be comparable among all

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

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, a measure we call the *adjusted score*.[27]

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 74 (Figure 2, Panel A). Similar results are found when using the adjusted scores. During the same time period, the adjusted scores increased from 262 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 conclusion that quality was suffering during the recent period of investment expansion.[28]

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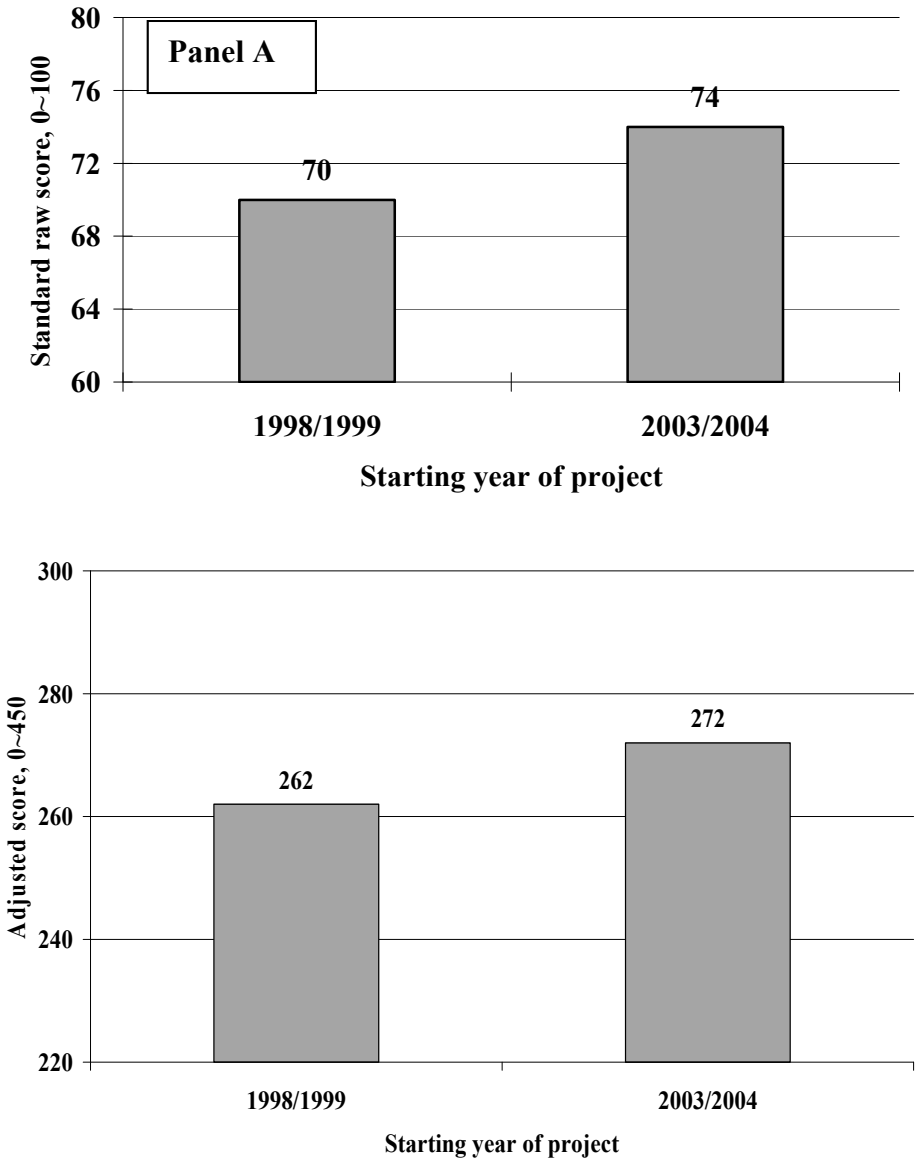
physically challenging environment (for example, in a mountainous area). In contrast, a village implementing a simple project (for example, a short segment of a feeder road linking a nearby county road to the village office) in a village that was located on a plain would have an easier time achieving a higher score.

[27] To create an adjusted score, a variable that reflects the degree of difficulty in implementing projects, 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. The new measure is called the adjusted score. Since each of the three adjustment elements ranges from 0 to 1.5, and the standard raw score ranges between 0 and 100, the adjusted score ranges from 0 to 450. Compared to standard raw scores, adjusted scores have the advantage of being more comparable across villages and projects which are designed and implemented in different environments and with different inputs from outside the village. Again similarly to Olympic diving scores, the adjusted measure is created by applying additive weights to the standard raw score. 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 consultation with our engineering consultants.

[28] As stated by Yu Zhao, "Baozhang woguo nongcun"; Lin Yang, Yanping Han and Zhimin Sun, "Gonggong caizheng"; Jianqiang Huang and Bisheng Xia, "Pianyuan shanqu".

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

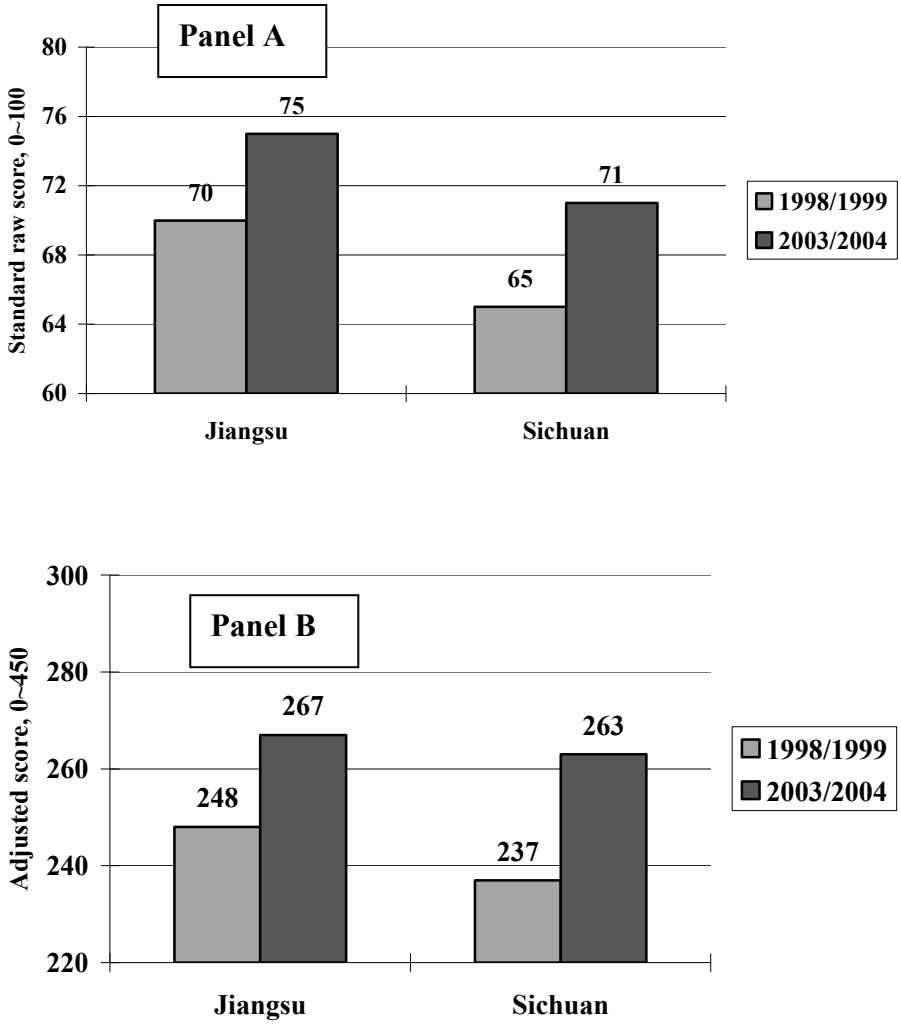


Source: Authors' survey.

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 Sichuan, 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 there increased from 70 in 1998 to 75 in 2003 (Figure 3, Panel A). The rising quality of infrastructure projects across the provinces in our sample also holds when using the adjusted scores. During the same period, the adjusted raw score of infrastructure projects 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.

Is Quality Being Compromised During Quantity Expansion?

To examine more carefully the within-village quality–quantity tradeoff, we also undertook a series of multivariate analyses. We regressed the standard raw scores of an infrastructure project (our basic measure of quality) on the investment volume of the project. To control for other factors, we also included measures of project-specific factors, such as the age of the project, the sources of project funding and other variables that measure the ways in which projects within a village differ with regard to their initiation (that is, who decided to do this project in the first place), the application process (who actually made the application for the project and to whom), design and implementation. We also included measures to capture the differences in the 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 our models perform fairly well. The goodness of fit measures (R-square ranges from 0.72 to 0.79) are relatively high (Table 2). When we examine coefficients of interest (that is, the coefficient on the quality variable), the within-village analysis leads us to reject the hypothesis that quality is compromised when the quantity of infrastructure expands. In fact, in none of our exercises is the coefficient of the project investment variable negative. In many of the regressions, the coefficients are positive and significant to at least the 10 per cent level. This means that, on average, project size and quality are correlated.

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.[29] When looking at the village level (that is, when we examine whether the average quality of projects deteriorates as the village invests in more projects), we also find little evidence that the quantity of infrastructure in rural China is compromising quality.[30] 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 increases from 66 to 76. This pattern suggests that there is a positive rather than negative relationship (Figure 4).

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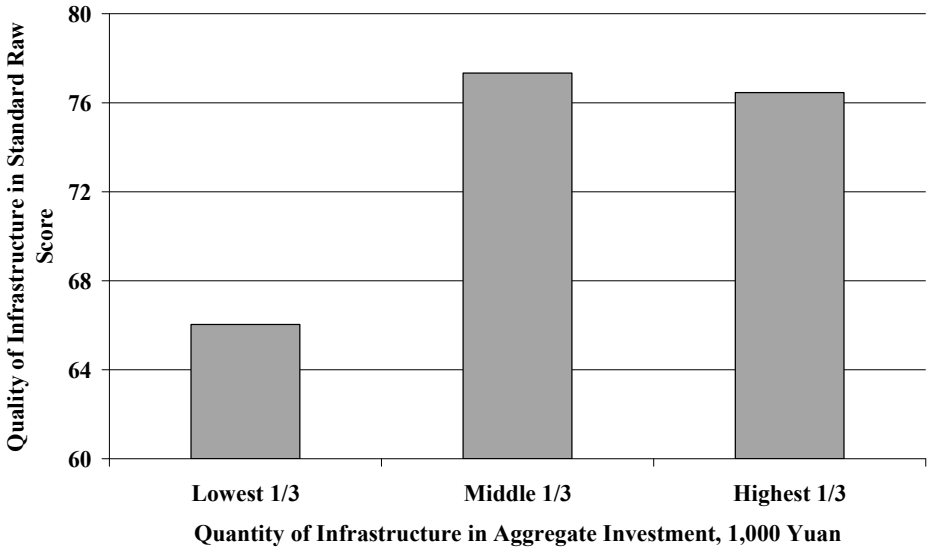
[29] In order to test whether there is a negative quality–quantity relationship at the village level, we constructed measures for the quality and the quantity of infrastructure at that level. Total (or average per year) village-level investment is generated by adding up the total quantity of investment effort in value terms. A measure of the average level of infrastructure quality for each village is created by computing the simple average of the quality of infrastructure projects in the village. We call this measure the simple average quality.

[30] Lin Yang, Yanping Han and Zhimin Sun, "Gonggong caizheng"; Jianqiang Huang and Bisheng Xia, "Pianyuan shanqu".

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

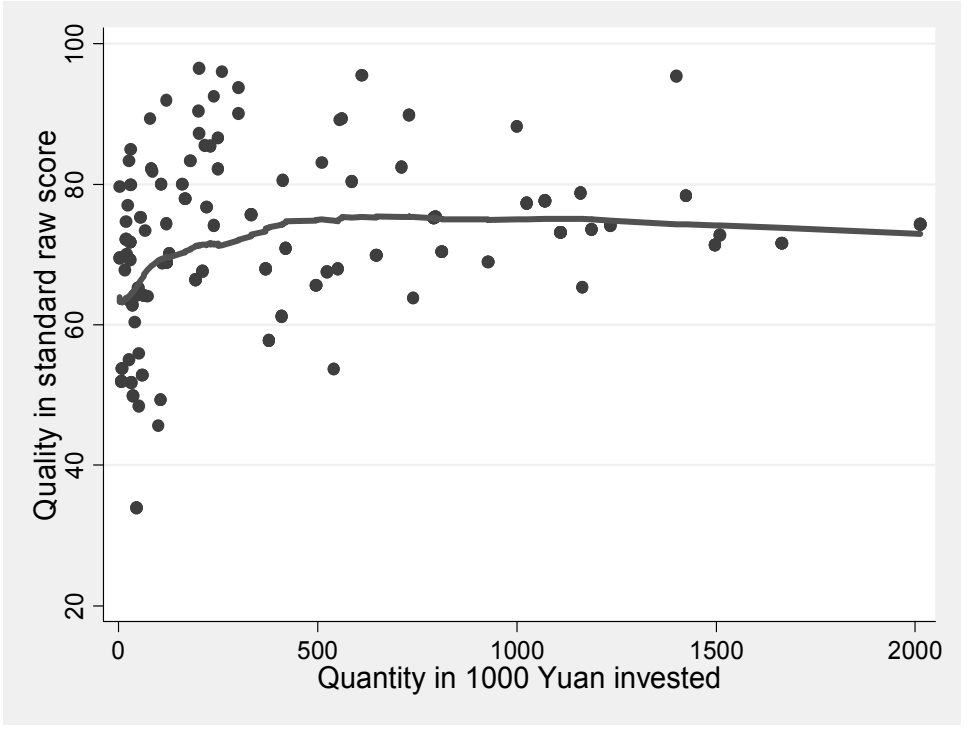


Source: Authors' survey.

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 Figure 4 does), non-parametric regression can be used to look at the continuous relationship between the quantity and quality of infrastructure. 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 500,000 yuan (which would include only the top 8 per cent of villages), the smoothed curve flattens gradually.[31]

[31] It is possible to show that these results match up to multivariate analysis. At the very most, in our most exercises, we can get an insignificant relationship between quality and quantity of infrastructure.

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



Note: We use a locally weighted regression or LOWESS estimator.

Source: Authors' survey.

Infrastructure Investment and Villager Satisfaction

While it appears that the government is making investments in a way in which the quantity of infrastructure is rising rapidly without compromising the quality, we still need to examine the more fundamental questions. Are farmers satisfied with these new projects? Is the quality of projects something that farmers demand? To answer these questions, we rely on the household part of the survey to create measures of villager satisfaction.

In each small village, eight farm households were randomly selected and interviewed inside their homes. There was no village leader present during these interviews. 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.

After collecting the data, we created two satisfaction variables. The first satisfaction measure, SM_i, is the *average of a binary evaluation* of project quality by the eight sample farmers in each village. The question that enumerators asked was: "Do you believe that [the project] could be called 'successful'"? If every farmer in the village believed that a project was successful, then the SM variable of the project would equal 1; if no one liked the project, the measure would equal 0.

The other satisfaction measure is a *project benefit ranking index*.[32] To explain how this measure was created, let i denote the project (i=1,…,N) where N denotes the total number of projects undertaken in this village during the 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 *benefit ranking index* of project i, denoted as RI_i, as $RI_i = [1-(R_i-1)/N] \times 100$.[33] This measure is a ranking of the projects in each village, where the best project gets the highest score. For example, in a village in which a total of 8 projects were undertaken during 1998–2004, a farmer ranked a particular road project 3rd. From the farmer's point of view, the benefit ranking index (RI_i) of this road project would be 75 $[=(1-\frac{3-1}{8}) \times 100]$. This number indicates that the farmer believed that this road project brought local residents more benefits than 75 per cent of all the projects undertaken in this village during the sample period.

Villager Satisfaction with Infrastructure

The 2005 CRG Survey data show that, as the overall volume of infrastructure investment rose, villager satisfaction with infrastructure increased slightly during the sample period. From 1998 to 2003 the satisfaction measure of infrastructure projects increased marginally from 0.843 to 0.852 (Figure 6, Panel A). Similar results are found when using the benefit ranking index. During the same period, the benefit ranking index increased from 59.5 to 70.0 (Figure 6, Panel B). Hence, using either the satisfaction measure or the benefit ranking index, our approach to measuring villager satisfaction does not support the finding that villager satisfaction with infrastructure was suffering during the recent period of investment expansion.[34]

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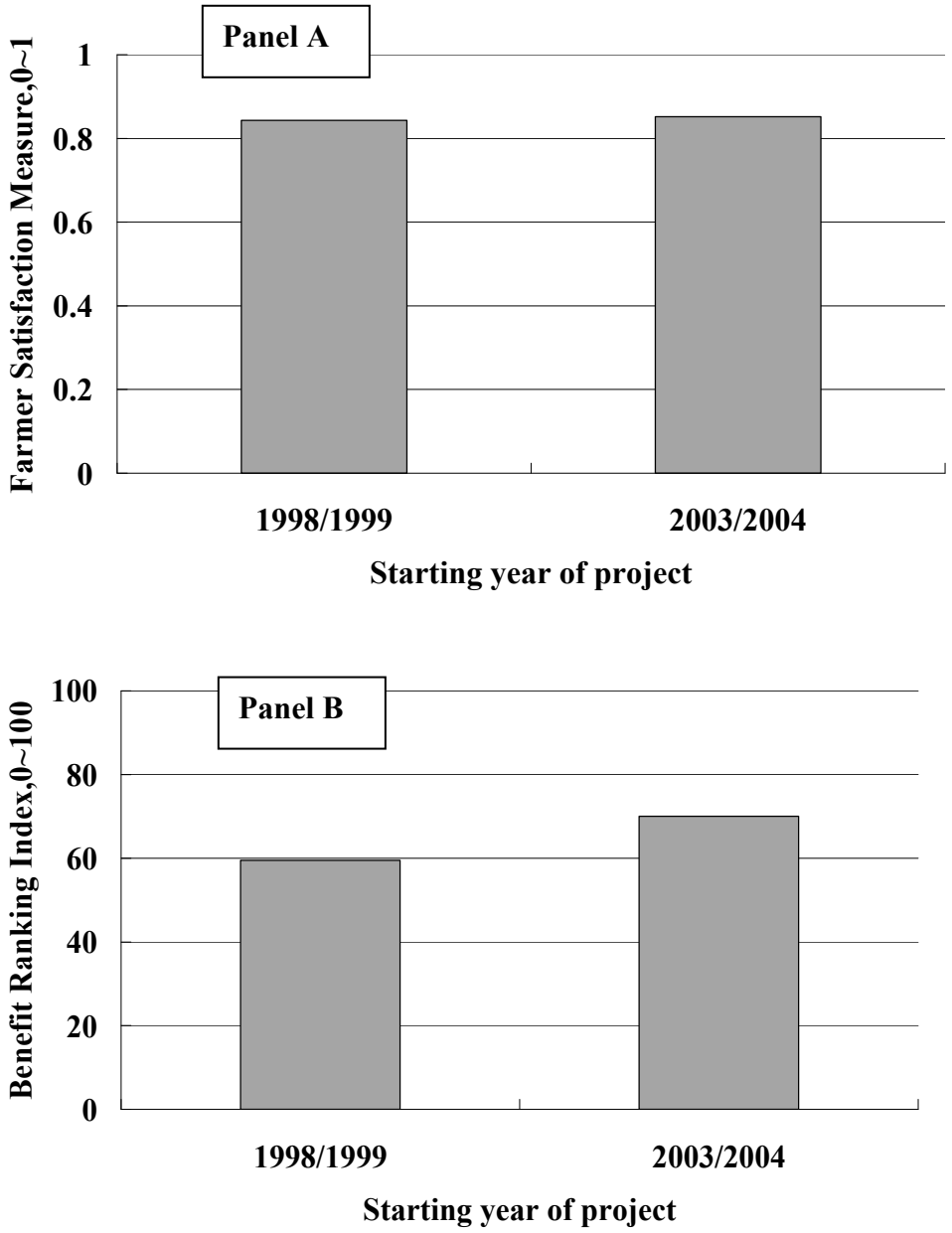
[32] Cheryl Doss, John McPeak and Christopher Barrett, "Interpersonal, Intertemporal and Spatial Variation in Risk Perceptions: Evidence from East Africa", *World Development*, Vol. 36, No. 8 (2008), pp. 1453-68.

[33] 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).

[34] For example, Jingzhong Ye and Hong Ni, "Butong juese dui xinnongcun jianshe de danyou" (Concerns of Different Stakeholders about Constructing a New Socialist Countryside), *Nongcun jingji* (Rural Economy) (May 2007).

Figure 6: Increase in Villager Satisfaction with Infrastructure over Time, China

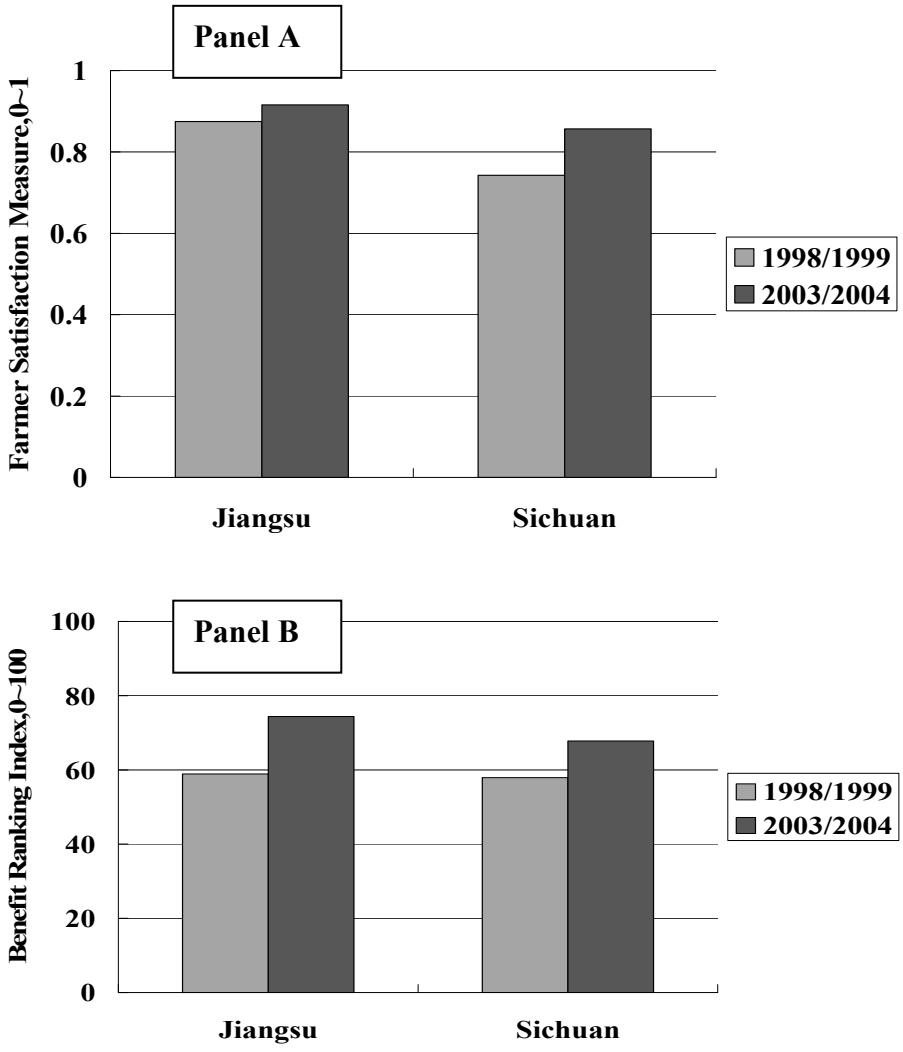


Source: Authors' survey.

The positive relationship between rising quantity and quality can also be seen when we examine villager satisfaction by province. The two satisfaction measures rose in all of the sample provinces—although at different rates. In Sichuan the

villager satisfaction measure increased from 0.743 in 1998 to 0.857 in 2003. A similar pattern appears in Jiangsu where the villager satisfaction measure increased from 0.875 to 0.916 during the same time period (Figure 7, Panel A). The rising pattern of villager satisfaction with infrastructure projects across provinces in our sample also holds when using the benefit ranking index. During the same time period, the benefit ranking index of infrastructure projects increased from 57.9 to 67.8 in Sichuan. In Jiangsu the benefit ranking index rose from 58.9 to 74.4 (Figure 7, Panel B).

Figure 7: Villager Satisfaction with Infrastructure over Time, Jiangsu and Sichuan



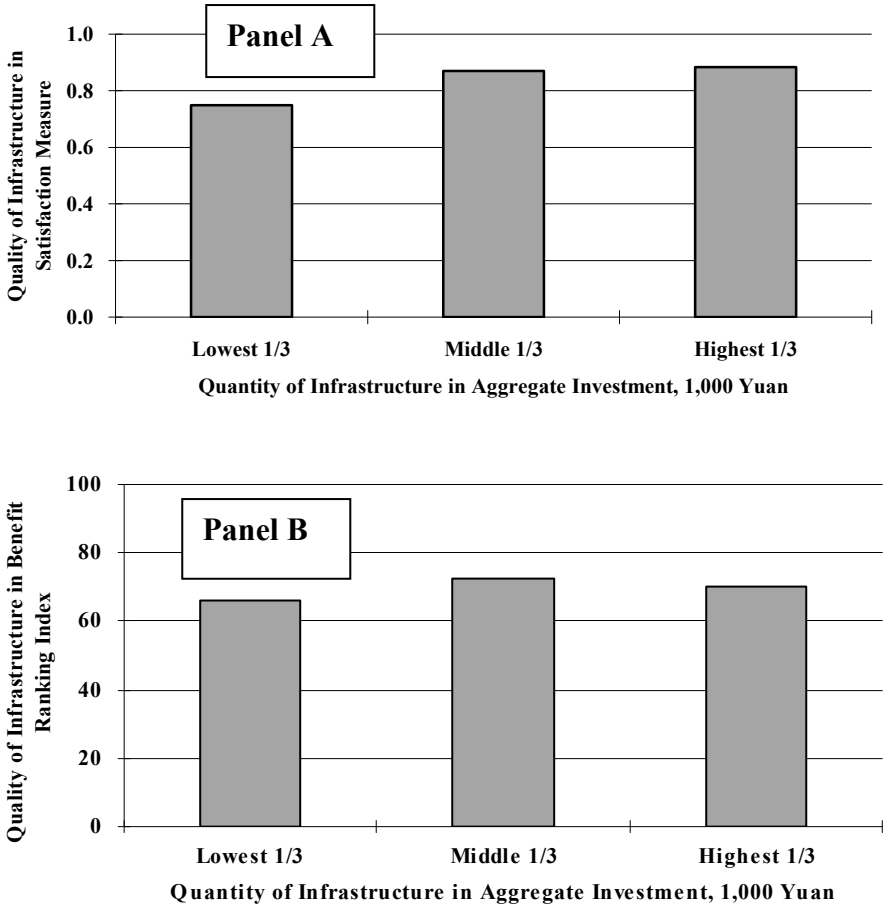
Is Villager Satisfaction Being Hurt During Quantity Expansion and Quality Rise?

To examine more carefully the relationship of villager satisfaction with infrastructure quantity and quality, we also undertook a series of multivariate analyses. We regressed the villager satisfaction measure of an infrastructure project on the project's investment volume and standard raw score. In our analysis we also included measures of other factors. The control variables in the regression analysis of the determinants of satisfaction are the same as those used in the regression analysis of the determinants of quality.

Regardless of the satisfaction measure, the results of multivariate analysis of the satisfaction–quantity/quality relationship at the project level demonstrate that the models perform fairly well. The goodness of fit measures are relatively high (ranging from 0.75 to 0.97). When examining our coefficients of interest (those coefficients of the satisfaction measure and benefit ranking index), it is clear that we reject the hypothesis that villager satisfaction is being hurt during quantity expansion and/or quality rise. In none of our exercises is either the coefficient on project quantity variable or on quality variable significantly negative. In fact, in many of the regressions, the coefficients are positive. As one might expect, farmers are satisfied when their villages receive investment in quality infrastructure.

When looking at the village level (that is, when asking the question whether farmers are more satisfied when their village as a whole gets more [higher quality] infrastructure investment), we also find little evidence that farmers are not satisfied (Figure 8). As villages move from the lowest tercile when ranked in terms of volume of investment to the highest tercile, the average villager satisfaction measure of infrastructure projects in a village increases from 0.75 to 0.88 (Panel A). Similar results are found when using the benefit ranking index. The benefit ranking index increased from 66.0 in the lowest tercile to 70.1 in the highest tercile (Panel B). Hence, there is a positive rather than a negative villager-satisfaction–quantity relationship at the village level.

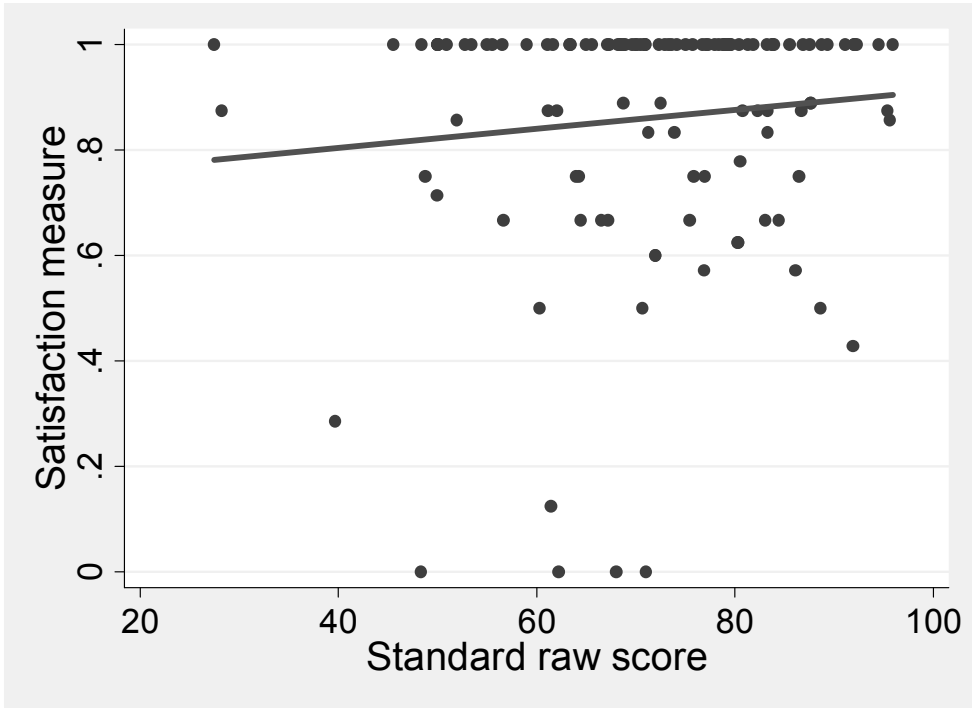
Figure 8: Villager Satisfaction and Quantity of Infrastructure Projects at the Village Level



Source: Authors' survey.

Moreover, when we plot the average villager satisfaction with infrastructure projects in a village on a graph with the quality of the infrastructure projects in the same village (using the average standard raw score), the trend line appears to be upward-sloping. This means that villager satisfaction with infrastructure projects does not fall as quality rises.

Figure 9: Scatter Plot of Villager Satisfaction and Standard Raw Score



Discussions and Conclusions

Using descriptive results, we have discovered that in recent years both the quantity and the quality of infrastructure in rural China have increased over time. Moreover, contrary to the concern expressed by some scholars, the quality of infrastructure in rural China has not been compromised for quantity during the sample period.[35] In addition, we find that rural residents are more satisfied with projects when they are larger and when they are of higher quality. Moreover, rural residents are also more satisfied when their village receives more infrastructure investment (in total) and the average quality of the investments is higher.

So why is it that the quantity and quality of investments are rising over time? If villagers are more satisfied, why do all villages not get more and better-quality infrastructure investment? While a complete answer is beyond the scope of this paper, we can draw on our data and interviews to provide

[35] For examples, Yu Zhao, "Baozhang woguo nongcun"; Xiaohe Ma and Songhai Fang, "Woguo nongcun".

some insights.[36] According to our data, the average quality of China's projects went up by 4 points between 1998 and 2003 when using the standard raw score measure of quality (10 points when using the adjusted score measure). However, in some provinces it went up more than others. In some villages the quality went up, while in others it actually went down. What is causing these differences?

One of the most consistent findings in our analysis is that the greater the contribution of upper level governments, the higher the quality of infrastructure projects (Table 2). In other words, when villages are left on their own, the quality of the projects tends to be lower.[37] While we do not know exactly why, during interviews the village leaders and townships/county officials said that a large part of the reason was that quality is expensive. It also requires advanced technical assistance. Therefore, villages—which are almost by definition more fiscally constrained than upper-level governments (especially after the 2003 Tax for Fee reform)—need resources from higher levels.[38] In the future, then, as long as the government's commitment to building more and higher-quality infrastructure does not wane, we should expect to see rural residents increasingly satisfied with their village's environment. The enormous effort which the government has put into rural areas in recent years may be responsible for the somewhat surprising results reported by Whyte, who finds that rural residents in China are relatively satisfied with their lives—despite the fact that their income levels have lagged considerably behind their urban counterparts.[39]

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36 The interested reader should read Linxiu Zhang, Renfu Luo, Chengfang Liu and Scott Rozelle, "Investing in Rural China", for a more detailed discussion of the determinants of the quantity of infrastructure investment.

37 The share of village-funded-only projects has fallen over time (from 49 per cent in 1998 to 40 per cent in 2004) and the share of projects that are funded only by a higher level of government has risen (from 10 per cent to 24 per cent during the same period). We believe that this accounts at least in part for the observed rise in quality.

38 The Tax for Fee reform was supposed to implement a standardized tax system that would replace the range of eliminated taxes, fees and levies (henceforth local fees) which had previously been imposed on farmers by village leaders and upper-level officials. Because village governments lost fee income but still had to carry out a wide range of mandates, including investing in their village's infrastructure, the county government and other upper-level agencies were supposed to increase direct transfers. In addition, the reform policies set restrictions on corvée labor assessments which local officials could demand from farm households. In-kind labor inputs had always been one of the main ways that villagers invested in their village's infrastructure.

39 Martin Whyte, "What Do Chinese Citizens See As Fair and Unfair about Current Inequalities?" Working Paper, Harvard University, Cambridge MA, 2007.

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 for the project, 1=yes, 0=no		-4.231
		(0.68)
Township or above government officials applied for 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

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

Three points should be noted. First, although our data show that most farmers in sample villages are satisfied with the infrastructure delivered to their villages, our field survey shows that farmers said they still need more infrastructure, and they still want better quality infrastructure. According to the survey, 90 per cent of households stated that they believed that their villages needed better roads; 81 per cent stated that the village needed better irrigation; and 83 per cent stated that the village needed to improve the drinking water.

Second, it is very easy to imagine that, while in the past a system that depended on top-down planning and funding could deliver the services and investments which increased the satisfaction of rural residents, it does not necessarily hold that the government can do so in the future. When the rural infrastructure was as poor as that in rural China during the 1990s, it is easy to understand that whatever the government built—roads, irrigation, drinking water, schools, clinics—could increase villager satisfaction. Every village needs these; every village was short of these; thus, it was an easy planning problem. However, once the basic infrastructure of a village is built, given the nature of China's rapidly growing and increasingly complex economy, there will soon come a time when a village's needs are relatively specialized. At that point, a top-down investment process will no longer work and new governance methods will be necessary.

Finally, although our data show that both the quantity and the quality of infrastructure in rural China are rising, if we compare China with its neighbors in East Asia (such as Japan and South Korea), we see that China still faces challenges in improving its rural infrastructure. Therefore, while there has been progress, from a comparative perspective the process is just beginning and needs to be followed up by a long-term commitment to sustained investment in rural infrastructure. The 11th Five-Year Plan suggests that China is actually in the process of making additional new investments in rural infrastructure.[40] Leaders should make every effort to meet the plan in volume and continue to improve project quality.

[40] National Development and Reform Commission, "Guanyu jiaqiang nongcun jichu sheshi jianshe zhashi tuijin shehuizhuyi xinnongcun jianshe de yijian" (Suggestions on Strengthening the Development of Rural Infrastructure and Pushing Forward the Building of a New Socialist Countryside), NDRC Agricultural Economics Document (2006) #2325 (Beijing: 30 October 2006).