

# *Property Rights and Fertilizing Practices in Rural China*

## Evidence from Northern Jiangsu

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Economists have long assigned property rights a central role in economic development. In particular, secure property rights, which allegedly exist only under a regime of private ownership, are believed crucial for inducing wealth-maximizing behavior because rational individuals will not invest if the fruits of their investment are not adequately protected (Alchian and Demsetz, 1972; Demsetz, 1967). Applying this premise to agriculture, one would expect that without secure property rights, farmers would not effectively use land in a manner compatible with long-term societal interest (Feder and Feeny, 1993; Johnson, 1972).

The nature of property rights associated with the land tenure system in postreform China arguably offers an example of how an incomplete regime of private ownership can undermine economic efficiency. China's break with collective farming has been credited with driving increased agricultural productivity and output during the initial reform period (circa 1979-1984).[1] Ironically, the subsequent slowdown in

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crop output growth has also been attributed to property rights matters—only this time to the incompleteness of its transformation.[2] True, farm households in China since the early 1980s have been able to farm on an individualized basis, and yet from a property rights perspective, what they have gained are only the rights to use the land formerly cultivated by the collective and to receive a residual income. Land remains collectively owned and was distributed to the families for use in a basically egalitarian manner on decollectivization—in some places, on the basis of household size, while in others, the distribution process included consideration of a family's labor capacity (Kung, 1994). In either case, what is clear is that a villager is unconditionally entitled to a share of this scarce communal resource.

This entitlement is, however, also a constraint collectively imposed on the village community as a whole. As the right to land can either be acquired by birth or through marriage, the existing allocation will have to be undone in response to demographic and other structural changes in the village economy, to be followed by a new round of reassignment (Kung, 1995, 2000).[3] This arguably gives rise to tenure insecurity, with the corollary that farmers would be unwilling to make plot-specific investments for fear that they might not be able to recoup their value in the event of a land reallocation. Specifically, this argument attributes farmers' reluctance to fertilize their contracted plots with organic matter such as night soil and animal manure to tenure insecurity. This is because they are most effective in preserving soil fertility rather than enhancing yields and, as such, could only be felt over a longer time horizon (Prosterman, Hanstad, and Li, 1996; Wen, 1995; Zhou Qiren and Liu Shouying, 1994). Farmers are, on the other hand, inclined to overuse chemical fertilizer because of its more pronounced yield-enhancing property in the short term. The contention is that this imbalance would not have occurred had farmers' tenure been more secure.

While the postulated negative relationship between ill-defined property rights in land and suboptimal fertilizing practices is an intuitively plausible hypothesis, it is not adequately supported by empirical evidence. For example, after having slowed down between 1985 and 1990, crop output growth has regained its vigor. By 1997, China's grain harvest of close to 500 million metric tons was almost 100 million more than the first bumper harvest of 1984. While the question of

what enabled China to reach yet higher levels of crop output is important, it goes beyond the concern of this article. Still, it is safe to say that the alleged negative implications of China's current land tenure system are overblown.

By the same analysis, the allegation regarding the dwindling use of organic fertilizer by the Chinese farmers since the reform is also not borne out by empirical evidence. First, while the share of organic fertilizer in overall fertilizer use has declined in relative importance, the phenomenon in question represents basically a secular trend that predates the reform; that is, the decline in relative importance of organic fertilizer application is part of the ongoing process of agricultural development.[4] This secular trend for economies to increasingly employ chemical fertilizers arises from its land-augmenting property and is well documented for economies having successfully transformed their traditional agriculture.[5]

Second, the practice of farmers using proportionately more chemical fertilizer in the postreform period can be attributed to reasons other than insecure tenure. The increase in chemical fertilizer use by the Chinese farmers has been by and large a rational response induced by a government policy that relied on a sharp increase in the supply of this critical soil nutrient as a means to increase agricultural productivity and output (Stone, 1989). Farmers welcomed this change because, compared with organic fertilizer, chemical fertilizer is far more effective in boosting crop yields (Kueh, 1984; Lin, 1992; Putterman, 1993; Wang, Halbrendt, and Johnson, 1996). Equally important has been the change that as agricultural productivity went up and as control on labor was radically relaxed (due also to the rural reform), nonagricultural activities emerged. As the returns to these activities go up, an increasing proportion of surplus farm laborers are employed off the farm. As a result, the share of income from crop production goes down, and farmers therefore devote less time to it. Given the arduous nature of collecting and applying organic fertilizer, less of it will be used. This labor-saving role that chemical fertilizer plays does much to explain its increasing relative importance.

The premise that the changing economic environment has Chinese farm households more carefully allocating their labor does not mean they no longer fertilize their contracted plots with organic nutrients. Our study of 135 farm households in five Chinese village communit-

ies shows that the allegation of farmers neglecting to preserve the soil fertility of their contracted plots is wholly unfounded. Farmers still accumulate organic fertilizer from a number of sources, although not to the same extent as before. With less organic fertilizer at their disposal, farmers carefully ration its use, with the specific criterion of rationing patterned on a number of village characteristics. These factors range from the relative importance of off-farm income and therefore time opportunity costs to farm size, as well as the availability of organic fertilizer supply that can be obtained from complementary farming activities, most notably animal husbandry. Our study suggests that farmers' fertilizing practices are far more complicated than can be adequately explained with a simple property rights theory.

In the next section, we discuss how we expected certain village characteristics to affect farmers' fertilizing practices. We then provide evidence regarding farmers' subjective perception of land reallocations or tenure insecurity, on one hand, and fertilizing practices, on the other hand. We discuss the implications of an increase in the supply availability of chemical fertilizer after the reform and the rising nonagricultural economy on fertilizing practices, and then we examine the specific rationale by which farmers in these five villages fertilize their contracted plots.

## *VILLAGE CHARACTERISTICS AND THEIR EXPECTED EFFECTS ON FERTILIZING PRACTICES*

Our field research was conducted in Hongze County first during June to August 1996 and later from December 1996 to January 1997. Hongze County is located in the western part of Jiangsu Province.[6] This county's economy is largely agricultural. Roughly 40% of its 1995 fiscal revenue came from agriculture. In 1995, per capita net income in Hongze County was 1,906 yuan. This compares favorably to the national average of 1,578 yuan but is significantly below the provincial average of 2,457 yuan. Incomes in Hongze lag behind those in the vastly more industrial southern part of the province. As is typical of this part of the Yangzi River Delta, the main crops grown in this county are rice and wheat. Corn and other oil crops are also cultivated.

We chose to study Hongze County for the following reasons. First, its level of economic development mirrors to a considerable degree the economic environment that most Chinese farm families face: simultaneously cultivating small plots of land while trying to augment family incomes with off-farm work. This continuing dependence on agriculture for a livelihood in the face of the rising importance of off-farm income is an essential context in which to examine issues pertaining to the effect of land tenure policy on land-specific investments. Second, we enjoyed particularly good access to villages in this county. Altogether, we have chosen five villages from four townships for our study. Villages 1 and 2 belong to the same town, while villages 3, 4, and 5 belong to the other three townships.[7] In each village, we interviewed the village's party secretary, head, and accountant. We also interviewed members of 135 farm families in the five villages. Finally, we interviewed two to three officials in each township.

In choosing our villages, we wanted to have as much diversity as possible in a number of key parameters between them to serve as predictors of variations in fertilizing practices. Information on these key indicators is summarized in Table 1. Instead of describing the village characteristics in detail, we highlight observations we think provide the motivations for fertilizing practices. In particular, we want to show how these are affected by the development of a nonagricultural sector in China's village economy, natural resource endowment (farm size), the availability of organic fertilizer supply, and the size of grain quotas.[8] Increasing participation in off-farm employment (including self-employment) leads to rising costs of labor time, and this influences fertilizing practices.

First, we examine the degree to which a household is involved in off-farm economic activities and the corresponding share that it derives from such income opportunities, on one hand, and per capita net income—a crude measure of economic welfare—on the other. With the exception of village 1, where resource endowment in terms of farm size is more generous, it can easily be seen that the average net income of a village correlates positively with the importance of off-farm income (columns 4, 6, and 8, respectively). For example, net income is highest in village 2 (2,390 yuan), where 93% of the families are involved in off-farm employment[9] and whose income made up 84% of overall household income.[10] Conversely, although village 1 is

**TABLE 1: Socioeconomic Characteristics of Five Villages in Northern Jiangsu County, 1995**

| *Village* | *(1) Population* | *(2) Household Size* | *(3) Per Capita Farm Size (mu)* | *(4) Per Capita Net Income (yuan)* | *(5) Procurement Quota* (jin per mu)[a] | *(6) Proportion of Farm Households with Members Engaged in Off-Farm Work (%)* | *(7) Proportion of Farm Households with Members Engaged in Off-Farm Work outside the County (%)* | *(8) Share of Income from Nonfarm Sources (%)* | *(9) Income Received by Village Authorities (yuan)* | *(10) Number of Village-Run Enterprises* |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 973 | 4.05 | 3.0 | 1,940 | 250 | 63 | 8 | 31 | 20,950[b] | 1 |
| 2 | 1530 | 3.46 | 1.8 | 2,390 | 370 | 93 | 7.5 | 84 | 180,000[c] | 3 |
| 3 | 1157 | 3.50 | 1.3 | 1,932 | 400 | 82 | 25 | 64 | 9,500[d] | 0 |
| 4 | 759 | 3.56 | 1.2 | 1,980 | 550 | 91 | 27 | 70 | 6,000[e] | 1 |
| 5 | 2154 | 4.03 | 1.5 | 1,850 | 450 | 78 | 21.5 | 49 | 2,000[f] | 0 |

SOURCE: 1996 and 1997 fieldwork.

a. One jin = 0.5 kilogram, whereas one mu = 1/15 hectare.

b. From fish ponds, 10,950 yuan; from enterprise management fees, 10,000 yuan.

c. From enterprise profits (from grain processing, manufacturing of cement products, and machine tools), 165,000 yuan; from fish ponds and wasteland, 15,000 yuan.

d. From fish ponds, 5,000 yuan; land rents for factory use, 4,500 yuan.

e. From fish ponds, 3,000 yuan; from enterprise management fees, 3,000 yuan.

f. From enterprise management fee, 2,000 yuan.

the most favorably endowed of the five villages in terms of farm size, the per capita net income of its residents ranks only third and differs remarkably little from the two lower ranked villages (villages 3 and 5, respectively). Moreover, given the disproportionate importance of nonagricultural income, households are likely to send their primary (or most productive) labor (usually household heads and adult children) to work off the farm.[11] Such an allocation decision generally has a negative impact on the accumulation of organic fertilizer since collection is labor intensive and is not readily undertaken by a household's auxiliary labor. Thus, other conditions being equal, extensive household involvement in nonagricultural work leads to proportionately less application of organic soil nutrients. From this perspective, we expect households in village 2 to use less organic fertilizer on each unit of the land they farm and those in village 5 (the village with the lowest per capita net income) to use more of this soil nutrient.[12]

This takes us to the expected effect of the second factor on fertilizing practice—namely, the endowment of land resources. The relationship between farm size and organic fertilizer use is (like the effect of nonfarm income) a negative one: the larger the farm size, the lower the fertilizing rate per unit of land. We may thus expect organic fertilizer use on each mu of land to be low in village 1 since its land endowment is twice that of three of the other sample villages.[13] The hypothesized relationship between farm size and organic fertilizer use will be moderated, it should be pointed out, by the availability of this soil nutrient. Since animal manure has traditionally been an important source of fertilizer for the Chinese farm households, the extent to which animal husbandry is a mainstay of a village economy (as it is in village 3), the application of this soil nutrient will tend toward the high side.

Last but not the least, we also expect the size of grain quotas—the minimum amount of grain that farmers are obligated to sell to the government in return for the contractual rights to use the arable land—to affect fertilizing practices. Holding other variables constant, it is not unreasonable to postulate that a small procurement quota places less pressure on farmers to intensively use organic fertilizers. This will especially be the case when the small quota is combined with a lower man-to-land ratio, as in the case of village 1.[14] While speculative, we suspect the above-average land endowment and small procurement

quota go a long way toward explaining why the household participation rate in nonfarm work is lowest in village 1.[15]

## *INSECURE TENURE AND FERTILIZING PRACTICES: ALLEGATIONS AND REALITY*

Some argue that periodic reallocation of rural land produces tenure insecurity, which in turn weakens farmers' incentives to invest in their contracted plots (Prosterman, Hanstad, and Li, 1996; Wen, 1995). Most of these arguments are not substantiated with sound empirical evidence. Wen's (1995) allegation that a decline in effective irrigated and tractor-plowed acreage and in organic fertilizer use are unmistakable signs of dwindling farm-specific investments, for example, is faulty on several grounds. After having declined noticeably during the initial years of the transition to household farming, tractor-plowed acreage has steadily increased since 1986, as small walking tractors have since become more readily available and popularly used among the farmers. In the case of water conservancy works, agricultural decollectivization has effectively deprived local officials the mandate of compelling the villagers to work for little or no remuneration on this kind of community project.[16] The recent reinstatement of minimum obligatory and unpaid labor (*yiwugong*) for community public works testifies to this postdecollectivization predicament.

With respect to organic fertilizer usage, the claim that overall organic fertilizer application has declined since 1978 is simply not confirmed by empirical evidence. As Table 2 (or, for a longer time series, see the appendix) clearly shows, the absolute amount of organic fertilizer application has in fact increased. Only organic fertilizer's relative share in overall fertilizer usage has declined—from roughly 70% in 1975 to less than 40% in the early 1990s. As noted above, the increasing relative importance of chemical fertilizer represents more of a secular trend in the process of agricultural transformation—one that other late-developing economies have similarly experienced and thus cannot be attributed to property rights. In addition, the declining relative importance of organic fertilizer usage is to a considerable degree the result of government policies and actions that

**TABLE 2: China's Fertilizer Supply, Selected Years**

| *Year* | *Chemical Fertilizer (million metric tons)* | *Chemical Fertilizer (tons/mu)* | *Chemical Fertilizer (tons/agricultural laborer)* |
|---|---|---|---|
| 1952 | 0.078 | 3.68 | 0.0043 |
| 1957 | 0.373 | 15.81 | 0.0181 |
| 1962 | 0.630 | 29.95 | 0.0295 |
| 1965 | 1.942 | 90.35 | 0.0825 |
| 1969 | 2.886 | 136.5 | 0.1053 |
| 1972 | 4.312 | 194.3 | 0.1505 |
| 1975 | 5.369 | 239.4 | 0.1793 |
| 1979 | 10.863 | 487.8 | 0.3501 |
| 1982 | 15.134 | 697.0 | 0.4469 |
| 1987 | 19.997 | 919.7 | 0.5127 |
| 1991 | 28.051 | 1250 | — |

SOURCE: State Statistical Bureau (1990: 3); State Statistical Bureau (n.d.: 39-44); Wang, Halbrendt, and Johnson (1996).

drastically increased chemical fertilizer supply. While organic fertilizer usage in absolute terms may have waned in some villages (as in our five villages), its decline is attributable to the rising real value of labor time, as we shall later show.

The only study that empirically examines the input behavior of farm households while controlling for property rights is based on the survey work of Li, Rozelle, and Brandt (1998). Based on a subsample of 80 households in two northern Chinese provinces, these authors show that farmers have indeed put more organic fertilizer on their private plots than on their responsibility plots or on plots due for reallocation.[17] However, on translating the observed differences in input intensity into a productivity gap (measured in terms of output), the difference was a mere 25%—a remarkably narrow margin when measured against the difference between private plot output and collective land during the commune era, which was more than 100% (Burki, 1969). These authors attribute the low estimated output difference to the typically small output elasticity of organic nutrients. From this perspective, the increase in chemical fertilizer use after decollectivization may also be interpreted as farmers' intent to raise crop yields and, accordingly, farm income.

What concerns us more, though, is the potential effect of a plot's size, quality, and especially location on farmers' fertilizing behavior, variables that were not controlled for in the aforementioned study. Take location, for example. Private plots were located next to the farmhouses, while collective plots (now responsibility plots) were usually larger and some distance from the village houses. Because organic fertilizer is heavy and hard to transport, its greater use on private plots could well be explained by location rather than property rights.[18] This alternative explanation is supported by Kung's (1999) analysis of fertilizing behavior in villages where property rights in land are rendered secure by a specific government policy of freezing land reallocations for a period of up to 50 years. Instead of applying an equal amount of organic fertilizer among the rice paddies, located near farmers' residence, and the dry hilly slopes, usually farther away, farmers apply a disproportionately larger amount of organic fertilizer to the paddies, with location being the main determining factor.[19]

While we would like to replicate the kind of study that Li, Rozelle, and Brandt (1998) have usefully conducted, we were unable to do so as private plots in the strictest sense no longer exist in our five villages. To be sure, some private land has indeed been assigned to the households; however, it is primarily intended for new home construction instead of for crop production. After the new houses were built, the remaining private space, which is typically no larger than a small yard surrounding the new home, is invariably too small for planting crops, although some households manage to grow a few patches of vegetables for self-consumption, whereas others plant a tree or two. And while farmers do apply organic fertilizer to these vegetable patches, only night soil is customarily used, as animal manure is typically saved for fertilizing the fields where the major staple crops—namely, wheat and rice—are grown.

Owing to the foregoing limitation, we resorted to asking our interviewees their perceptions of the effect of land reassignment on fertilizing practices, using the frequency of land reallocations in a village as a crude predictor for tenure insecurity (see Table 3, column 4). Property rights theory suggests that the more frequently a village readjusts its land, the more insecure the perceived tenure becomes. Accordingly, fewer land-specific inputs will be invested. Contrary to this reasoning,

**TABLE 3: Land Readjustments, Perceived Tenure Insecurity, and Fertilizer Usage in the Five Villages**

| *Village* | *(1) Number of Households* | *(2) No Influence Whatsoever (%)* | *(3) Some Influence (%)* | *(4) Frequency of (full-scale) Land Adjustments* | *(5) Organic Fertilizer Use (kg/mu)* | *(6) Chemical Fertilizer Use (kg/mu)* |
|---|---|---|---|---|---|---|
| 1 | 29 | 82.7 | 17.3 | 3 | 200-300 | 90-100 |
| 2 | 27 | 81.5 | 18.5 | 3 | 200-300 | 90-100 |
| 3 | 30 | 80.0 | 20 | 4 | 800-900 | 65 |
| 4 | 24 | 83.3 | 16.7 | 2 | 400-500 | 70-80 |
| 5 | 25 | 76.0 | 24 | 4 | 700-800 | 65 |
| Total | 135 | 80.7 | 19.3 | — | — | — |

SOURCE: 1996 and 1997 fieldwork.

however, an overwhelming majority of the 135 households (80%) explicitly say there is no effect (*meiyou*), whereas less than 20% felt there is only a slight (*you yidian*) effect (see Table 3).

Equally interesting is the finding that the crude predictor of tenure insecurity—the frequency of land adjustments—fails to confirm the supposed relationship between land reallocations and perceived tenure insecurity. As Table 3 (column 5) shows, the quantity of organic fertilizer applications in the five villages is not contingent on how frequently a village reallocates its land. For instance, one would expect farmers in village 4 to apply more organic fertilizer on each mu of land, in light of the fact that land is reallocated least frequently in this village (only twice by the end of 1996). By the same analysis, farmers in villages 3 and 5 should apply less of this soil nutrient per mu of land, given that land has been readjusted more frequently in these villages. Our empirical inquiry nonetheless reveals that organic fertilizer use in village 4—a village that may be regarded as more "secure" in tenure—was only about half the amount applied in village 3 and about 60% the amount of dosage applied in village 5 (see Table 3, column 5).[20]

A key question is what encouraged farmers in villages 3 and 5 to use more organic fertilizer. In both, the continuing availability of this supply soil nutrient rather than secure property rights is a crucial factor affecting the levels of the applications of this soil nutrient. Historically famous for its ox-breeding business, village 3 continues to specialize in this pursuit and thus has more organic matter to deploy in its fields than the other villages in our study. In village 5, the greater engagement of farm households in animal husbandry—in particular, hog raising—also enables farmers there to obtain and use larger amounts of organic fertilizer. These are the only two villages of the five that obtain more than 10% of the household income from animal husbandry. In addition, the greater dependence of farm households in village 5 on agriculture and land as a major income source further provides stronger incentives for them to maximize organic fertilizer use—a point to which we shall return later.

In sharp contrast to villages 3 and 5, organic fertilizer use per unit of arable land is lowest in villages 1 and 2. Given the relatively low priority families in village 2 assign to farming, their low application of organic fertilizer is not surprising. Farmers in village 1 are more dependent on agriculture for their livelihoods than those in village 2.

Village 1's low usage may therefore be attributed to the exceptionally large farms found there.

Finally, Table 3 shows that the application of chemical and organic fertilizers is inversely related. The two complement one another in the farm production process, and their use is contingent on factors such as the opportunity costs of labor and the availability of organic fertilizer.

With regard to the general question of tenure security, it is important to note that officials in these villages have moved to minimize the potentially negative effect of land reallocations on farmers' tenure insecurity. One such measure is to announce major reallocations well ahead of time so that farmers could adjust their farm input investments.[21] Organic fertilizers are typically used at the beginning of a planting season, so full-scale land reallocations are usually announced shortly before the harvest to allow plenty of time for farm households to fertilize the plots newly assigned to them.[22] In this way, the uncertainty of one's investments being "confiscated" as a result of land reassignment is therefore mitigated (but not completely eliminated). What has not been removed, though, is the difference in land quality arising from the initial differential investments made by farmers on the contracted plots. For example, while farmer A has optimally fertilized the contracted plots during his or her tenure, farmer B may have failed to do the same, so that the plots will be of varying quality on reassignment. And if the two were made to swap a plot between them, farmer A would be shortchanged. Interestingly, informal mechanisms allegedly put pressure on those households that have failed to adequately fertilize their contracted plots. We heard of an incident in which a few households refused to include one family in the reallocation exercise on grounds that its plots were sloppily farmed during its tenure. In a small community such as a hamlet, this kind of information is not difficult to acquire, as villagers can easily tell how well their neighbors have worked their land.[23]

## *THE ACCUMULATION OF ORGANIC FERTILIZER BEFORE AND AFTER DECOLLECTIVIZATION*

The foregoing shows that nonprivate property rights do not inevitably give rise to tenure insecurity. In this section, we demonstrate that

the relative decline in organic fertilizer use mainly stems from two factors. First, the Chinese government's dramatic increase in chemical fertilizer supply in the late 1970s and early 1980s led to a wider availability of this chronically scarce soil nutrient. Second, the post-1984 structural transformation of China's rural economy had dramatically increased the real value of labor. Organic fertilizer has to be collected by the user, so he or she will have to weigh between the relative returns between this and the other income-producing opportunities now available.

### *SUPPLY CONSTRAINT AS A DETERMINANT OF FERTILIZING PRACTICES*

The relative applications of chemical and organic fertilizers are basically a function of their availability. Prior to the late 1960s, the Chinese government rationed a steady but slow-growing supply of fertilizer to a limited number of eligible users—primarily to farming areas with high-yield potentials (Stone, 1989: 46). This can be gleaned from Table 2 or the longer time-series data in the appendix. Although chemical fertilizer supply increased from a negligible 0.1 million metric tons around the early 1950s to more than 2 million metric tons by the end of the 1960s, organic fertilizer use still accounted for the lion's share of overall fertilizer use, approximately 80%. By 1969, for example, the amount of organic fertilizer applied to each mu of land was almost four times as much as its chemical counterpart. While chemical fertilizer supply continued to grow steadily in the 1970s, it was not until late in the decade when it began to grow rapidly, to the extent that the priority farming areas experienced a chemical fertilizer glut (Stone, 1989: 46; see also Table 2). By this time, the relative share of organic fertilizer use declined to only slightly more than one-half of overall fertilizer use. And by 1982—a time when more than 70% of China's farm families in China had already adopted the Household Responsibility System—organic fertilizer was the less important of the two in nutrient terms. Even then, however, organic fertilizer remained an important soil nutrient, especially in those regions where chemical fertilizer application rates remained low (Kueh, 1984; Wang, Halbrendt, and Johnson, 1996).

Through the 1960s and much of the 1970s, most farming communities in China had to rely on organic fertilizer for raising crop yields. Our sample villages were subject to this same constraint. In those communities, commune authorities would first distribute the scarcely available chemical fertilizer to the production brigade, which then allocated it to production teams based on the amount of land each worked. Teams were allotted meager amounts, usually enough for 15 to 20 kilograms per mu. Today, farmers in villages 1 and 2, for example, use 90 to 100 kilograms for each mu of land (cf. column 6, Table 3). Such small inputs could not maximize crop yields. To make up for the shortfall in plant nutrients, these production teams—like others in China—used organic fertilizer. According to our informants, production teams applied between 2,500 to 5,000 kilograms of this traditional soil nutrient on each mu of arable land. As the state did not supply this organic fertilizer to primary production units, the production team had to accumulate this traditional soil nutrient by itself.

Before discussing how collective era teams collected a wide variety of organic fertilizers, it is important to identify the relative importance of organic soil nutrients. Table 4 selectively summarizes this information for the period from 1952 to 1992. It shows that night soil, draft animal manure, and hog manure have long been the three most important sources of organic fertilizer in China.[24] From the early 1950s, they accounted for more than 70% of the organic fertilizer supply. Of the three, night soil remains the single largest contributor of this soil nutrient, although its overall importance has slightly declined over time, primarily because farms are no longer the primary recipients of urban night soil.[25] As with night soil, the relative importance of manure from draft animals has declined (though to a lesser extent) to account for roughly one-quarter of the overall supply. By contrast, manure from hogs has steadily increased since the early 1970s, although its contribution in relative terms still lags behind that of night soil and manure from draft animals.[26] Green manure has been the fourth major source of organic fertilizer.

How did our five village communities accumulate organic fertilizers during the period of collectivized agriculture? While the relative use of each of these four major sources (night soil, draft animal manure, hog manure, and green manure) varied from one village to another, informants confirmed their importance. For example, night

**TABLE 4: Composition and Sources of China's Organic Fertilizer Supply, Selected Years (10,000 tons)**

| Year | *Night Soil* | % | *Hogs* | % | *Draft Animals* | % | *Sheep and Goats* | % | *Green Manure* | % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | 198.17 | 33.93 | 57.00 | 9.760 | 184.52 | 31.590 | 22.14 | 3.790 | 12.13 | 2.080 |
| 1957 | 253.16 | 31.80 | 105.88 | 13.30 | 234.71 | 29.48 | 40.37 | 5.070 | 41.71 | 5.240 |
| 1962 | 260.74 | 35.84 | 72.55 | 9.970 | 201.08 | 27.64 | 55.15 | 7.580 | 47.99 | 6.600 |
| 1967 | 335.71 | 31.50 | 155.17 | 14.56 | 289.61 | 27.18 | 66.50 | 6.240 | 103.78 | 9.740 |
| 1972 | 384.35 | 31.36 | 215.27 | 17.56 | 307.24 | 25.06 | 68.80 | 5.610 | 137.26 | 11.20 |
| 1977 | 417.88 | 31.52 | 238.22 | 17.97 | 299.36 | 22.58 | 74.35 | 5.610 | 181.57 | 13.69 |
| 1982 | 439.56 | 31.41 | 245.56 | 17.55 | 321.02 | 22.94 | 83.76 | 5.990 | 154.55 | 11.04 |
| 1987 | 462.91 | 30.42 | 267.57 | 17.59 | 388.08 | 25.51 | 83.09 | 5.460 | 126.18 | 8.290 |
| 1992 | 490.51 | 29.18 | 313.68 | 18.66 | 432.14 | 25.70 | 95.53 | 5.680 | 152.30 | 9.060 |

SOURCE: Adapted from Wang, Halbrendt, and Johnson (1996: 288).

soil from nearby schools and premises was considered an important source of organic fertilizer for the villages in question, and production teams made arrangements to collect night soil from their premises. The manure of oxen and water buffaloes provided a rich source of nutrients for the soil. Our informants, however, reported that manure from pigs provided the largest source of organic fertilizer supply.[27] This was the case because hogs were typically raised in larger numbers, thus rendering their overall contributions important. In addition, since households also raised hogs on their private plots, they were frequently encouraged to deliver manure collected from these private pigsties to the team in exchange for work points—which would later be translated into a cash distribution.

Conceived in part to collect as much fertilizer as possible but also to absorb labor during the winter slack seasons, production teams also organized specialized work squads to collect river and lake sludge. In villages such as village 5, production teams dug ponds to accumulate fertilizer. Teams also organized farmers to pick leaves from trees and remove weeds wherever available. These were then left to decay in the ponds for later use as soil nutrients. Last but not least, production teams typically left fallow a small amount of their land each year for growing green manure.

Implementation of the Household Responsibility System took most agricultural production and investment decisions out of the

hands of production teams. Households now decide which economic activities are the most profitable for them to engage in, allocating their labor accordingly. In this new context, it is important to note that since there is not a market for organic fertilizer, the latter could only be accumulated by the farm households themselves. Farmers are no longer keen to keep draft animals to help perform essential farm tasks such as plowing and harvesting, and they are not particularly eager to raise animals for profits. Our farmer informants think that it is not generally worthwhile to keep draft animals because of the relatively low economic return to farming and the limited range of tasks that draft animals can perform.[28] Unless forced by special circumstances, such as hilly terrain, farmers prefer to substitute small walking tractors for water buffalo. Households without walking tractors prefer hiring combine crews to work for them during the harvesting season—a service that has become increasingly available. The consensus, at least in the villages we studied, is that it is not worthwhile to keep water buffalo.

This leaves pigs to provide the bulk of the animal manure applied to the land. With a couple of exceptions (villages 3 and 5), animal husbandry in general, particularly hog raising, is not popular among the households in our surveyed villages, accounting for less than 10% of household incomes in 1995.[29] Once again, it is the relatively unattractive economic returns of hog raising that contributes to its lack of popularity. According to our informants, it typically takes at least one year for a piglet to grow to be big enough for sale. Owing to the various taxes and costs of forage, however, the net income obtained—before netting labor costs—is less than 100 yuan. This does not provide sufficient motivation for households with limited labor to take up animal husbandry as a major economic activity. Not every family in these villages raises even one hog, and very few keep more than two.[30] Only extended households with more than three generations living together—particularly those with an elderly person who has little or no opportunity costs or those who can afford to stay at home all day long to attend to the needs of the animals—would do so. On the whole, the limited number of hogs that farmers in our surveyed villages raise severely constrained the amount of organic fertilizer available for use in the fields.

By contrast, the supply of chemical fertilizer expanded during the reform era. Referring once again to Table 2, chemical fertilizer supply increased from approximately 5.37 million metric tons in 1975 to more than 15 million metric tons by 1982—a threefold increase. This rise in supply did not abate in the 1990s. By 1993, the state supplied farmers with more than 30 million metric tons of chemical fertilizer, double the 1982 amount. Since sown acreage remained relatively stable over the period, chemical fertilizer use on each mu of arable land intensified. Table 2 does show that this index has increased, respectively, from 239 tons per mu of crop land in 1975 to almost 700 in 1982 and to 1,250 in 1991.[31]

Farmers, of course, appreciate chemical fertilizer's yield-enhancing property. While a separate production function has not been carried out for estimating the contribution of this soil nutrient to grain yields, researchers have confirmed its yield-enhancing property.[32] First, their studies show that it has become dominant in nutrient terms since 1982. Second, they demonstrate that grain yield has correspondingly increased, from 3,124 kilograms per hectare of land in 1982 to more than 4,000 kilograms per hectare in 1993 (Wang, Halbrendt, and Johnson, 1996). Our sample villages are no exception to this general trend: whereas the rice yield was less than 300 kilograms/mu during the collective period, it has since risen by more than 30% to 450 to 500 kilograms/mu today. The same can be observed for wheat, whose yield was a mere 200 kilograms/mu before the reform but is now 350 kilograms/mu. And if it is indeed the case that current fertilizer usage (331 kilograms/hectare in 1993) is still below the optimal application rate—estimated to be approximately 424 kilograms per hectare—then it is likely that we will continue to witness an absolute increase in chemical fertilizer applications in the future (Wang, Halbrendt, and Johnson, 1996; also see Stone, 1989).

Important as they are, the abundant availability of chemical fertilizer and its yield-enhancing properties is by no means a sufficient condition behind farmers' sustained preference to using it in proportionately larger quantities. In a context where the opportunity cost of labor has appreciated considerably, due to the increasing availability of higher value-added off-farm income opportunities, chemical fertilizer's labor-saving property is another qualitatively different reason

why its usage has sustained over time. In what follows, we examine how changes in the structural aspects of these local economies have resulted in the rising real value of labor time and how that has in turn affected fertilizing practices.

### *NEW OFF-FARM WORK OPPORTUNITIES AND THE RISING OPPORTUNITY COSTS OF LABOR*

Villagers in our study work in a variety of off-farm jobs. Table 5, which breaks down these jobs into four main categories, shows how they are distributed among the five villages. By and large, these nonagricultural jobs are divided between local opportunities, such as manufacturing production and petty commerce, and opportunities that require leaving the area, such as migrant labor work and transportation. A striking finding is that village 2 is the only village where many farm households do not leave their home of residence to engage in and benefit from nonfarm employment because of three successful collective enterprises.[33] Most farmers in the other four villages have to leave their families and farming to take advantage of more lucrative income opportunities. Typically, day-to-day field management such as insecticide applications and removing weeds is left to those who stay behind at home, usually the elderly and the women.[34] While this auxiliary labor can perform these farm tasks, these people are not usually strong enough to collect and apply organic fertilizers, whose labor-intensive nature is well known.[35] One would therefore expect that the increasing engagement of farm families in nonfarm pursuits away from home would produce a less-than-optimal use of organic soil nutrients.

This does not account, however, for the low rate of organic fertilizer use in village 2—a village where most nonfarm jobs are available locally. While the seasonal nature of farming appears to allow farm households to continue cultivating their small plots and maximizing their income by working off the farm, these two activities do compete for farmers' limited time.[36] In village 2, the most industrialized village of the five, some households were once found to be so busily engaged in manufacturing pipes for making water pumps that they had altogether neglected harvesting their crops. This prompted irritated

**TABLE 5: Distribution of Nonfarm Income in the Five Villages, by Employment Type**

| | *Types of Nonfarm Work* | | | |
|---|---|---|---|---|
| *Village* | *Migrant Work (%)* | *Manufacturing (%)* | *Transport (%)* | *Petty Commerce (%)* |
| 1 | 64.3 | 0 | 14.3 | 21.4 |
| 2 | 11.4 | 57.0 | 22.8 | 8.8 |
| 3 | 69.0 | 5.2 | 5.2 | 20.7 |
| 4 | 71.6 | 3.0 | 6.0 | 19.4 |
| 5 | 70.8 | 0.0 | 6.3 | 22.9 |

SOURCE: 1996 and 1997 fieldwork.

village cadres to cut off the electricity supply to interrupt their work and to force them to return to the fields to harvest their crops. To avoid a repeat of this, these households soon hired others to perform this time-critical task. As one informant remarks, "The 30 to 40 yuan charged for each mu of the crop harvested are but a tiny fraction of what could be made from producing the pipes." Not everyone resorted to such subcontracting practices for solving this problem of time management. Many instead bought their own walking tractors to expedite time-critical tasks such as plowing the land and harvesting and transporting the crops.

The priority farm households attach to off-farm work over crop production and the disproportionate amount of time that they correspondingly allocate to the former suggest that chemical fertilizer is valued for its labor-saving properties. This is especially the case when compared with organic fertilizer, which has to be accumulated from a wide variety of sources, taking time and energy. With readily available chemical fertilizer, farmers are spared from undertaking chores such as cutting weeds, picking leaves from trees, draining ponds for mud, or transporting the mud to the land with a two-wheeled barrow or with a shoulder pole. Given the rapidly diversifying rural economy and its rising opportunity cost of labor, farmers do not elect to pursue such activities. The (slightly) declining use of organic fertilizer per agricultural worker since 1979 is attributable to the rising opportunity costs of labor time in response to rural economic diversification rather than to a flawed system of land tenure (cf. Table 2). Unless a market exists

for buying and selling organic fertilizer, the rising real value of labor time will surely result in its declining use per agricultural laborer.[37]

This is not to suggest that farmers in China are no longer concerned with preserving the soil fertility of their contracted plots by applying organic fertilizer. As we have seen from the previous section, farmers in the five villages have continued with their applications of this traditional soil nutrient alongside chemical fertilizer. With limited quantities of this soil nutrient at their disposal, however, we have found, interestingly, that the criteria for "rationing" organic fertilizer use are patterned on the varying levels of local economic development, opportunity costs of labor, quota constraints, and so forth between the villages.

## *ORGANIC FERTILIZER APPLICATIONS IN THE FIVE VILLAGES OBSERVED*

Farmers continue applying organic fertilizers because they perceive benefits associated with it. Many observers stress the yield-enhancing property of chemical fertilizer, but its weakness, when used in isolation, has received scant analytical attention. According to farmers with whom we have spoken, the isolated use of chemical fertilizer hurts the entire root system of the crop; this, in turn, gives rise to ineffective tilling and results in higher rates of hollow rice husks (*gao kong kelu*) and therefore lower yields (Kung, 1999). Moreover, without nitrogen and other trace materials provided by the organic matter, the soil structure will cease to remain in a crumbly condition, an essential condition for healthy crop growth. Crops grown in soil fertilized with organic nutrients also tend to exhibit stronger resistance to lodging and tend to be less susceptible to injurious insects. All these beneficial effects motivate Chinese farmers to continue fertilizing with organic nutrients, albeit in smaller quantities than in the collectivized era.

Three distinct criteria guide farmers in our villages in rationing the use of their scarce organic matter. In villages 1 and 2, farmers fertilize only those plots located near their homesteads, whereas their counterparts in villages 3 and 4 rotate their applications from some plots in

one year to others in another, largely in a random fashion. In contrast, farmers in village 5 apply a disproportionate amount of their limited organic fertilizer to plots that they believe will be most responsive to this soil nutrient. How can we account for this variation?

*VILLAGES 1 AND 2: TIME SAVING*

With regard to the first two villages, the selective application of organic fertilizer based on a plot's location suggests that farmers there value the time saved from fertilizing the more distant plots. This makes sense for those households whose income is derived disproportionately from off-farm sources, as in the case of village 2. In village 1, however, agriculture still contributes substantially to household income. Why, then, would farmers there fertilize only those plots located near their homestead? Unlike typical (natural) villages or hamlets, which coincide or overlap with the same production group so that members reside and farm within a well-demarcated spatial environment, members of these two villages belong to different production groups, some of which are located far from their residences.[38] Land assigned for cultivation by individual households is distributed within the context of a production group, so those households belonging to the more distant groups receive plots located far from their homestead. To illustrate the contrast, in the case when a hamlet coincides with a production group (as in village 3, for example), the distance between plots located at opposite ends of the village's fields can be covered on foot in twenty minutes. By contrast, in villages 1 and 2, farmers have to ride bicycles for more than a half hour to their more distant plots. Manually transporting organic fertilizer over a long distance is an arduous task, even for those focused on agriculture. In addition, farmers in village 1 have to fertilize a larger land area. Most of their organic fertilizer is easily exhausted on the nearest plots.

It is worth noting that the size of grain quota also bears on the rationale behind a village's particular choice of fertilizing practice. As noted earlier, both villages 1 and 2 happen to have the smallest quota of the five. With a small procurement quota, farmers can selectively fertilize only those plots that would impose the least opportunity costs on them—in this case, plots located near their residence. This degree

of freedom afforded by a small grain quota is especially important as it allows villagers with high opportunity costs of labor, such as those in village 2, to produce just enough grain for self-consumption and to meet state deliveries.

### *VILLAGES 3 AND 4: BALANCING TIME CONCERNS, SUPPLY LIMITS, AND A DESIRE FOR MAINTAINING OVERALL PRODUCTIVITY*

In villages 3 and 4, where the distance between farm plots cultivated by a household does not pose as costly a barrier to fertilizer use as it does in villages 1 and 2, farmers rotate applying their limited organic matter to their various plots. Since the effect of organic fertilizer typically lasts longer than one year, plots that do not receive any organic nutrients in a given year may still have enough from the previous dose to last until the next one is applied. To the extent that farmers do want to fertilize all of their contracted plots but lack an adequate supply of organic matters to do so, rotating their applications on a plot-by-plot basis is a logical choice. Putting the organic fertilizer onto select plots in rotation saves on overall labor and still offers important benefits. Moreover, such a method is likely more feasible in villages 3 and 4, where per capita farm size is small (smallest of the five villages).

### *VILLAGE 5: SEEKING MAXIMUM RETURN*

In village 5, farmers fertilize their contracted plots according to an altogether different principle. Instead of fertilizing only the nearby plots or rotating their applications on a random basis, farmers in this village apply their limited fertilizer to those plots that they believe will respond most favorably to this input application—plots having the largest expected elasticity response. We initially found such a behavior puzzling, given that there are quasi-private plots in this village or plots distributed to the households for producing their own food and are thus not destined for returning to the village authorities for reallocation. If the property rights argument concerning the relationship between land reallocation and tenure security is correct, then farmers

in this village should rationally apply all or at least the bulk of their limited organic fertilizer to these plots. But farmers here choose to sink their fertilizers into those plots that they believe will be most responsive to these farm inputs, regardless of land tenure type. How are we to account for such a behavior? Are these farmers acting irrationally, or is the theory of property rights flawed in its reasoning?

There are two important related factors, we think, in accounting for the observed behavior. First, the disproportionate weight that farmers in village 5 assign to increasing crop yields and output is perhaps attributable to the relatively low level of economic development there.[39] Many feel that to increase their incomes, these farmers must get more from the land. Farmers in village 5 spend ten to twenty days more on farming on average than their counterparts in the other four villages do. But if the standard of living is what predisposes farmers in village 5 to adopt a fertilizing practice that aims at maximizing crop output, why is fertilizing practice in, say, village 1 all that different, in view of their similar levels of standard of living? We think the more generous land endowment in village 1 and the higher transaction costs associated with fertilizing all the plots in that village are important determinants. Second, the two villages also differ markedly with respect to the burden of procurement quotas. Village 5 is subject to a much larger quota than is village 1: 225 kilograms/mu compared with 125 kilograms/mu (cf. Table 1). Villages burdened with large quotas (in relation to their crop yields) are subject to greater pressure to maximize their grain output, so it is thus rational for farmers in such villages to apply fertilizer more heavily on plots where the anticipated elasticity to farm input is the greatest.

## *CONCLUSION*

For peasant families, the use of organic fertilizer is a major farm investment. While this soil nutrient is not as effective as chemical fertilizer in raising crop yields, it better preserves the fertility of the soil and is therefore regarded as no less important a farm input when viewed from the perspective of sustainable agricultural development. Since decollectivization, China's farmers are using relatively less

organic fertilizer than they did before. Some attribute this application drop to tenure insecurity caused by the collective land ownership and periodic reallocation of land use rights. Such analysts fail, however, to observe that the declining share of organic fertilizer in overall fertilizer usage reflects a secular trend in agricultural development rather than a flawed land rights system. In fact, the relative importance of organic fertilizer in total fertilizer usage has continuously declined since the early 1950s rather than with the post-1978 reforms, and other developing countries have also resorted to increasing reliance on chemical fertilizer.

The rise in the relative importance of chemical fertilizer in China stems from the government's efforts to provide more of this modern farm input to the agricultural sector as a means to raise crop yields and to a more recent diversification of the rural economy. As the proportion of household income from farming declines, households are less willing to invest the labor that accumulating and applying organic fertilizer requires.

Do property rights influence fertilizing practices? Can such influence be tested?

Whether tenure is rendered insecure by periodic land reallocation is largely an empirical issue, depending on farmers' perceptions. Most of our farm informants do not view their tenure as insecure. Accordingly, they indicate that the present land tenure system exerts little if any influence on their fertilizing practices. Our findings indeed suggest that both the amount of organic fertilizer applied and the specific rationale according to which it is applied are not related to tenure security (using the frequency of land adjustments as a crude predictor). Instead, they are determined by such factors as the relative importance of off-farm income, factor endowment (farm size), the availability of this nonmarketed soil nutrient, and the size of grain quotas. For instance, in villages where off-farm income is important, villagers not only apply less of this type of fertilizer to their land, but they also economize on the time spent on this activity by fertilizing only those plots located near their residence. Conversely, where farm income continues to make up the bulk of a household's income and where complementary farm activities such as animal husbandry supply a household with significant amounts of organic fertilizer, proportionately more of

this soil nutrient will be used. By the same analysis, instead of applying a smaller dosage of organic fertilizer on nearby plots, households with low opportunity costs of labor are found to fertilize plots they believe are most responsive to this farm input. All of these findings squarely suggest that fertilizing practices—whether we are speaking in terms of quantity usage or the criteria of applications—are patterned on factors that have little to do with property rights or tenure insecurity.

**APPENDIX: Chemical and Organic Fertilizer Applications in China, 1952-1991**

| *Year* | *Chemical Fertilizer (million metric tons)* | *Chemical Fertilizer (tons/mu)* | *Chemical Fertilizer (tons/agricultural laborer)* | *Organic Fertilizer (million metric tons)* | *Organic Fertilizer (tons/mu)* | *Organic Fertilizer (tons/agricultural laborer)* | *Share of Organic Fertilizer in Total Fertilizer Applications (%)* |
|---|---|---|---|---|---|---|---|
| 1952 | 0.078 | 3.680 | 0.0043 | 5.840 | 275.6 | 0.3201 | 98.68 |
| 1953 | 0.108 | 5.000 | 0.0058 | 6.277 | 290.5 | 0.3373 | 98.31 |
| 1954 | 0.139 | 6.260 | 0.0073 | 6.726 | 303.1 | 0.3524 | 97.98 |
| 1955 | 0.232 | 10.24 | 0.0119 | 7.018 | 309.7 | 0.3594 | 96.8 |
| 1956 | 0.296 | 12.40 | 0.0148 | 7.359 | 308.2 | 0.3675 | 96.13 |
| 1957 | 0.373 | 15.81 | 0.0181 | 7.962 | 337.6 | 0.3871 | 95.52 |
| 1958 | 0.561 | 24.61 | 0.0263 | 7.792 | 341.8 | 0.3658 | 93.28 |
| 1959 | 0.522 | 24.44 | 0.0251 | 7.717 | 361.3 | 0.3713 | 93.66 |
| 1960 | 0.649 | 28.73 | 0.0328 | 7.017 | 310.7 | 0.3551 | 91.53 |
| 1961 | 0.457 | 21.27 | 0.0226 | 6.872 | 319.9 | 0.3393 | 93.76 |
| 1962 | 0.630 | 29.95 | 0.0295 | 7.276 | 345.9 | 0.3404 | 92.03 |
| 1963 | 0.937 | 44.55 | 0.0425 | 8.244 | 392.0 | 0.3741 | 89.79 |
| 1964 | 1.153 | 53.55 | 0.0503 | 9.181 | 426.4 | 0.4008 | 88.84 |
| 1965 | 1.942 | 90.35 | 0.0825 | 9.867 | 459.1 | 0.4193 | 83.56 |
| 1966 | 2.742 | 124.5 | 0.1121 | 10.43 | 473.4 | 0.4264 | 79.18 |
| 1967 | 2.944 | 135.4 | 0.1161 | 10.66 | 490.2 | 0.4201 | 78.35 |
| 1968 | 2.168 | 103.4 | 0.0825 | 10.78 | 514.2 | 0.4103 | 83.26 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1969 | 2.886 | 136.5 | 0.1053 | 10.88 | 514.4 | 0.3969 | 79.03 |
| 1970 | 3.224 | 149.8 | 0.1147 | 11.47 | 533.1 | 0.4080 | 78.06 |
| 1971 | 3.774 | 172.7 | 0.1313 | 12.06 | 552.0 | 0.4195 | 76.17 |
| 1972 | 4.312 | 194.3 | 0.1505 | 12.26 | 552.5 | 0.4278 | 73.98 |
| 1973 | 5.213 | 234.0 | 0.1781 | 12.55 | 563.1 | 0.4287 | 70.65 |
| 1974 | 4.858 | 217.9 | 0.1637 | 12.726 | 570.8 | 0.4287 | 72.37 |
| 1975 | 5.369 | 239.4 | 0.1793 | 13.023 | 580.6 | 0.4349 | 70.81 |
| 1976 | 5.830 | 259.6 | 0.1934 | 13.081 | 582.5 | 0.4340 | 69.17 |
| 1977 | 6.480 | 289.3 | 0.2142 | 13.259 | 591.9 | 0.4383 | 67.17 |
| 1978 | 8.840 | 392.6 | 0.2885 | 13.525 | 600.7 | 0.4415 | 60.47 |
| 1979 | 10.863 | 487.8 | 0.3501 | 13.874 | 623.0 | 0.4472 | 56.09 |
| 1980 | 12.694 | 578.1 | 0.3987 | 13.758 | 626.6 | 0.4322 | 52.01 |
| 1981 | 13.349 | 613.1 | 0.4086 | 13.804 | 634.0 | 0.4225 | 50.84 |
| 1982 | 15.134 | 697.0 | 0.4469 | 13.994 | 644.5 | 0.4132 | 48.04 |
| 1983 | 16.598 | 768.5 | 0.4785 | 13.955 | 646.1 | 0.4023 | 45.67 |
| 1984 | 17.398 | 804.2 | 0.4837 | 14.158 | 654.5 | 0.3936 | 44.87 |
| 1985 | 17.758 | 824.3 | 0.4791 | 14.691 | 681.9 | 0.3964 | 45.27 |
| 1986 | 19.306 | 892.5 | 0.5082 | 15.033 | 695.0 | 0.3957 | 43.78 |
| 1987 | 19.997 | 919.7 | 0.5127 | 15.216 | 699.8 | 0.3902 | 43.21 |
| 1988 | 21.415 | 985.5 | 0.5345 | 15.510 | 713.8 | 0.3871 | 42.00 |
| 1989 | 23.571 | 1072 | 0.5758 | 15.818 | 719.6 | 0.3864 | 40.16 |
| 1990 | 25.903 | 1164 | — | 16.333 | 733.9 | — | 38.67 |
| 1991 | 28.051 | 1250 | — | 16.562 | 738.1 | — | 37.12 |

SOURCE: State Statistical Bureau (1990: 3); State Statistical Bureau (n.d.: 39-44); Wang, Halbrendt, and Johnson (1996).

## NOTES

1. The gross value of agricultural output increased in real terms at an annual rate of 7.6% during this period, whereas that of grain production rose by 4.9% annually (State Statistical Bureau, 1989).

2. The effect of property rights on agricultural performance had been ferociously debated among the Chinese academics and policy makers in the latter half of the 1980s. For a review of this voluminous literature, see Kung and Liu (1997). Putterman (1993) also contains an interesting discussion of the subject matter.

3. According to the results of a government-sponsored survey, 95% of the Chinese villages have readjusted land between the early 1980s and the mid-1990s, amounting to an average of 3.1 times (Office of Fixed Investigation Points of Rural China, 1997).

4. See the time-series data presented in the appendix. Moreover, it is important to note that the absolute quantity of organic fertilizer used has in fact grown over time, from approximately 13.5 million metric tons in 1978 to 16.5 million metric tons in the early 1990s.

5. Japan, for example, went through such a phase approximately during the period from 1878 to 1938, when chemical fertilizer use became intensified in response to rising land prices (Hayami and Yamada, 1991; see also Perkins, 1969).

6. Most people in Jiangsu think of the province as being divided into north and south along the Yangzi River. Hence, although Hongze is not exactly located in the northern part of the province, it is regarded as belonging to the north (*subei*) instead of to the south (*sunan*). We follow this classification in considering the county part of northern Jiangsu.

7. Local officials have asked that we not provide the names of these villages.

8. Under the Household Responsibility System (HRS), farmers promise to deliver a stipulated amount of grain or other crop output in the form of procurement quotas and agricultural tax to the state. In exchange, they are granted use rights over the collectively owned land and, contingent on this use, the right to a residual income. As quotas were originally assessed in the 1950s and have changed little since then, variations between villages of even the same province could be enormous.

9. The percentages in column 6 are calculated by dividing those households that reportedly have at least one member engaged in off-farm work with the total number of households in the selected "small groups" (*cunmin xiaozu*) of the five villages.

10. An analysis of data from 400 farm families in China shows that the returns to that member of a family with the highest education—who invariably works off the farm—is positive and significant (Kung and Lee, 1999).

11. Among our subjects, 56% of the families engaged in nonfarm employment had the household head working off the farm, and 28% of the families have sent their adult children to pursue such income opportunities.

12. Although the share of nonfarm income is lowest in village 1, its overall income is not the lowest because of favorable land endowment—with each person having on average 3 mu of arable land.

13. One mu equals one-sixth of an acre or one-fifteenth of a hectare.

14. Grain quotas were historically determined on the basis of the physical productivity of land rather than the sheer size of it. This may explain why, despite the more generous land endowment in village 1, its procurement quota is relatively small, whereas the quota size is highest in village 4—the village with the highest man-to-land ratio (see Table 1).

15. This village's long tradition of crop production and especially aquaculture and its lack of industry may also bear on the lower incidence of its residents seeking off-farm work.

16. The same may be said to apply to the disappearance of other mandatory labor services and other uneconomic excesses of agricultural intensification—most notably, triple rice cropping after the demise of collective farming. We owe this observation to an anonymous referee.

17. This subsample represents less than 10% of the total surveyed ($n = 1,200$). These 80 families were selected for analysis because the authors wanted to control for the effect due to differences in crop choice on fertilizing behavior. The subsample is small for two reasons. First, Chinese farmers typically grow crops of higher value on private plots; in this connection, it is indeed rare to find households growing essentially the same crop on both private and responsibility plots. These authors offer no explanation as to why these 80 farm families behave in an atypical fashion. Second, many villages no longer make a distinction between their private plots and their contracted plots. Even if they do, the former is usually earmarked for new housing construction (see below).

18. We owe this observation to an anonymous referee.

19. The other reason is that the topsoil of the dry hilly slopes is too thin for retaining any nutrients applied to it. This is especially the case after a heavy rain.

20. In addition, local officials in village 4 set aside a "land bank" in the late 1980s to accommodate population growth, the aim of which was to contain the frequency of land reassignment. Village 4 farmers, therefore, should perceive their land tenure to be even more secure.

21. In our sample villages, the village small group administers the land reallocations. The small group corresponds to the production team during the collective era and consists of an average of 25 farm households.

22. Shortly after the announcement is made, the procedure and the methods of land reassignment are discussed and agreed on by the villagers, followed by a drawing of lots to determine the specific plots to be assigned.

23. Even someone as certain of the superiority of market allocation of resources as F. A. Hayek (1988) conceded that there is a place for "socialism" in small groups. We are grateful to an anonymous referee for noting this.

24. As Perkins (1969) noted, China has had a long history of using a wide variety of organic fertilizers. By the 1400s, for example, the Chinese were already using diverse sources of organic matter ranging from night soil, lime, mud from ponds and river sludge, and sewers. Only in the 1960s did China begin to moderately increase the supply and use of chemical fertilizers.

25. This has to do with farmers having better off-farm employment and, accordingly, better income opportunities. The increasing need for cities to deal with the problem of sewage disposal using their own resources reflects just such an underlying trend. We owe this observation to D. Gale Johnson.

26. Perkins (1969: 71) noted that for centuries, manure from hogs and draft animals combined had eight times the impact of night soil. This is not inconsistent with the contemporary experience, however, as the importance of night soil is likely to vary positively with the rate of urbanization.

27. Owing to the high population density in early twentieth-century North China and thus the preclusion of an extensive development of animal husbandry, it was hogs, not draft animals, that provided the main source of fertilizer for peasant households (Huang, 1985: 150). In addition, not only did hogs provide a greater quantity of compost than draft animals, but the quality was allegedly also of a higher grade.

28. Such calculations are not new. Huang (1985: 149) showed that in North China during the 1930s, peasants carefully weighed the costs of maintaining a draft animal against the possible benefits. In particular, only under circumstances in which the benefits of using draft animals in crops cultivation were substantial—most notably in villages having both a longer growing

season that facilitated double cropping and a good drainage system—would it be more relied on. As small walking tractors are becoming more widely available, they will almost certainly be substituted for draft animal use.

29. Income from animal husbandry for both villages 1 and 2 was a mere 4%. It was 8% for village 4. Only in villages 3 and 5 did this income surpass 10% (13% and 12%, respectively). This contrasts markedly with the survey results from four counties in the provinces of Hunan and Sichuan, where 400 farm families obtained more than 20% of their income from animal husbandry (Kung and Lee, 1999).

30. Again, there is a historical parallel. In Shajing in the 1930s, one of the villages examined in Huang's (1985: 151) study, most households "routinely raised one hog for market" but felt that "it did not pay" to raise more. Huang concluded that "even counting the benefits of fertilizer, the market prices were not high enough relative to feed costs to make the enterprise [hog raising] worthwhile" (p. 151).

31. In Japan, farmers turned to increasing chemical fertilizer inputs when land prices rose prior to World War II, thereby resulting in the increase in plant nutrients input per unit of arable land (Hayami and Yamada, 1991: 38). In the contemporary Chinese context, it is the low relative price of chemical fertilizer (in relation to the market price of rice) that has partially encouraged the sustained use of this soil nutrient. In the 1930s in the Yangzi River Delta region, the high price of chemical fertilizer relative to that of rice severely constrained farmers from applying more of this input to raise crop yields (Huang, 1990).

32. A number of researchers have shown that increased chemical fertilizer usage was the second most important factor responsible for crop output growth during the 1979 to 1984 period (McMillan, Whalley, and Zhu, 1989; Lin, 1992). Lin's (1992: 51) estimate, for example, shows that chemical fertilizer input contributed 32.2% to the output growth during this period.

33. These enterprises are a machine tools factory, a cement factory, and a grain-processing plant (cf. Table 1).

34. This has led to a phenomenon referred to by some as the "feminization" of agriculture (Jacka, 1997; Rawski and Meade, 1998).

35. That collecting organic fertilizers is exceedingly strenuous is evident in the collective agricultural practice in which only the physically strongest workers would be assigned the responsibility of collecting and applying organic fertilizer. Specifically, only those who were able to shoulder-carry two buckets full of (mud-mixed) fertilizers weighing altogether more than 50 kilograms to the fields with a wooden pole would be assigned the maximum work point rating—a value of 10 for a day's work (see Kung, 1999). In the production team, a worker would be assigned a work point rating based on age, sex, physical strengths, and farming skills. This rating, when multiplied with its value (a proxy for wage rate), determined a worker's income.

36. This occurs despite the fact that the average amount of time that households in the five villages now spend on farming is only two months, including the peak agricultural seasons.

37. We did ask some villagers if they would purchase any organic fertilizer in the market if there were indeed one. They discarded our question outright by saying that it was simply not possible, as nobody would spend their time and effort doing it. Even the elderly, who used to get up early in the morning and wander about in the fields looking for organic fertilizer for use on private plots, no longer do so.

38. A hamlet or a natural village corresponds to the production team under the three-tier commune structure.

39. Per capita net income in this village is in fact the lowest of the five.

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