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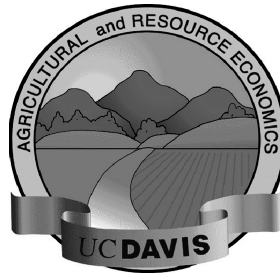## University of California Davis

Agricultural Productivity Growth in China: Farm Level versus National Measurement

By

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Agricultural Productivity Growth in China: Farm Level versus National Measurement

I. Introduction

It is generally accepted that the rapid output growth in China's agriculture from 1979 to 1984 was due to significant productivity gain.[1] In most developing countries such as China, agricultural productivity gains are central to the growth of national wealth, enabling the diversion of agricultural labor into producing non-agricultural products, leading to higher real per capita incomes.[2]

The continuation of agricultural productivity growth in China is particularly important, as more than 300 million workers remain in agriculture (nearly 50 percent of the country's total labor force).[3] An increase in rural incomes, through further agricultural productivity gains, would not only help close the urban-rural income gap,[4] but it would also serve as an important source of national economic growth. The coastal-centered economic boom has recently slowed down and the ongoing reform of China's state owned enterprises has resulted in 150 million

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[1] Guanzhong James Wen, "Total Factor Productivity Change in China's Farming Sector: 1952-1989," *Economic Development and Cultural Change* 42(1993):1-41.

[2] D. Gale Johnson, "Richard T. Ely Lecture: Agriculture and the Wealth of Nations, " *American Economic Review*, 97 (1997): 1-11.

[3] There is considerable variation in estimates of the percent of the labor force engaged in agriculture in China. With a total population exceeding 1.2 billion, China's rural population accounts for roughly three-fourths of this number and about three-fourths of the employed population is rural. The Statistical Yearbook of China 1996 (State Statistical Bureau), reports that approximately 330 million workers remain in China's agriculture, which represents over 70% of the rural work force (450 million in total). However, according to the 1990 National Population Census (conducted on July 1, 1990 and published by the Population Census Office), the rural labor force and agricultural labor force is underreported in the SSB Statistical Yearbook. The Census data suggest there could be an additional 80 to 100 million employed in agriculture. Alternatively, Thomas Rawski and Robert Mead "On the Trail of China's Phantom Farmers" *World Development*;26(5), May 1998, pages 767-81, argue that China's official data significantly overestimate the number of Chinese farm workers.

[4] See Nicholas R. Lardy, *China in the World Economy*. Washington, DC: Institute for International Economics, 1994. Lardy (p.24) suggests that the gap in China's urban-rural living standards is wider than anywhere else in Asia.

unemployed city residents.[5] This means that policy will continue to discourage labor movement from the countryside to the cities and therefore the rural economy itself will be viewed as a key to future national economic growth.

Not only is labor an abundant resource in rural China, but a large percentage of the labor force is also used in grain production. However, grain cultivation is a relatively low-return activity, and the marginal labor productivity in grain is thought to be low. Further economic reforms in the countryside would encourage farmers to withdraw from grain in favor of other forms of crops or activities. However, major agricultural reforms are on the back burner. From 1998, the central government reasserted its emphasis on "grain self-sufficiency" and introduced renewed government control over grain prices, by prohibiting private agents in the grain market.[6]

According to national aggregate data, total factor productivity (TFP) in China's agriculture increased by 55 percent from 1979 to 1984.[7] This was unprecedented in the developing world, and most of the rapid change was attributed to the Household Responsibility System (HRS), which was a one-off institutional change.[8] After the effects of the HRS petered

[5] Trish Saywell, "Steady As She Goes." *Far Eastern Economic Review*, October 1, 1998.

[6] Frederick W. Crook "Agricultural Policies in 1998: Stability and Change", *China: Situation and Outlook Series*, Economic Research Service, U.S. Department of Agriculture, WRS-98-3, July 1998.

[7] Wen.

[8] Stone indicates that several technological improvements were made prior to 1979. These included the adoption of new varieties of wheat, rice, and corn. For wheat and rice it was new short-straw varieties and for corn it was hybrid varieties. In addition, Stone documents the significant improvement in irrigation facilities prior to institutional reform, and the accelerated growth of fertilizer supplies. Stone notes that: "For staple crops, the increased supply of fertilizer nutrients was more significant than labour incentives fostered by the responsibility system reforms, which on balance led labour away from the previous over-concentration on staples. Food grain yields had been constrained not by inadequate labour application, but by insufficient soil nutrients." See Bruce Stone, "Basic Agricultural Technology under Reform." in Y.Y. Kueh and R.F. Ash, eds., *Economic Trends in Chinese Agriculture: The Impact of Post-Mao Reforms*, chap. 9, New York: Oxford University Press, 1993, p.352.

out, a policy issue that surfaced in the late 1980s and early 1990s was a slowdown in the growth

of investment in agriculture.[9] Despite this apparent investment slowdown, we find, in this paper,

that the national data indicate there have been tremendous productivity gains in China in the

1990s. The TFPI increased by 47 percent from 1990 to 1996, according to the national aggregate

statistics, and using Wen's methodology. Is this large agricultural productivity gain in the 1990s

plausible?

Perhaps the answer is no, because recent concerns over the reliability of national

production statistics calls into question the accuracy of the national productivity index.[10] The

purpose of this paper is to measure post-reform agricultural productivity growth in China using

farm level (i.e., household) data and compare the results to national data, for the 1978 to 1996

time period. Measuring productivity growth is a complicated task, even in western economies

where data are much better than is the case for China. Previous studies of China's agricultural

growth have all used very aggregate national or provincial data, even though the theory is based

on microeconomic decision-making relationships at the individual farm level. Our disaggregate

household level data are unique and they were obtained from farm cost surveys in Jiangsu

Province, one of the most progressive agricultural provinces in China.

Comparing the Jiangsu productivity growth results with those from national aggregate

data, we find that the results are quite similar from 1978 to 1987, but much different from 1988

to 1996. We argue that the 1988 to 1996 results from the household data are more convincing

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[9] Total investment in agriculture slowed down between 1985 and 1990, and actually fell in real terms over this period. It then resumed growth at the beginning of 1990s, but fell again in 1993 and 1994, in real terms. Investment in agriculture then increased significantly in 1996 (*Statistical Yearbook of China*, 1997).

[10] See F. Fuller, D. Hayes, and D. Smith, "Reconciling Chinese Meat Production and Consumption Data," *Economic Development and Cultural Change* (forthcoming). Fuller, Hayes, and Smith find that the growth of livestock production may be grossly overstated by China's national statistics and this would clearly bias any measurement of agricultural productivity, because livestock accounts for about 30 percent of agricultural GDP.

and more consistent with expectations, given the slowdown in investment in China's agriculture in the 1980s. According to the Jiangsu household data, the TFPI increased by 14.6 percent from 1990 to 1996, much less than the 47 percent growth implied by the national aggregate figure.

The rest of this article is organized as follows. In the next section, we will describe the data and method used in this study. In section 3, we report results for national productivity indices. In section 4, productivity results are reported for Jiangsu province, using farm level household data. Section 5 provides concluding comments.

II. Data and Methodology

We chose Jiangsu province for the purposes of our disaggregate analysis because Jiangsu represents one of most important agricultural provinces in China. In 1996, Jiangsu's total gross value of agricultural output (GVAO), including farming, forestry, animal husbandry, and fisheries was the second largest of any province in the country, only second to Shandong. Compared to other provinces, the value of Jiangsu's production from farming, animal husbandry, and fisheries all ranked in the top three in the nation in 1996.[11] Jiangsu was the third largest rice producing province and the fourth largest wheat producer in China in 1996.

Jiangsu should have enjoyed as much, or even more, productivity growth than the national average, since 1979. In 1996, the per capita net income of rural households in Jiangsu was the third highest of any province in the country,[12] and was more than one third higher than the national average. The more advanced economic status suggests that Jiangsu would have

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[11] *Statistical Yearbook of China*, State Statistical Bureau, 1997.
[12] The municipal cities of Beijing, Tianjin, and Shanghai are excluded.

invested more in agricultural research and development than the average province, which presumably would give rise to higher productivity growth.[13]

Although the Statistics Bureau system in China is the main source of data for economic studies, the Jiangsu data used in this paper were collected using a different procedure, namely farm household surveys. The Jiangsu provincial Price Bureau conducts these surveys, and they have been carried out for decades. Many of the same households are included in the survey each year. The number of included households varies across agricultural activities, according to the relative importance of each activity in each household. For example, the 1996 survey covered almost all counties in the province and more than 800 households were included in the survey. However, only 32 counties and 111 households were included in the portion of the survey dealing with cash crops, while 43 counties and 203 households were included in the part of the survey dealing with wheat production. For the purposes of our analysis, the household survey data were aggregated to county averages, and then to prefecture averages.[14] We report the Jiangsu provincial average data, which are based on the prefecture averages, from 1978 to 1996.

The Jiangsu data cover almost all-farming activities, including cropping and livestock. This includes wheat, indica rice, japonica rice, corn, soybeans, cotton, rapeseed, hogs, and fresh water fish. These sum of these activities accounts for over 90 percent of total agricultural output value and 85 percent of sown area in the province.[15] The results of the household survey contain detailed information on both outputs and inputs for all crops, hogs and fish. The crop data are based on unit-sown area (*mu*) and the livestock data are on an animal unit basis. The farming

[13] For evidence of the linkage between advanced economic status and more investment in agricultural research, see Jikun Huang, and Scott Rozelle, "Technological Change; Rediscovering the Engine of Productivity Growth in China's Rural Economy," *Journal of Development Economics*, 49(1996):337-369.

[14] There are 67 counties and 13 prefectures in Jiangsu Province. Officially, there were 11 prefectures prior to 1996.

cost data is very detailed and is classified into non-labor and labor costs, with several sub-categories.

National aggregate data published in various issues of *China's Statistical Yearbook* were used for the national productivity estimates in this paper. Wen studied China's GVAO, which consists of two main components: crop output (GVCO) and noncrop output (GVNCO). The latter is defined as production of animal husbandry, forestry, fishing, and sideline activities.[16] Following Wen's approach, we use four aggregate input categories: labor, land, capital, and current inputs.

At the national level, agricultural labor is defined to include all workers engaged in farming, animal husbandry, sideline activities, fisheries, forestry, and water conservancy. The amount of arable land was adjusted for both multi-cropping and irrigation, following Wen. Farm capital is the sum of the value of draft animals, nondraft animals, poultry, and farm machinery. Current inputs include such items as seed and feed, organic and chemical fertilizer, electricity and insecticides.

For the national aggregate data, the total factor productivity index (TFPI) is defined as follows:

TFPI= {100 × (GVAO Index)}/{ (L index) + (K index) + (S index) + (C index)}   (1)

where , , , and   are weights and *L*, *K*, *S*, and *C* are indexes of labor, capital, land, and current inputs. The numerator is the index of the gross value of agricultural output (GVAO), and the denominator is the weighted index of the four inputs. The weights proposed by Wiens[17] to

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[15] Of the total value of provincial agricultural output in 1996, 63 percent was from crop farming, 21.8 percent was from livestock and 14.1 percent was from fisheries.

[16] The gross output value from rural industry run by townships and villages was excluded from the GVAO calculation.

[17] Tom B. Wiens, "Technological Change," in *The Chinese Agricultural Economy*. ed. R. Barker and R. Sinha (Boulder, Colo.: Westview, 1982).

aggregate inputs were used to calculate the weighted input index, as in Wen. All variables were

deflated, following Wen's technique.

To compute the TFPI using farm-level data in Jiangsu province, we first calculate an

output and input index for each farming activity. Except for hogs and fisheries, the output value

was calculated as the product of output quantity and the corresponding price in 1995.[18] In

computing the input indexes, we made use of two approaches. In first approach, we computed

the index for labor, nonlabor, and land inputs[19] for each farming activity, and then used the fixed

weights proposed by Wiens to compute the overall input index. We call this the fixed-weight

approach. With this approach, results from farm-level data can be directly compared with those

derived from national aggregate data.

However, the weights assigned to different inputs are somewhat arbitrary. Therefore, as

an alternative approach, we aggregated inputs for which we had quantities with those for which

we had values. For those inputs such as chemical fertilizer, seeds and draft animals, for which

quantity data were available, the value of these inputs was computed as the product of annual

quantity and the price paid in 1995. For other inputs, for which we had value data only, we based

the values on 1995 prices, using the national purchasing price index of agricultural inputs.[20] We

call this the variable-weights approach. Labor inputs were measured as man-day equivalents, and

the cost of labor was computed as the product of man-days and the wage rate in 1995.[21] This

approach minimized impacts of price fluctuation on the construction of input indexes. However,

using 1995 prices means that an input such as labor is assigned a much higher weight in the early

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[18] Given the quality improvements in hogs and fish over the study period, output values were
used (instead of quantities) to construct output indexes for these two activities.

[19] The land index was kept at 100 throughout the whole period, as the survey was based on unit
area (*mu*). The weight assigned to nonlabor inputs was the sum of weights to capital and current
inputs.

[20] *Statistical Yearbook of China*, State Statistical Bureau, 1997.

time period compared to the later period, because the quantity of labor usage in the early period was much higher than during the later period. Therefore, the weight on the labor input might be unreasonably high in the early period. Given the pros and cons of both the fixed and variable weight approach, we report results using both approaches. In the rest of this paper, we focus more on the fixed-weight approach, as one of our objectives is to compare the results with national data. However, both approaches gave fairly similar results.

Using the fixed-weight approach, the TFPI for each crop and livestock activity was estimated as the ratio of the output to the input index. The TFPIs for the cropping sector and the entire agricultural sector were constructed. The input and output indexes for the cropping sector were computed as the weighted average of input and output indexes of each cropping activity, and weights were set equal to the share of each crop in total acreage. The input and output indexes of the entire agricultural sector were the weighted averages of those for cropping, hogs, and fisheries, and the weights were equal to the share of output value in the GVAO for each year, for Jiangsu. Thus, the weights varied from year to year.[22]

III. Results Using National Data

Using Wen's approach and national data, the productivity results are reported in Table 1 and Figure 1. In Table 1, summary growth rates for three time periods are given; namely 1978-1987, 1988-1996, and 1978-1996. We find that the total factor productivity index (TFPI) increased sharply in the 1990s, after relatively slow growth in the late 1980s. The TFPI increased

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[21] The wage rate was assumed to be 9 *yuan* per man day of labor in farming and animal husbandry in 1995.

[22] As an alternative, we tried another method of computing the productivity indexes by calculating the direct ratio of the output to input values for each of the nine sectors and then aggregating. This method gave us very similar results as those reported in Table 4 for the Jiangsu farm level data.

by 5.8 percent per year, on average, from 1988 to 1996 (Table 1 and Figure 1). Indexes for the gross value of agricultural output (GVAO) and for the gross value of crop output (GVCO) are also reported in Table 1. The difference between them represents the gross value of noncrop output. The gap between the two indexes grew after 1984, especially in the 1990s.

According to the national data, the annual growth rate of GVAO was 7.8 percent from 1990 to 1996, exactly twice the growth rate for the 1985-1990 time period. The growth rate of the value of noncrop activities increased even more rapidly, attaining a remarkable annual growth rate of 12 percent in the 1990s, compared to 5.8 percent in the second half of the 1980s. Estimated labor productivity lagged behind TFP until the 1990s, and has increased rapidly in recent years (Table 1), due to the swift growth in reported national agricultural output and a fall in labor usage. The number of estimated farm workers increased from 283 million in 1978 to 350 million in 1991. In 1992 the absolute number of workers in agriculture began to decline for the first time since reform, and by 1996, there were an estimated 329 million workers engaged in agriculture, according to the official national data. Rapid rural industrial growth and migration has allowed for the movement of labor out of agriculture.

Turning to the other input indexes, we find that the aggregate effective sown area did not change significantly throughout the time period. Capital was computed as the sum of the value of draft animals, nondraft animals, poultry, and farm machinery. The total value of machinery in 1996 was more than three times that used in 1978, and the total value of animals increased by 50 percent during the same period. Thus, the capital index in the mid 1990's was double the level in 1978, with an annual growth rate of 4.1 percent.

For the purposes of calculating current inputs, Wen made an effort to include as many items as possible, and he assigned weights to each category. The same weights are used in this paper and the "current input" index is computed as the weighted index of nutrients (i.e.,

fertilizer), feed, seed, electricity and insecticides.[23] The total nutrients index is a weighted sum of green fertilizer, human night soil, draft animal manure, hog manure, oil cake, compost, mud and pond manure, and chemical fertilizer. While chemical fertilizer application increased by more than three times from 1978 to 1996, the slow increase in the other components of the nutrient index meant that the total nutrient index only increased by about 100 percent from 1978 to 1996. The feed index increased by 62 percent, and the seed index, which is computed as a function of sown area, was almost constant during the whole period. The value of electricity usage doubled from 1978 to 1996, but the usage of insecticides in 1996 was only 33 percent of the level in 1978. Thus, the index for electricity and insecticides decreased from 100 in 1978 to 70 in 1985, and then reached 81 by 1996. And, the overall index for current inputs only increased 20 percent from 1978 to 1996.

Using Wen's approach, three of the four inputs: labor, effective sown area, and current inputs, have changed very little during the last two decades, while the IGVAO and IGVCO have increased significantly, especially in the early 1980s and early 1990s. Consequently, the TFPI more than doubled from 1978 to 1996.

Do these national TFP results accurately reflect the genuine effects of agricultural development in China in the 1990s? Or alternatively, is the accuracy of the aggregate data questionable? According to the official aggregate data, the gross value of animal husbandry sector grew at a rate of 12 percent in the 1990s. However, it has been shown that the figures for livestock production data are exaggerated and annual production growth for beef, pork and poultry could be over-estimated by at least 7 percent per year.[24] This is reason enough to distrust the national data.

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[23] The weights are follows: 0.646 (nutrient index), 0.155 (feed index), 0.155 (seed index), 0.044 (index of electricity and insecticide).
[24] F. Fuller, D. Hayes and D. Smith.

IV. Results Using Household Data

Detailed household level data enables us to compute productivity measures for each output activity. The problem with the national data is that we can only compute the TFPI for the total agricultural sector, due to the fact that there is no national measure of the proportions of each specific input used for each crop or livestock activity. In other words, one main advantage of our household data set is that it contains actual quantities of the major inputs applied to each crop or livestock activity, at the farm level. In contrast, national or even provincial data, only include an aggregate measure of inputs used for all agricultural activities lumped together.

Based on the reported yields per *mu* for the major grain and cash crops in Jiangsu province, we observe in Table 2 that the growth rates from 1988-1996 (i.e., the second period) were much slower than from 1978-1987 (i.e., the first period). Wheat was the only exception. For example, there was virtually no increase in the yields of hybrid indica paddy rice or corn from 1988 to 1996. Yields for cash crops, such as cotton, increased at a rate of 1.1 percent per year from 1988-1996 (Table 2). For all grain, the annual yield growth rate in Jiangsu for the entire 1978 to 1996 time period was 2.7 percent (Table 2).

According to national data, grain yields grew at an average annual rate of 2.9 percent across all provinces from 1978 to 1996. From 1978 to 1987 national grain yields grew by 4.1 percent and from 1988 to 1996 by 2.9 percent (Statistical Yearbook of China). This suggests that measured grain output per *mu* at the national level was slightly higher than at the (Jiangsu) farm-level from 1978 to 1996.

Turning to Jiangu's household input usage, reported in Table 3, we find that for grain as a whole, labor usage in grain production decreased at an annual rate of 4.9 percent for the whole period, at a rate of 9.6 percent for the first period (i.e., 1978-1988), and 2.4 percent for the second period (i.e., 1988-1996). The decline in associated labor costs was completely

overshadowed by the rapid increase in the nonlabor costs for grain production. In real terms, the nonlabor costs of grain production increased much faster in the second period at a rate of 5.2 percent, compared to a rate of 0.8 percent in the first period (Table 3). Thus, the total cost of grain production displayed an average annual 5.9 percent decrease in the first period, but increased at a rate of 1.6 percent in the second period, as a result of the rapid increase in nonlabor costs, such as the cost of fertilizer. Unit fertilizer usage for grain maintained a growth rate of 5.2 percent annually during the 1990s, and for wheat in particular, this growth rate was as high as 11.8 percent. This indicates that the large increase in fertilizer usage pushed up grain production costs in the second period. This, in turn, implies that the observed output increases in the 1990s was largely caused by the increased usage of nonlabor inputs. As reflected in the TFPI (using fixed weights), the productivity of all crops increased at a rate 4.8 percent for the first period and slowed down to 1.2 percent for the second period (see Table 4 and Figure 2).

For the livestock sector, as represented by hogs and fisheries, production costs in the second period were generally declining (Table 3), and the fall in production costs was accompanied by a decline in the value of output (Table 2). This means the productivity gain in hogs was low and for fisheries it was negative in the second period (see Tables 4 and 5).

Using fixed weights and comparing TFPIs across all major farm activities (see Table 4), we find that grain experienced the highest growth rate, especially during the first period. However, for hybrid rice, the TFPI declined in the second period. This was also the case for cotton and fish (Figure 2). Turning to Table 6, we find that the growth rate of the TFPI for the entire agricultural sector increased much slower in the second period with an average annual growth rate of 0.1 percent, compared to 6.3 percent annually in the first period.

Using the alternative variable weight approach (based on 1995 prices and wages), we found that the growth rates for the cropping sector and agriculture as a whole are higher than the

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results obtained using the fixed weight approach. The growth rate of TFPI for each farming activity in the second period, however, was still much smaller than that in the first period.

Using variable weights, the estimated labor productivity increased significantly and steadily over the study period. Grain output per labor day increased 8.4 percent annually for whole period, with a 10.3 percent increase in the first period and a 6.2 percent increase during the second period. Similarly, the output of cotton per labor day enjoyed a growth rate of 4.0 percent annually during the entire period. The decline in labor usage led to a decrease in the share of labor in the total cost of grain production, from an average of 50.4 percent in the first period, to 42.8 percent in the second period. At the same time, the nominal labor wage rate increased at a rate of 15.5 percent annually. This observation is consistent the experience in other developing countries, in that labor productivity growth in agriculture has been greater than in other sectors of the economy during rapid economic development.[25] The measured improvement of labor productivity, using disaggregate data, indicates that the economy is following a normal growth pattern, and this is an important finding.

Measuring labor productivity by using labor costs per *mu* may be more accurate than using aggregate farm labor. The reason is that there are a considerable number of farmers working on the farm part time, and much of the farming work is conducted by the older rural residents and even teenagers, who are not counted as farm labor in the national aggregate data.

Overall, agricultural productivity, as measured by the TFPI, displayed a steady growth rate from the late 1970s to late 1980s, but then the growth slowed down. Individual agricultural sectors such as livestock and fisheries also displayed similar patterns, they experienced significant productivity increase up to the mid 1980's, but have enjoyed very mild productivity growth since then.

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[25] Johnson, 1997.

V. Conclusions

By using national and household data for China, we find that both data sets result in agricultural productivity growth estimates that are similar for the 1978-1987 time period, immediately following economic reform. The national data suggests productivity growth of 6.7 percent per year during this period, compared to 6.3 percent for the household data, obtained from Jiangsu province.

However, the national aggregate data show much higher productivity growth from 1988 to 1996, compared to the results obtained from using Jiangsu household level data. The estimated annual productivity growth rate for this period was 5.8 percent using national data, versus 0.1 percent using the household data. We believe the household results are more plausible due to superior data and given that there was reduced investment in China's agriculture in the 1980s. According to the household data, any increases in farm product prices since the mid 1980s has been accompanied by rising farm input prices.

The reasons for the large discrepancy between the two approaches are worthy of further study. One obvious explanation is that the national aggregate data overstate the total value of agricultural output, from the bottom up. In addition, some important cost items might be left out of the national data. These include indirect costs such as depreciation of fixed assets and expenses on farm tools. Indirect costs account for about 13 percent of total nonlabor costs according to our household data. Certainly, there are other reasons that might explain this discrepancy. Nevertheless, our results cast doubt on the accuracy of using aggregate data in studying agricultural productivity gains in China.