Department of Agricultural and Resource Economics
University of California Davis

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by

Guo Li, Scott Rozelle and Jikun Huang

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GUO LI, SCOTT ROZELLE, AND JIKUN HUANG*

* Guo Li is economist in the EASRD department of the World Bank. Scott Rozelle is professor, Department of Agricultural and Resource Economics, University of California, Davis. Jikun Huang is director, Center for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Sciences, Beijing, China.

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LAND RIGHTS, FARMER INVESTMENT INCENTIVES, AND AGRICULTURAL PRODUCTION IN CHINA

Understanding land rights formation and measuring its effects on production are two of central issues of the political economy of development (Eggertsson, 1990; Besley, 1995). The theoretical and empirical analyses in our previous work (summarized in Brandt, Huang, Li and Rozelle, 2000) show that, facing diverse economic environments, the village leaders' decision-making authority over land has resulted in a broad spectrum of land rights in China.

The efficiency and impacts of these heterogeneous rights arrangements have provoked a hot debate about land rights in both academic and policy spheres. Participants of this debate have taken both sides of the argument. Some say that land rights is one of the areas most in need of reform in the rural sector (Wen, 1995; Yao and Carter, 1996; Zhou, 1994; Feder et. al., 1992; Johnson, 1995; Prosterman, Hanstad, and Li, 1996). Weak or incomplete land rights, which arise from frequent land readjustments, restrictions on land rental rights, and regulations covering other land rights, weaken farmers' investment incentives for investments in the land, especially long-run, land-saving investments. They recommend that China's leaders should privatize land to overcome the inefficiencies.

Another group of researchers and policy analysts, however, believes that the gain from land privatization is not expected to be large. Farmers are not in favor of privatization because they actually enjoy more security under current collective ownership of land (Kung, 1995; Kung and Liu, 1996; Dong, 1996).[1] This school of thought asserts that China does not have propitious conditions for privatizing land at current time. Poor credit markets, a nonexistent land registration system, and an incomplete legal system would make privatization of land inefficient and socially dangerous (Dong, 1996).

Given the policy implications and the vitriolic nature of the debate, it may be surprising that so little empirical research has been conducted. Because of data limitation, little empirical evidence has been provided either to validate or to invalidate the competing arguments. In most

of the existing work, much of the institutional richness is lost in favor of theoretical abstraction. A complete answer to the question about the impact of land rights on agricultural production should include two parts. First, do land tenure and its associated land rights affect farmers' investment incentives? Second, if there is an efficiency loss, how serious is it? Few previous studies have used data on explicit land rights, while controlling for land quality, to measure the impact of specific rights on agricultural production. Most, if not all, published empirical studies at most discuss the relationship between tenure types and production efficiency, not the relationship between the land rights and production efficiency (e.g., Shaban, 1987). Although Besley (1995) argues that his analysis focuses on transfer rights, his measure actually is a conglomeration of 6 different rights. Since he did not control for other rights in the empirical analysis, the index of transfer rights actually may be nothing more than an index of tenure type.

The overall goal of our paper is to estimate the impact of China's land rights on farm investment incentives and agricultural production. To meet the goal, the paper pursues three specific objectives. First, the paper briefly reviews the various linkages between land rights and investment incentives. Next, we demonstrate how land use behavior differs according to the tenure regime and land rights. Third, by using our field survey data, this paper identifies the links between specific land rights, instead of just the land tenure type, and investment incentives. The paper also measures the size of efficiency loss from the current land rights arrangements.

Land Rights and Investment Incentives

In much of the economics literature, the effect of land rights on production is assumed to affect an individual's investment incentives (Alchian and Demsetz, 1972; Feder and Feeny, 1993; Besley, 1995). Three positive links between land rights and investment incentives have been explicitly identified and formally modeled in the literature (Shaban, 1987; Feder and Feeny, 1993; and Besley, 1995). The first link captures the positive relation between the tenure security and investment incentives (Jacoby, Li, and Rozelle, 2000). The second link emphasizes the effect of

the rights to collaterize land on the investment incentives (Feder and Feeny, 1993). The third is one between investment incentives and land transfer rights (Besley, 1995). In addition to the above three links, there are other channels through which other components of land rights also can affect investment incentives (e.g., quota policy—Lin, 1993).

Theories on the links between rights and investment incentives imply the importance of distinguishing the rights at household level from the rights at plot level in the empirical analysis. Some rights at the household level matter to investment decisions; some rights, however, only affect investment decisions at plot level. For example, the right to use land as collateral will matter at household level: if a farmer can better collaterize a particular plot of his land, he may use the additional capital to invest in all rest plots. Therefore, for some rights, there is not necessarily a direct link between the right on a particular plot and investment in that plot. Other rights, for example, the rights to sell or rent land will matter at plot level. Farmers may only willingly increase investment on the plots on which they have the right to rent or sell. Tenure security rights also could affect investment decisions at the plot level. If farmers know that they can hold one plot for a longer time than another, their production behavior should be expected to differ.

Because of space constraints and data limitations, the paper mainly discusses the effects of three basic land rights: tenure security right, land rental rights, and the right of the state to extract a mandatory delivery quota from the farmer on the use of organic and phosphate fertilizer. In the context of rural China, many other land rights are less important or universally absent. For example, banking laws prohibit the use of farming land as collateral. Because of collective ownership of land, farmers do not have the rights of bequest or inheritance. Moreover, data from our household-level and village-level field surveys show that whereas there is a great heterogeneity among villages in the way they set tenure and transfer rights, there is more homogeneity in the other rights, such as control rights, making the study of these other rights somewhat less interesting.

Unfortunately, despite the importance and relevance of good rights for establishing a healthy investment environment for fixed investments, the study cannot test for the effect of land rights on such activities. In rural China, decisions about investment in irrigation systems, drainage, and terracing frequently remain village-level decisions and in many of our survey villages currently are not part of the locus of individual household decision-making (Dong, 1997). A nation-wide village survey conducted by Rural Center for Rural Economy (RCRE) of Ministry of Agriculture shows that 92.3 percent of villages planned and organized farmland capital construction projects (RCRE, 1991).

Tenure Types and Land Rights in China

Land in most villages can be divided into two types: private plots (*ziliu di*) and collectively controlled land (*jiti di*).[2] Even during the 1960s and 1970s, when the agricultural sector was largely organized into communes, farmers still managed their own private plots. In most villages, leaders do not intervene into decisions on private plots; farmers have rights to the residual production, and enjoy a fairly high degree of security. Although many inter-village differences exist, private plots largely have remained in the possession of the original families since the early 1960s (and were allocated to new families in the 1970s and early 1980s). Interviews by the authors reveal that many farmers in villages across China treat their private plots as if it were their own (Li, 1997). State Statistical Bureau survey (1992) and our national village survey (1996) show that private plots account about 6.2 percent of total cultivated land.

After rural economic reform, which is represented by the implementation of the Household Responsibility System (HRS) in early 1980s, local leaders allocated the rest 93.8 percent of cultivated land (i.e., the collectively controlled land) to farm households using three different tenure forms: ration land (*kouliang tian*), which goes to farmers mainly to meet household subsistence requirements; responsibility land (*zeren tian*), which goes to farmers on

the condition that farmers deliver a low-priced grain or cotton quota to the state; and contract land (*chengbao tian*), which is auctioned off or allocated by village leaders for a fee.

Not all villages have all three categories of land, however. A detailed field survey of 184 randomly selected villages in six provinces by the authors and an independent enumeration by the State Statistical Bureau (reported in Cheng and Tsang, 1995/96) demonstrated that land tenure types differ sharply among villages. Whereas most villages have responsibility land (more than 90 percent), only 17.5 percent have ration land, and only 30.6 percent have contract land.

The differences of land rights associated with each tenure type are quite striking. Unlike the picture portrayed by some (e.g., Prosterman, Hanstad, and Li, 1996), the land rights associated with each tenure type are not only different across provinces or regions, but also differ from village to village in the same jurisdiction. For example, in terms of tenure security, leaders in over 90 percent of sample villages in Hubei province have readjusted land in past 15 years. In Sichuan Province, however, the percentage of villages in which land has been readjusted is only 22 percent. The authors' field survey also shows that in about 60 percent of sample townships, two villages within a single township reported different land readjustment frequencies.

Although the rights associated with private plots and collectively controlled land generally are different, some rights or regulations about certain rights apply to both private plots and collectively controlled land. For example, during the field survey, enumerators noted that the regulations about land rental rights and prohibitions of using land as collateral generally apply to both private plots and collectively controlled land.

The complexities of China's land rights arrangements and inter-village heterogeneity provide an opportunity to conduct an experiment to measure the impact of tenure forms and land rights on farm productivity. For example, one can identify the land rights effects on individual investment incentives and production efficiency by comparing how farmers use inputs on one type of land relative to another. Production behavior on private plots can be compared with that on collective plots. Even though only 6.2 percent of China's land is farmed as private plots, the

way leaders have assigned rights to these plots means that they can be used as a paradigm of how farmers might use their land if all land were given to them with rights equivalent to those associated with private plots.

Another experiment is facilitated by the fact that the composition of that bundle of a single tenure type may vary from place to place. Because each tenure type is a conglomeration of a bundle of rights, even if one finds that inefficiency is associated with a certain tenure type, without detailed information on the exact land rights composition of the tenure form, one may not be able to identify which imperfection in the bundle of rights is causing the inefficiency. By disaggregating the various tenure types into their component parts, it is possible to study how specific rights, instead of the land tenure types, affect production behavior.

Farmers' Production Behavior and Land Rights: Descriptive Evidence

To study the impact of tenure types and land rights on production behavior, a household survey of 664 households from 31 villages in 6 counties in Hebei and Liaoning was conducted in the summer of 1995. Hebei and Liaoning provinces, located in North and Northeast China, are two of China's major agricultural provinces, and the 6 sample counties are located in major agricultural regions of the two provinces. Most agricultural producers in the sample counties depend on grain or cash crop production. Farmers primarily grow maize, which accounts about 70 percent of total sown area, but also cultivate soybeans, rice, and cotton.

For each of the 664 farm households in the survey, enumerators recorded detailed information about household characteristics and agricultural production activities. Total landholdings of each household were enumerated on a plot-by-plot basis. After getting the basic information about each plot, the supervisor of the enumeration team chose two plots from each household for more careful investigation. An effort was made to choose plots that were producing the same crop and whenever it is possible to ensure the two plots were being farmed under different tenure forms. Enumerators systematically surveyed the two selected plots from

each household, eliciting information about the plot's tenure status, specific land rights, all inputs and outputs, and land quality. After data cleaning, there are 1073 plots from 612 households which form the major data set used for the empirical analysis in this paper.

Productivity and Characteristics of Private and Responsibility Plots

Farmers used more inputs and produced higher yields on their private plots when compared with their responsibility land. On average, private plots yielded about 159 jin per mu (1193 kilograms per hectare) more than responsibility plots, about 24 percent higher on average (Table 1, row 1). Yield differences between plots of different tenure type appeared in each of Fengning's five sample villages. While these findings may point to a difference in productivity arising from the tenure type and associated land rights, it is important to note such differences are small when compared to the gaps that existed in the pre-reform period between private and collective fields. Burki (1969), for example, observed that private plots had a yield that averaged more than twice the collective yield.

The more intensive use of inputs by farmers on private plots may account for the differences in output (Table 1, rows 2-6). When cultivating their private plots, farmers applied somewhat more labor (11 percent), animal traction (3 percent), nitrogen fertilizer (5 percent), organic fertilizer (35 percent), and phosphates (22 percent). When working on their responsibility plots, households under utilized organic fertilizer and phosphate, the two inputs which have more long-term impacts on the land, to the greatest degree (significant at 1 percent level).

Differences in land rights associated with private and responsibility plots may explain part of the observed difference in production behavior. For example, the average length of tenure (the number of years farmers farmed one plot) for private plots is about 21 years. Farmers cultivated responsibility land, however, for an average of only 9 years. Insecure rights on responsibility land also arise since the contracts of over 35 percent of the responsibility plots

were scheduled to expire in 1995. Leaders also assess a mandatory delivery quota (46 kg per capita) on responsibility plots.

The yield and input intensity differences could be caused by difference in inherent characteristics of the plots, and in fact may be unrelated to land tenure or the other associated land rights. If there are economies (diseconomies) in the utilization of input, input use per unit of land will be lower (higher) on larger (smaller) plots. Input use also can be positively or negatively related with the quality of the land, with certain qualities of land requiring more or less of a particular input. Time will be involved in commuting and in transporting inputs such as organic fertilizers to the plot and costs for these inputs may increase as the distance grows between the plot and the farmer's homestead. Input intensity could be expected to fall on plots located further from the homestead. Plot specific weather and other shocks during crop season also could have an important effect on input use.

In fact, plot characteristics systematically vary in ways that may account for differences in plot productivity (Table 1). The average size of responsibility plots (1.84 mu) is almost twice the average size of private plots (1 mu--row 9). Private plots also are typically superior in terms of overall land quality. Farmers designated over 85 percent of private plots as top quality. In contrast, only 65 percent of responsibility plots belong to the top quality group (row 10). The authors' village soil survey also found that the average amount of organic matter in private plot soil exceeds the level in responsibility plots (row 11). Private plots also are located nearer to the farmer's house, on average, about one quarter of a kilometer nearer (row 12). The differences of size, quality and distance between private and responsibility plots are significant at the 1 percent level. These differences must be accounted for in any inter-plot comparisons.

Land Rights, Yields and Input Intensities

Examining the sample of all 612 households, yields and input intensity also vary systematically with land rights as in the case of comparison between private plots and responsibility plots. Plots with longer length of tenure produce 146 jin per mu (1095 kilograms

per hectare) more than plots with shorter length of tenure, about 24 percent higher (Table 2, row 1). More intensive input use also rises with more secure tenure rights (Table 2, row 2-6). Farmers generally applied 27 percent more labor, 13 percent more animal traction, 9 percent more nitrogen fertilizer, and 71 percent more organic fertilizer on plots that they had cultivated for more than 8 years than on plots they had used for less than 8 years. Except for the difference of nitrogen fertilizer, all other differences are significant at least at 5 percent level.

Empirical Models and Econometric Concerns

Following the above discussion, the link between input intensities and land rights can be represented by the following equation:

$$x_i = \alpha_0 + \sum_{k}^{K-1} \varphi_{ki} S_k + \sum_{j=1}^{J} \gamma_{ji} R_j + \sum_{m=1}^{M} \beta_{mi} D_m + \sum_{n=1}^{N} \theta_{ni} H_n + \sum_{l}^{L-1} \phi_{li} C_l + \varepsilon_i \qquad (1)$$

where x is input intensity, i represents ith input, α_0 is a constant, S_k is an indicator variable representing the kth tenure type, R_j is an approximation of jth property rights, for example, the security of a plot's land use rights, or the degree of freedom a farmer enjoys in determining land transfer transaction on the plot. When all components of land rights in S are explicitly expressed by R, S may be redundant and meaningless.[3] If one or more rights that makes up the property rights bundle represented by a tenure type is excluded, the coefficient on the variable, $\varphi_{ki,}$ will measure the impact of those excluded rights on input use. The variable, D_m, is mth plot-specific characteristics, for example, soil quality; H_n represents nth household characteristic, such as farmer's management ability, a household's capital constraint, and inputs and outputs prices. For a single household, all n household characteristics have the same effects on the choice of input intensity on all plots farmed by the household. In other words, household characteristics have no plot-specific impact. The term, C_l, is a dummy variable representing the *lth* crop. The symbols, φ, γ, β, θ and ϕ, represent parameters to be estimated, and ε is the error term.

Equation (1) includes three land rights variables: the length of tenure, land rental rights, and compulsory grain quotas. The estimation includes formal education of household head, age of head, number of males, number of females, value of durables and number of rooms in home as household characteristics. This list of household variables is almost identical to that used by Besley (1995).

Yield Response Function and Production Function

Even if the above analyses show that land tenure and associated land rights affect investment incentives, an equally important question is how severe the impact is. Given the high political and social costs of land privatization, if the cost of China's current land system is modest in terms of inefficiency, policy makers may need to consider whether or not at this stage of China's economic transition the gains from radically reforming land policy are worth the costs or risks. The paper also will measure the size of the impact on crop yields by estimating a yield response function and physical production function directly. Replacing x_i by y (the crop yield), equation (1) becomes a crop yield response equation:

$$y_l = \alpha_0 + \sum_{k}^{K-1} \varphi_k S_k + \sum_{j=1}^{J} \gamma_j R_j + \sum_{m=1}^{M} \beta_m D_m + \sum_{n=1}^{N} \theta_n H_n + \sum_{l}^{L-1} \phi_l C_l + \varepsilon \qquad (2)$$

If input levels replace prices in the right hand side of equation (2), the equation becomes a production function.

Both yield response and production functions of equation (2) will be estimated in the paper. In equation (2), however, it is possible that output (y) and certain inputs are determined simultaneously. For example, farmers may increase the amount of nitrogen fertilizer or use more labor if they expect that yield will be higher after some realization of a random factor, such as the weather, has been observed. Indeed, accounting for the simultaneity of inputs in a yield function is a common econometric problem. Some inputs, however, such as organic manure and phosphate fertilizer, that are used before the crop season begins (as ground fertilizer), should not

be subject to this simultaneity problem. The estimation of production function of equation (2) includes fitted values of nitrogen fertilizer, labor, and animal traction.

Data

The data used in the empirical analysis come from the authors' field survey in Northeast China (described earlier). The dependent variables include levels of different current input use (input intensity) and outputs of different crops. The independent variables include major land rights variables and control variables. Descriptive statistics of the study's key variables are summarized in Appendix Table 1.

Inputs and Outputs

For each plot, detailed information was collected on five key inputs: organic fertilizer, phosphate fertilizer, nitrogen fertilizer, labor, and draft animal services. The application of organic manure was enumerated in cubic meters and does not differentiate among types of manure. In the sample area most farmers apply a mixture of soil, hog manure, and nightsoil. Chemical fertilizer application, on the other hand, was collected by type and converted into its pure nitrogen and phosphate equivalents. Labor was enumerated in days and includes all labor input by the household during the 1994 cropping year in all farming activities on each plot. Animal traction includes the number of days a farmer used either his/her own or hired bullock for plowing, transport, and threshing for each plot. Information about outputs of each plot also was collected.

Tenure Security

For each of the two plots, enumerators asked the farmer for the information about the number of years that the household had already cultivated it. For example, on average, households had been farming their plots for 7.8 years (Appendix Table 1, row 10). However, the length of time the farmer farmed one plot varies greatly among different tenure types. For the collectively controlled land, enumerators also asked farmers if the contract covering the plot was

to expire in 1995.[4] On about 16 percent of the collectively controlled plots, farmers expected the contract to end that year.

In our analysis, the major variable to capture farmers' expectation regarding tenure security is the number of years that the plot already had been farmed. However, some may argue that it is possible that in some cases the longer the farmer has held a plot, the closer he is to a readjustment. Therefore, length of plot level tenure captures the tenure insecurity instead of tenure security. To show the robustness of our results, we also include in the equation a measure of tenure insecurity: a village-level variable measuring the number of times that a village has reallocated land since the onset of the Household Responsibility System. Villages in our sample range in the frequency of reallocation from 0 to 12. To the extent that such a variable captures tenure insecurity, the coefficient on the length of tenure variable more precisely provides an unbiased measure of the impact of tenure insecurity on production efficiency.

Land Rental Rights

There is no information about a village's land rental rights in the 1995 household survey. To get information about land rental rights and for better controlling for other village characteristics, a village level survey was carried out in the same 31 villages in summer 1997. Enumerators asked detailed information about the village leadership's management of land rental activities. The empirical analysis includes a village level dummy that is coded one if farmers in the village have completely free rental rights, and zero otherwise. The village survey showed that farmers in about 70 percent of all 31 sample villages have a completely free rental rights. In these villages, farmers did not need get permission from leaders to engage in land renting activities in 1995, and could rent to whomever they want. In the other 30 percent of the sample villages, however, village leaders restricted the rights of farmers to freely transfer their land.[5]

Mandatory Grain Quotas

Mandatory delivery quotas may or may not affect input decisions (Wang, 2000; Lohmar, 2000). Ideally, we would like a measure of the household's expectation that the quotas bind or

that they might increase if yields are high. Since this information was not available, one can ask under what conditions would a household's quota in a village the more likely to run the risk of being adjusted. This study assumes that the larger quota, the greater the likelihood is that the quota binds. It could also be interpreted as those with higher quotas are more likely to have their quota adjusted. To capture the possibilities of existence of ratcheting effect, the per capita quota of each household is used. The mean of all sample households is 292 kg, less than 15 percent of average annual production.

Other Control Variables

Physical characteristics of the plots, household attributes, and input and output prices also may influence a farmer's decision-making as much or more than property rights. A farmer considers the quality of the land and input prices when determining how much fertilizer or other current inputs to apply. Similarly, after holding the household's capital constraint constant, off-farm employment opportunities and the household's management ability could affect input use. Without well functioning labor markets, how much labor a household supplies to agriculture will depend on the how much labor it is willing and able to allocate to the off-farm sector (Lohmar, 2000).

In the empirical analysis of the paper, information about years of formal education and age of the household head, family size, the value of durable assets, the number of rooms in the farmers home, and the off-farm wage level are used for capturing the major household characteristics. Plot-specific indices for distance, size, land quality, and self-reported plot disasters (the dummy equals 1 if the plot was hit by a drought, flood, or other natural disaster, and 0 otherwise) are employed for capturing plot attributes. The off-farm wage rate, grain price and fertilizer prices also are used in the empirical analysis since these variables affect input demand. Descriptive statistics for the key household and plot characteristics are reported in Appendix Table 1.[6]

Results

The input demand equation (1) is estimated with and without village dummies for each of the 5 inputs using OLS estimator. The results are presented in Table 3 (without village dummies) and Appendix Table 2 (with village dummies). The models performed well and produced robust results that largely conform to a priori expectation; the performance of many control variables also are as expected.

Plot Attributes and Household Characteristics

Table 3 shows that input use decreases as the size of the plot increases (row 9 of Table 3), which is consistent with the prediction that there may be economy of size in input use. In research about farmers' agricultural investments, similar results also are found by Feder, Lau, Lin and Luo (1992) in China and Besley (1995) in Ghana. The distance of a plot from the farmer's home, however, did not affect input use except for labor input, a result that also is consistent with Besley's analysis (row 8).

The signs on the coefficients of variables measuring household characteristics also are generally consistent with expectations. The results demonstrate that the number of rooms in home, a proxy for wealth, has a positive effect on organic fertilizer. The wealth effect also appears strong in the analyses by Feder, Lau, Lin and Luo (1992) and Besley (1995). The negative sign of education variable confirms the findings of Yao and Carter (1996). Formal education may reduce green manure planting (in their case) and organic manure (in this study) since more education increases the chance of getting a wage job, and raises the farmer's household-specific opportunity cost.

Land Rights

After holding constant other factors, secure tenure rights positively affect the use of inputs, especially those with long-term effects on land fertility (Table 3 and Appendix Table 2, row 2). As the length of tenure increases by one year, the amount of organic fertilizer use will increase by 0.04 cubic meters per mu. This value means that for every one-year increase in the

length of time a farmer cultivates a plot organic fertilizer use increased by about 1 percent. The signs of tenure security variable in the other input equations also are positive (and in the animal traction equation, it is significant at 5 percent level, Table 3). Poor tenure security in contemporary China apparently has a negative effect on use of inputs with long-term effects on land fertility.

Better land rental rights also appear to have a positive effect on the use of both organic and phosphate fertilizer (Table 3, row 3), a result that may be explained by two factors. It a may be that a farmer can increase the return to rental activity by increasing the use of organic and phosphate fertilizers and asking a higher rental rate. Farmers may be signaling the quality of their land to potential renters by increasing the level of organic and phosphate fertilizer use. The estimated coefficients show that farmers will use about 0.44 cubic meters more organic fertilizer per mu and about 13 jin (6.5 kg) more phosphate fertilizer per mu on a plot with free rental rights. Since the rental right is a village level variable, we cannot identify its impact on organic and phosphate fertilizer use when village dummies are included. The results also show that compulsory grain quota does not have an effect on most inputs (row 4).

After controlling for tenure security, rental rights and the grain quota, the private plot dummy still has a significant effect on the use of organic fertilizer. The coefficients show that farmers generally use 1.20 to 1.30 cubic meters (or about 27 percent) more organic fertilizer on private plots than that on the collectively controlled land (Table 3, row 5). For other inputs, however, private plot does not have a significant effect.

There are several explanations about the significant effects of private plots on organic fertilizer use. Because tenure type is a conglomeration of many specific rights, a natural explanation may be that some important difference of land rights between private and collectively controlled plots is not explicitly included in the estimation, therefore, its effect is captured by tenure dummy. Given the fact that land rights are hard to codify with any precision, one may also argue that some explicitly expressed rights do not fully capture the effects of that rights, for

example, the length of tenure may not capture the effects of tenure security completely. The residual effects of these explicitly expressed rights degenerate into tenure dummy and making its coefficient become significant.

Besley (1995) suggests another possible explanation, if we believe that the effects of major rights already have been captured fully and explicitly. The significant coefficient on the private plot dummy may be that the proxy captures a farmer's general confidence about the current land rights, and this confidence is an important determinant of investment. The farmer's general confidence results from the interactions among the specific land rights that cannot be captured by the explicitly expressed rights. For example, villages not reporting the free rental rights may not necessarily mean that a farmer in the village cannot engage in rental activities freely, his confidence in his ability to do so may be increased by having other rights, such as secure tenure rights. Neither the proxy for tenure security, nor the proxy for transfer rights, would capture the interactive effect. Based on this argument, even if all the components of land rights of a tenure type have been explicitly included, it may still be necessary to include a tenure-type dummy to control for farmer's general degree of confidence under the tenure type.

Magnitude of the Rights Impact

While the input demand results demonstrate that land tenure and associated land rights affect farmers' investment incentives, it remains to be shown how serious the problem is. For this purpose, we estimate both yield response and production functions of equation (2) for maize, the major grain crop for all 6 sampled counties. Both equations are estimated with and without village fixed effects (Table 4). For the purpose of comparison, both functions also are estimated with a complete sample that includes all major different crop types. The dependent variables in both cases are the yields of the relevant crops. The results from the large sample are generally consistent with those for maize (not reported).

In both the yield response and production function equations, the parameter estimates of plot attributes and household characteristics are generally consistent with a priori predictions.

Land quality always has a positive significant effect on yield (Table 4, row 10). The highest quality of land generally produces about 58 to 83 jin per mu (435 to 623 kilograms per hectare) more of maize than that produced by lower quality land, about 11 percent higher. The variable indicating that some shock (e.g., a natural disaster) hit the plot also has a significant negative coefficient (row 11). Education of the household head has a significant and positive effect on the yield (row 12). The education index may not only capture the effect of the probability that a farmer is able to get a wage job (Yao and Carter, 1996), a result that leads to lower organic manure use, it also may capture the effects of the farmer's ability on the farm.

The estimation shows that the production elasticities are plausible and consistent with several previous studies. For example, the elasticity of yield with respect to organic fertilizer is about 0.013, which is almost the same as that found by Wiens (0.01, 1982) and Ye (1991).[7] The results also suggest that the elasticity of yield with respect to the labor ranges from 0.29 to 0.33, which is similar to estimates produced by Brandt (1987) in his study about north China (0.32), and also close to the findings of Lau et al. (1979), Weimer (1990), and Fleisher and Liu (1992).

While the performance of the control variables in the yield response functions is quite good, the performance of the price variables is mixed (as they also are in the input demand equations). In all cases of price parameters estimated, none of them are statistically significant (e.g., Table 4, columns 1 and 2).

The mixed performance of price variables may plausibly be a result of collinearity problems embodied in the cross sectional price data.[8] If the input and output markets generally function well, prices should be same for all regions. Prices should differ only by transport costs, part of which may already be accounted for by the inclusion of location dummies and other variables. According to Rozelle, Park, Huang, and Jin (1997) and Xiao and Fulton (1997), China's agricultural input and output markets have become fairly well integrated after two decades economic reform. In fact, there is little variation observed in the village-specific price data for most output and inputs.[9]

Secure tenure rights has a significant and positive effect on yield, but the effect does not appear to be too large (Table 4, row 2). In the case of yield response function without village dummies, the result shows that for each one year increase of length on land tenure, yields will increase about 6 jin per mu (45 kilograms per hectare, column 1). Based on the mean values of length of tenure and maize yield, the elasticity of yield with respect to tenure security is only 0.07. In the case of the production function analysis, both with and without village fixed effects, the parameter estimates show that yield will increase about 5 to 6 jin as the length of tenure increase one year, estimates that also imply that the elasticity of yield with respect to the tenure security ranges from 0.06 to 0.07 (row 1). The low value of yield elasticity with respect to tenure security suggests that while the tenure security affect farmer's investment incentives, the problem may not be that serious in terms of inefficiency. The results show that, however, rental rights and compulsory grain quotas generally do not appear to have a significant effect on the yield.

Although it has been shown that land rights do affect farmers' production behavior from the results of input demand analyses, the results from the yield response and production functions imply that the magnitude of tenure insecurity and rental rights on production efficiency may be small. For example, the value of elasticity of yield with respect to tenure security means that the yield would only increase about 7 percent if the length of tenure had been doubled from current 8 years to 16 years. The effect is small comparing with the efficiency loss found in China during commune era (Perkins and Yusuf, 1984; Burki, 1969; Dernberger, 1982) and in India (Shaban, 1987).[10]

The small magnitude of land rights on production efficiency may not be puzzling if we take into account the following factors. First, in current rural China, decisions about investment in irrigation system, drainage, and terracing remain village-level decisions and are not part of the locus of individual household decision-making (Dong, 1997). As long as improved land rights encourage higher levels of such fixed investments, the study will underestimate the efficiency loss

due to weak land rights. Second, because of the data limitation, the land rights proxies may not be fully capturing the effects of the rights. For example, if we had a better measure of expected length of tenure, the estimated effects of tenure insecurity could be larger. Third, it could also be that there are other institutions in the village that prevent farmers from shirking on applying organic fertilizer and phosphate on their plots. For example, it is possible that farmers could mutually monitor the organic fertilizer application of each other. If a farmer was caught underapplying organic fertilizer, when land was readjusted, he/she could be given the same piece of land or even lower quality piece or his reputation would be harmed in local community. Finally, at least in short-run, land readjustment (tenure insecurity) could have a positive effect on production efficiency in some places, if village leader allocates more land to more capable farmers or to farmers who have more of a willingness to stay in farming sector, then there may be rise in yield.

Robustness of Results

In this section, we will show the robustness of previous results by addressing three issues concerning using length of tenure as an index of tenure security. First, it may be that the longer a farmer holds a plot, the more the farmer worries about losing it, given there is no unambiguous commitment from local leaders. Hence, instead of capturing tenure security, length of tenure captures the insecurity of tenure. Second, the length of tenure may be endogenous. The more a farmer invests in his plots, the more likely he will lobby against reallocations of the plots, and as a result, he may hold these plots longer. Finally, it also is possible that length of tenure captures nothing but farm experience of the household on that specific plot. For the sake of simplicity, we only present the results of organic fertilizer equation since we are mainly interested in the impacts of land rights on investment incentives of farmers.

Accounting for Tenure Insecurity

For dealing with the argument that length of tenure captures the tenure insecurity, we use a village level variable—frequency of land readjustment—to isolate the effects of tenure

insecurity. The rationale behind using this variable is that after frequency of land readjustment is included in the regression, the length of plot tenure would only capture the degree of tenure security.

Table 5 (column 1) contains the results after controlling for the frequency of land readjustment. It is important to note that the results are strikingly similar as those in Table 3 and Appendix Table 2. A one year increase in land tenure results in a 0.03 cubic meter (and significant at the 1 percent level) increase of organic fertilizer (row 2). In contrast, each time land is readjusted farmers decrease organic manure use by 0.28 cubic meters (also significant at the 1 percent level--row 3). Better rental rights retain their positive effect (row 4).

Accounting for Endogeneity Argument

Endogeneity comes from the possibility that farmers are more likely to resist reallocations of their land if they invest more heavily on their plots. Therefore, endogeneity argument allows that the decision to invest affects tenure security. Because of the improved land rights, tenure security will strengthen farmer investment incentives, we may underestimate the effects of land rights on investment incentives without taking into account endogeneity problem (Besley, 1995).

To deal with endogeneity of tenure security, we need to find some instrumental variables that will affect tenure security but not affect the investment incentive directly. We use village level budget, the agricultural tax, village and township tax (*tiliu* and *tongchou*), and proportion of party membership as instruments. As shown in Brandt and Benjamin (2000), these variables have significant effects on land rights decisions of village leaders. It is also reasonable to argue that, however, these variables will not affect farmer investment incentive directly. We first regress actual length of tenure on these instrument variables and other exogenous variables, and then put the fitted value of length of tenure into the organic demand function.

Table 5 (column 2) presents the 2SLS results. The effect of tenure security on investment incentives is significant and robust: better land rights increase significantly the use organic fertilizer. As what we expected, instrumenting for land rights increases the size of the coefficient length of tenure, from 0.03 (column 1) to 0.12.[11] The effects of other rights variables on investment are almost the same as in other specifications. The fact that the magnitude of tenure security effects increases after instrumenting implies that just using length of tenure may underestimate the importance of land rights to investment. As argued in Besley (1995), there is measurement error in the observed rights variables, because these variables may not fully reflect what farmers actually care about in making their investment decisions. Column 3 of Table 5 reports the results of the first stage regression.[12]

Farm Experience Argument

The previous results show that the increase of length of tenure significantly results in the increase of organic fertilizer use. Some people may interpret the result as effects of the farm experience. Their logic is that the longer the length of tenure, the more familiar the farmer with the plot (or the farmer will be more experienced on this plot), and the more input the farmer will use on it. Even if it is the case that length of tenure captures the farm experience, there is an inherent weakness in previous interpretation. The higher degree of familiarity with one plot does not necessary mean the higher input use. Indeed, it may just mean the opposite: since farmer knows this plot very well, so he knows what the plot really needs. The farmer can avoid over-investment on that plot because of this information, and what we will observe may be less input use. Therefore, even if the farm experience argument is valid, the sign of coefficient of length of tenure is undetermined.[13]

We test farm experience argument in two methods. First, we run private plots (total 115 plots) and non-private plots (total 961 plots) separately. Given the private plots do not have any tenure security problem, the length of tenure on these private plots can only represent farm experience. If the coefficient of length of tenure is insignificant in private plots regression but

significant in non-private plots regression, the farm experience argument will not be true. However, small sample size of private plots results in large standard error that may weaken our confidence on results. To keep sample size the same, we also run the same regression on randomly select 115 non-private plots.

The second method that can better overcome the sample size problem is to pool all plots together and run the following regression:

$$x = \alpha_0 + \beta_l R_l + \beta_f R_f + \beta_o R_0 + \gamma D_p + \delta_{lp} D_p R_l + \delta_{fp} D_p R_f + \phi Z + \varepsilon \quad , \qquad (3)$$

where, x is the intensity of organic fertilizer use, R represents land rights and the subscripts *l, f,* and *o* represent length of tenure, frequency of land readjustment, and other rights (such as rental rights, grain quota) respectively, D_p is the private dummy, D_pR is the interaction terms of private dummy with length tenure and frequency of readjustment, Z is a set of plot-level and household characteristics, and ε is the error term. To invalidate the farm experience argument, we need to show that β_l is positive and significant, but $\beta_l+\delta_{lp}$ equals zero, i.e., the total effect of length on private plots is 0. These tests show that private plots and non-private plots respond to the length of tenure differently. However, if farm experience argument is correct, private plots and non-private plots should respond to the length of tenure in the same way.

Table 6 shows results from using the two methods discussed above. No matter which method is employed, the results consistently reject the farm experience argument. For example, length of tenure is not significant in the private plots only regression (column 1), however, it is positive and significant in the regression of non-private plots in either 961 sample size case (column 2) and 115 randomly selected non-private plots case (column 3).[14] Through comparing the standard errors of the coefficient of length of tenure in different specifications, we find the small sample size is a problem indeed. For example, the standard error of length of tenure in 115 sample cases is around 0.038, however, it is 0.015 in 961 sample case.

By pooling all plots together, the results also strongly reject the farm experience argument (Table 6, column 4). First, the coefficient of length of tenure is positive and significant at 5

percent level. However, hypothesis test cannot reject the null hypothesis that the total effect of length of tenure on private plots is 0, i.e., $\beta_l+\delta_{lp}=0$ (F-value=1.61). This result implies that length of tenure does not represent plot level farm experience. In fact, the private plots and non-private plots not only respond to the length of tenure in different ways, but also respond to the frequency of readjustment in a different way. Hypothesis test also cannot reject that the total effect of frequency of land readjustment on private plots is 0. However, the frequency of land readjustment on non-private lots is significantly negative (at 1 % level, row 4).

In this section, we show that results in previous sections are robust. The results in this section strongly support that length of tenure adequately captures the degree of tenure security, even though results from endogeneity analysis suggest that there may be measurement error in these self-reported land rights variables. The observed rights variable may not exactly correspond to what farmer actually care in planning their investment activities; however, examining the impacts of these self-reported rights variables on investment incentives is a good place to begin (Besley,1995).

Conclusion

This paper has provided evidence that land tenure and associated land rights in rural China affect the production behavior of farmers. The strongest, most robust finding is that the better tenure security rights encourage the use of land-saving investments. This paper also has shown that better rental rights positively affect land-saving investments. Tenure security and land rental rights, however, generally do not appear to affect the incentive of farmers to use inputs with short-term effects on land fertility.

While the direction of land rights impacts are expected, perhaps the most important and somewhat surprising result is that the magnitude of poor rights effect is small. The elasticities of output with respect to the land rights and certain inputs (e.g., organic fertilizer) are generally small. Small elasticities mean that yield gains from increasing the length of tenure would

probably be minimal, and privatization of land in China may not have a large immediate effect. The yield differences between private and responsibility plots and between plots with different land rights, is small compared to the yield difference between private plot and collectively controlled land that existed in the pre-reform period (Burki, 1969). The differences in the use of certain inputs also is small compared to the degree of Marshallian inefficiency measured by Shaban (1987) between crops grown on owner-cultivated plots and sharecropped plots in India.

If these small elasticities are indicative of the case across China, it may imply that the cost of China's current land system may be modest in terms of efficiency loss. Other authors have suggested that China's current land system provides other benefits to farmers (such as insurance against economic fluctuations and periodic recessions in the off farm job market--Dong, 1996; Kung and Liu, 1996). It may be that in the short term the benefits of having "insurance" provided by having land under the stewardship of the collective outweighs the inefficiency costs.

If the elimination of the inefficiencies could only come about through land privatization, the results may indicate that at some point time leaders should move to liberalize land rights. The time to do so, however, may not be now. Some conditions required for operating a private land system efficiently, such as land registration system, credit markets, and a complete legal system, do not exist in China's current rural economy. Without such institutions, land privatization could have a high cost to society. Privatization with the prerequisite accompany institution could create a landless class that might have a long-run instability implication for the nation. So whereas the results of this study clearly show there are gains to reform China's land system, the relevant question for policy makers is whether or not at this stage of China's development or during this point of time in the economic transition the gains are worth the costs or risks.

Table 1. Differences in Production and Input Intensity of Sample Maize Farmers on Private Plots and Responsibility Land, Fengning County, 1994 (n=160).

	(1) Private plots	(2) Responsibility land	(3) Absolute difference (1)-(2)	(4) Percentage difference {[(1)-(2)]/(2)}·100
Yields (jin/mu) [a]	808	649	159	24**
Labor (day/mu)	13.8	12.4	1.4	11**
Animal traction (day/mu)	3.4	3.3	0.1	3
Nitrogen fertilizers (jin/mu)	15.7	14.9	0.8	5*
Organic fertilizers (cubic meters/mu)	4.6	3.4	1.2	35**
Phosphate fertilizers (jin/mu)	1.1	0.9	1.4	22**
Tenure plots (years farmed)	21	9	12	133**
Contracts terminating in 1995	n.a	38	n.a	n.a
Size (mu)	1.04	1.84	-0.80**	-43
Quality[b]	0.85	0.65	0.20**	31
Organic matter (%)	1.30	1.25	0.05	4
Distance (km)	0.49	0.73	-0.24**	-33
Proportion of plots hit by disaster(%)	0.14	0.14	0.00	0

Note: [a] 1 jin equals 0.5 kilogram and 1 mu equals one fifteenth hectare. [b] Land class, which is the villager and village leaders' subjective evaluation. i for the highest quality land and 0 for others.
* and ** represent the differences are significant at 5 percent and 1 percent level respectively.
Source: Authors' field survey.

Table 2. Differences in Production and Input Intensity of Sample Maize Farmers on Plots with Different Length of Tenure, Hebei and Liaoning Provinces, 1994 (n=861).

	(1) Length of tenure longer than 8 years	(2) Length of tenure shorter than 8 years	(3) Absolute difference (1)-(2)	(4) Percentage difference {[(1)-(2)]/(2)}·100
Yields (jin/mu) [a]	742	596	146	24**
Labor (day/mu)	8.88	6.99	1.89	27**
Animal traction (day/mu)	1.20	1.06	0.14	13*
Nitrogen fertilizers (jin/mu)	21.27	19.44	1.83	9.4
Organic fertilizers (cubic meters/mu)	1.16	0.68	0.48	71**
Phosphate fertilizers (jin/mu)	1.90	2.32	-0.42	-18*

Note: [a] 1 jin equals 0.5 kilogram and 1 mu equals one fifteenth hectare.
* and ** represent the differences are significant at 5 percent and 1 percent level respectively.
Source: Authors' field survey.

Table 3. Testing for the Impact of Land Rights and Tenure on the Input Intensity, Hebei and Liaoning Provinces, 1994 (without village dummy, n=1076).

Independent variables	Dependent variable				
	Organic fertilizers	Phosphate fertilizers	Nitrogen fertilizers	Labor input	Animal traction
Constant	-7.24***	196.84**	78.31***	10.40	-2.45
	(3.18)	(2.37)	(5.88)	(1.01)	(0.92)
Land rights					
-- Length of tenure	0.04***	0.29	0.04	0.72	0.31**
	(3.20)	(0.61)	(0.58)	(1.21)	(2.02)
-- Rental rights	0.44**	12.81*	-5.33***	-0.98	0.18
(1 free, 0 no)	(2.29)	(1.85)	(4.80)	(1.15)	(0.80)
-- Grain quota	-0.00	-0.00	0.01***	-0.00	-0.00
	(0.52)	(0.22)	(2.73)	(0.87)	(1.23)
-- Dummy of private plot	1.28***	-4.63	-0.52	1.56	0.22
(1 yes, 0 no)	(3.10)	(0.31)	(0.22)	(0.84)	(0.45)
-- Dummy of responsibility land	-0.00	0.85	1.25	-0.20	-0.23
	(0.01)	(0.08)	(0.71)	(0.15)	(0.66)
(1 yes, 0 no)					
-- Dummy of ration land	0.16	-0.68	1.00	-0.13	-0.18
(1 yes, 0 no)	(0.46)	(0.06)	(0.50)	(0.08)	(0.45)
Plot attributes					
-- Distance	-0.01	-3.82	0.19	1.15**	0.21
	(0.09)	(0.94)	(0.29)	(2.30)	(1.61)
-- Size	-0.05**	-0.12	-0.26**	-0.77***	-0.07***
	(2.27)	(0.15)	(1.97)	(7.67)	(2.65)
-- Land quality	0.03	5.94	1.73**	-1.39**	-0.10
	(0.20)	(1.10)	(2.00)	(2.08)	(0.57)
-- Organic matter	0.15	-20.97**	-5.08***	2.49**	0.18
	(0.60)	(2.35)	(3.55)	(2.27)	(0.64)
-- Disaster dummy	-0.25	0.25	0.17	-0.14	-0.39**
(1 yes, 0 otherwise)	(1.56)	(0.04)	(0.18)	(0.20)	(2.08)

[Continued]

Table 3 (Continued). Testing for the Impact of Land Rights and Tenure on the Input Intensity, Hebei and Liaoning Provinces, 1994 (without village dummy, n=1076).

	Dependent variable				
Household characteristics					
-- Formal education of head	-0.05*	1.45	-0.29*	0.02	0.15***
	(1.66)	(1.41)	(1.74)	(0.19)	(4.41)
-- Age of head	0.02***	0.19	-0.04	0.11***	0.04***
	(2.87)	(0.84)	(1.04)	(3.74)	(5.81)
-- Number of males	-0.22***	0.63	0.89*	-0.14	-0.31***
	(2.70)	(0.21)	(1.87)	(0.39)	(3.28)
-- Number of females	-0.16**	2.48	-0.19	-0.52	-0.39***
	(2.13)	(0.88)	(0.43)	(0.15)	(4.31)
-- Value of durables	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.02)	(0.20)	(0.52)	(0.26)	(1.04)
-- Number of rooms in home	0.08**	-0.26	0.09	0.05	0.00
	(2.32)	(0.21)	(0.46)	(0.30)	(0.02)
Prices					
-- Off-farm wage rate	-0.11***	0.23	0.21*	-0.12	-0.07***
	(5.63)	(0.33)	(1.86)	(1.40)	(3.14)
-- Price of nitrogen fertilizers	-0.83***	11.86	-1.41	-1.93*	-0.77***
	(3.25)	(1.28)	(0.95)	(1.69)	(2.58)
-- Price of phosphate fertilizers	1.35***	3.83	-3.52***	0.81	1.09***
	(11.40)	(0.88)	(5.06)	(1.51)	(7.88)
-- Price of maize	11.48***	-378.06***	-92.44***	-11.77	2.15
	(3.43)	(3.10)	(4.72)	(0.78)	(0.55)
Crop dummies					
-- Maize	0.33	3.24	13.47***	3.45**	0.75*
	(0.89)	(0.24)	(6.14)	(2.04)	(1.71)
-- Rice	-0.38	55.45***	19.88***	5.11***	0.14
	(0.86)	(3.46)	(7.74)	(2.58)	(0.27)
-- Cotton	0.09	14.26	13.01***	18.26***	0.10
	(0.18)	(0.79)	(4.50)	(8.20)	(0.18)

Note: Absolute values of t-statistic are reported in parenthesis. *, ** and **** denote coefficients are significant at 10, 5 and 1 percent level of confidence respectively according to standard t-ratio tests.

Table 4. Testing for the Impact of Land Rights and Tenure on the Maize Yield, Hebei and Liaoning Provinces, 1994 (n=861).

Independent variables	Yield response function		Production function	
	Without village dummy	With village dummy	Without village dummy	With village dummy
Constant	706.44***	-9405.04**	759.93**	659.6***1
	(5.41)	(2.26)	(2.18)	(3.00)
Land rights				
-- Length of tenure	5.66**	3.47	5.89*	5.00*
	(2.31)	(1.33)	(1.86)	(1.69)
-- Rental rights (1 free, 0 no)	47.81		21.66	
	(0.06)		(0.25)	
-- Grain quota	-0.00	-0.00	0.00	0.00
	(0.40)	(0.08)	(0.51)	(0.70)
-- Dummy of private plot (1 yes, 0 no)	59.77	87.88	22.28	46.33
	(0.75)	(1.09)	(0.27)	(0.57)
-- Dummy of responsibility land (1 yes, 0 no)	91.26	78.75	101.16	93.84
	(1.47)	(1.26)	(1.60)	(1.47)
-- Dummy of ration land (1 yes, 0 no)	95.44	95.59	100.94	125.06*
	(1.39)	(1.34)	(1.47)	(1.74)
Plot attributes				
-- Distance	-20.91	-14.76	-28.48	-14.76
	(0.92)	(0.63)	(1.05)	(0.61)
-- Size	-6.37	-11.77*	6.19	-1.91
	(1.13)	(1.84)	(0.43)	(0.26)
-- Land quality	57.89**	61.10**	79.10***	83.25***
	(2.31)	(2.42)	(2.95)	(2.88)
-- Disaster dummy (1 yes, 0 otherwise)	-195.89***	-145.72***	-218.09***	-212.57***
	(6.44)	(4.04)	(5.70)	(5.44)
Household characteristics				
-- Formal education of head	16.48***	14.37***	22.38***	20.04***
	(3.25)	(2.78)	(3.67)	(3.15)
-- Age of head	-1.07	-0.74	-1.33	-0.92
	(0.94)	(0.65)	(0.68)	(0.58)

[Continued]

Table 4 (Continued). Testing for the Impact of Land Rights and Tenure on the Maize Yield, Hebei and Liaoning Provinces, 1994 (n=861).

Independent variables	Yield response function		Production function	
	Without village dummy	With village dummy	Without village dummy	With village dummy
Household characteristics				
-- Number of males	-20.42	-17.24	-27.11*	-15.00
	(1.40)	(1.17)	(1.66)	(0.88)
-- Number of females	-24.01*	-19.03	-51.22**	-38.01**
	(1.66)	(1.28)	(2.60)	(2.06)
-- Value of durables	0.00	0.00	-0.00	-0.00
	(0.35)	(0.53)	(0.24)	(0.07)
-- Number of rooms in home	3.53	-4.16	2.12	-2.09
	(0.57)	(0.65)	(0.75)	(0.33)
Prices				
-- Off-farm wage rate	1.30	0.82		
	(1.17)	(0.71)		
-- Price of nitrogen fertilizers	-6.39			
	(0.13)			
-- Price of phosphate fertilizers	-7.20			
	(0.36)			
-- Price of maize	-41.42			
	(0.40)			
Input level				
-- Organic Fertilizers			9.16*	10.13*
			(1.77)	(1.78)
-- Phosphate fertilizers			2.75	4.58
			(0.70)	(1.07)
-- Nitrogen fertilizers			-10.78	-11.22
			(0.91)	(1.03)
-- Labor			24.03*	28.22**
			(1.67)	(2.55)
-- Animal traction			70.20	68.17
			(0.20)	(0.46)

Note: [a] Coefficients of village dummy are omitted for simplicity. Absolute values of t-statistic are reported in parenthesis. *, ** and **** denote coefficients are significant at 10, 5 and 1 percent level of confidence respectively according to standard t-ratio tests.

Table 5. Estimates of Organic Fertilizer Equation through Controlling Frequency of Land Readjustment and Taking into Account of Endogeneity of Length of Tenure, Hebei and Liaoning Provinces, 1994 (n=1076).

Independent Variables	Controlling Frequency of Land Readjustment	Instrumented (2SLS results)	Length of Tenure (1st stage results)
Constant	-15.45***	-13.88***	-7.60
	(5.99)	(5.01)	(1.19)
Land rights			
-- Length of tenure	0.03***	0.12***	
	(2.57)	(2.47)	
-- Frequency of Land Readjustment	-0.28***	-0.25***	-0.08
	(6.25)	(4.96)	(0.62)
-- Rental rights (1 free, 0 no)	0.60***	0.64***	-1.23**
	(3.19)	(3.30)	(2.10)
-- Grain quota	-0.00	-0.00	-0.00
	(0.48)	(0.16)	(1.19)
-- Dummy of private plot (1 yes, 0 no)	1.16***	-0.06	12.24***
	(2.86)	(0.08)	(13.94)
-- Dummy of responsibility land (1 yes, 0 no)	-0.04	-0.24	1.70***
	(0.15)	(0.75)	(2.45)
-- Dummy of ration land (1 yes, 0 no)	0.19	0.14	0.60
	(0.58)	(0.41)	(0.76)
5 plot attribute variables -- Distance, size, land quality, organic matter, and disaster	Yes	Yes	Yes
6 household characteristics -- Head education and age, numbers of male and female, value of durable and room number	Yes	Yes	Yes
4 price variables -- Off-farm wage, prices of nitrogen, phosphate and maize	Yes	Yes	Yes
7 instrument variables -- Village budget, proportion of party membership, per person village fee, township per and agricultural tax, procurement quota, irrigated land ratio	No	No	Yes
3 crop dummies -- Maize, rice and cotton	Yes	Yes	Yes

Note: Absolute values of t-statistic are reported in parenthesis. *, ** and **** denote coefficients are significant at 10, 5 and 1 percent level of confidence respectively according to standard t-ratio tests. Coefficients of the variables for plot attributes, household characteristics, prices, instrument variables and crop dummies are omitted for simplicity.

Table 6. Testing for the Farm Experience Argument.

Independent variables	1 Private plots only	2 Non-private plots only (I)	3 Non-private plots pnly (II)	4 Pool all plots together
Constant	-56.69*** (2.66)	-13.78*** (5.63)	-14.24** (2.11)	-15.87*** (6.03)
Land rights				
-- Length of tenure	0.02 (0.58)	0.04** (2.44)	0.09** (2.45)	0.04** (2.18)
-- Private dummy * length of tenure				-0.01 (0.35)
-- Frequency of land readjustment	0.34 (0.37)	-0.26*** (6.18)	-0.33** (2.23)	-0.29*** (6.27)
-- Private dummy * frequency of land readjustment				0.26 (1.03)
-- Rental rights (1 free, 0 no)	0.91 (0.52)	0.62*** (3.52)	1.19** (2.33)	0.61*** (3.22)
-- Grain quota	0.00 (0.70)	-0.00 (0.54)	0.00** (2.15)	-0.00 (0.49)
-- Private plot dummy (1 yes, 0 no)				0.86 (1.27)
-- Responsibility land dummy (1 yes, 0 no)		-0.04 (0.14)	-0.17 (0.25)	-0.05 (0.17)
-- Dummy of ration land (1 yes, 0 no)		0.19 (0.61)	0.27 (0.35)	0.19 (0.56)
5 plot attribute variables -- Distance, size, land quality, organic matter, and disaster	Yes	Yes	Yes	Yes
Household characteristics				
-- Formal education of head	-0.17 (1.31)	-0.04 (1.58)	-0.15** (2.36)	-0.05 (1.83)
-- Age of head	-0.00 (0.04)	0.02*** (3.01)	-0.02 (1.14)	0.02*** (2.78)
-- Number of males	-0.64 (1.55)	-0.15** (1.96)	-0.28 (1.51)	-0.22*** (2.75)
-- Number of females	-0.24 (0.55)	-0.13* (1.82)	-0.14 (0.73)	-0.17 (2.20)
-- Value of durables	0.00 (0.68)	-0.00 (0.23)	-0.00 (0.31)	-0.00 (0.14)
-- Number of rooms in home	0.18 (0.93)	0.07** (2.36)	-0.00 (0.01)	0.08 (2.53)
4 price variables for off-farm wage, prices of nitrogen, phosphate and maize	Yes	Yes	Yes	Yes
3 dummies for maize, rice and cotton	Yes	Yes	Yes	Yes
Hypothesis test H_o: $\beta_l+\delta_{lp}=0$				F-value 1.61 Prob>F=0.21

Hypothesis test H_o: $\beta_f+\delta_{fp}=0$				F-value 0.01 Prob>F=0.91
Sample Size	115	961	115	1076

Note: Absolute values of t-statistic are reported in parenthesis. *, ** and **** denote coefficients are significant at 10, 5 and 1 percent level of confidence respectively according to standard t-ratio tests.

Appendix Table 1. Descriptive Statistics.

Variables	Mean	Standard deviation
Inputs		
(1). Organic fertilizer (cubic meters/per mu)[a]	1.45	2.60
(2). Phosphate fertilizer (jin/mu)[b]	2.27	4.17
(3). Nitrogen fertilizer (jin/mu)	20.33	13.19
(4). Labor input (work day/mu)	11.10	10.70
(5). Animal traction (work day/mu)	1.63	2.78
Outputs		
(6). Maize (jin/mu)	711.5	371.2
(7). Rice (jin/mu)	922.4	219.6
(8). Cotton (jin/mu)	252.7	108.2
(9). Soybean (jin/mu)	260.3	114.1
Land rights		
(10). Number of years farmed the plot	7.83	6.56
(11). Private plots	19.01	9.33
(12). Responsibility land	7.03	4.68
(13). Ration land	5.14	4.06
(14). Contract land	3.78	3.53
(15). Proportion of village with free rental rights (%)	71	46
(16). Average grain quota per capita (kg/per capita)	292	1454
(17). Formal education of head (years)	6.17	2.65
(18). Age of head	44	12
(19). Number of males	1.96	0.84
(20). Number of females	1.87	0.88
(21). Value of durables (yuan)	5659	17869
(22). Number of rooms in home	4.80	2.35
Plot attributes		
(23). Distance from house (kilometers)	0.71	0.62
(24). Average size of one plot (mu)	3.22	3.46
(25). Quality of plots (1 highest quality, 0 otherwise) d	0.47	0.50
(26). Organic matter when quality equals 1 (%)	1.36	0.34
(27). Organic matter when quality equals 0 (%)	1.08	0.33
(28). Proportion of plots was hit by disaster (%)	39	49
Prices		
(29). Off-farm wage rate (yuan/day)	9.35	5.15
(30). Price of maize (yuan/jin)	0.61	0.03
(31). Price of nitrogen fertilizer (pure amount, yuan/jin)	1.08	0.36
(32). Price of phosphate fertilizer (pure amount, yuan/jin)	1.79	0.67

Note: [a] 1 mu equals one fifteenth hectare. [b] 1 jin equals 0.5 kilograms. [c] Applies only to collectively controlled land, i.e. responsibility land, contract land and ratio land. [d] Land class, which is the villagers' and village leaders' subjective evaluation. 1 for the highest quality land, and 0 for others.
Source: Authors' field survey.

Appendix Table 2. Testing for the Impact of Land Rights and Tenure on the Input Intensity , Hebei and Liaoning Provinces, 1994 (with village dummya, n=1076).

Independent variables	Dependent variable				
	Organic fertilizers	Phosphate fertilizers	Nitrogen fertilizers	Labor input	Animal traction
Constant	-2.63	83.83	51.44	104.44***	11.17
	(0.48)	(0.36)	(1.39)	(3.78)	(1.52)
Land rights					
-- Length of tenure	0.03**	0.34	0.10	0.03	0.01
	(2.33)	(0.64)	(1.21)	(0.41)	(0.83)
-- Grain quota	-0.00	0.00	0.001***	-0.00	-0.00
	(0.33)	(0.21)	(2.70)	(0.48)	(0.76)
-- Dummy of private plot (1 yes, 0 no)	1.19***	-2.62	-0.77	0.58	-0.03
	(3.29)	(0.17)	(0.31)	(0.32)	(0.05)
-- Dummy of responsibility land (1 yes, 0 no)	0.15	1.05	0.99	-0.34	-0.12
	(0.56)	(0.09)	(0.55)	(0.26)	(0.35)
-- Dummy of ration land (1 yes, 0 no)	0.25	4.01	-0.25	-1.51	-0.15
	(0.84)	(0.31)	(0.12)	(0.98)	(0.38)
Plot attributes					
-- Distance	-0.07	-5.55	-0.14	0.59	0.21
	(0.68)	(1.31)	(0.21)	(1.19)	(1.60)
-- Size	-0.06***	1.67*	-0.23	-0.56***	-0.06**
	(2.81)	(1.77)	(1.53)	(5.00)	(1.98)
-- Land quality	-0.00	2.30	0.91	-0.44	-0.08
	(0.01)	(0.33)	(0.82)	(0.53)	(0.37)
-- Organic matter	0.45	6.23	-0.42	-0.74	0.28
	(0.89)	(0.28)	(0.12)	(0.28)	(0.40)
-- Disaster dummy (1 yes, 0 otherwise)	0.03	-0.16	-0.14	1.94***	-0.04
	(0.21)	(0.03)	(0.13)	(2.49)	(0.19)

[Continued]

Appendix Table 2 (Continued). Testing for the Impact of Land Rights and Tenure on the Input Intensity , Hebei and Liaoning Provinces, 1994 (with village dummy[a], n=1076).

Independent variables	Dependent variable				
	Organic fertilizers	Phosphate fertilizers	Nitrogen fertilizers	Labor input	Animal traction
Household characteristics					
-- Formal education of head	-0.04*	1.72*	-0.31*	0.10	0.16***
	(1.64)	(1.65)	(1.85)	(0.82)	(4.91)
-- Age of head	0.01***	0.22	-0.01	0.10***	0.04***
	(2.43)	(0.92)	(0.15)	(3.51)	(5.51)
-- Number of males	-0.15**	-0.35	0.92**	-0.32	-0.04***
	(2.11)	(0.12)	(2.07)	(0.91)	(3.43)
-- Number of females	-0.07	2.87	-0.10	-0.19	-0.33***
	(1.00)	(0.99)	(0.22)	(0.54)	(3.59)
-- Value of durables	0.00	-0.00	-0.00	-0.00	-0.00
	(0.84)	(0.21)	(0.76)	(0.07)	(0.50)
-- Number of rooms in home	0.05*	0.03	-0.02	-0.12	-0.01
	(1.66)	(0.02)	(0.09)	(0.80)	(0.32)
Prices					
-- Off-farm wage rate	-0.09***	0.03	-0.23	-0.39**	-0.07
	(2.62)	(0.02)	(0.93)	(2.13)	(1.41)
Crop dummies					
-- Maize	0.26	-6.10	12.20***	1.77	0.57
	(0.79)	(0.43)	(5.38)	(1.05)	(1.26)
-- Rice	-0.72*	72.12***	17.34***	6.57***	0.36
	(1.69)	(3.88)	(5.88)	(2.99)	(0.61)
-- Cotton	1.29***	0.51	11.52***	19.71***	0.48
	(2.76)	(0.03)	(3.59)	(8.24)	(0.75)

Note: [a] Coefficients of village dummy are omitted for simplicity.
Absolute values of t-statistic are reported in parenthesis. *, **, and **** denote coefficients are significant at 10, 5 and 1 percent level of confidence respectively according to standard t-ratio tests.

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[1] For example, some suggest that China's current land system provide other benefits to farmers, such as insurance against periodic recessions in the off farm job market (Dong, 1996; Kung and Liu, 1996). It may be that the benefits of having "weak land rights system" provided by the having land under the stewardship of the collective outweighs the inefficiency costs. Therefore, even there is an efficiency loss from the current land rights system, government still may need to compare the cost (efficiency loss) with the social-insurance like benefits associated with it before making any big policy change.

[2] The term "private plots" may be somewhat misleading. According to Chinese law, all cultivated land belongs to the collective. Therefore, the actual owner of "private plots" often still belong to the village (collective). However, because it is so different from other land under collective control in terms of rights and obligations, farmers view private plots as different from the collective controlled land.

[3] However, there are different views about the issue. Some people argue that even all components of land rights in a tenure type have been explicitly expressed in the equation, it may still need to control the tenure type for capturing a farmer's general confidence about the set of land rights, because the interactions among specific land rights may not be captured by those explicitly expressed rights (Besley, 1995). We will return to this point later.

[4] The question was typically phrased: Will you land contract on the plot expires in 1995? Or, do you expect the village leader will take the plot away from you in 1995?

[5] In some villages, farmers needed to get permission from village leaders to rent. In other places, land rental transactions were strictly restricted to access only among local villagers, which means farmers could not rent their land to people from other villages. In several villages, leaders summarily prohibited land rental transactions.

[6] Variables about plot specific land quality are worth more explanation. During the household survey in 1995, the land quality was estimated by farmers as a subjective measure. Households classified their land on a scale from 1 to 4. Land type 1 was the highest quality and land type 4 was the lowest. Based on this information, the analysis generates a land quality dummy, assigning the variable a value of 1 if the plot was the highest quality, and 0 otherwise. Within a village, farmers almost never have trouble specifying land quality in these subjective terms. One shortcoming of the subjective measure, however, is that it ignores quality differences across villages. To help better controlling for the differences in land quality across village, the study uses average amount of soil organic matter of village's each class land as a village-specific soil variable. The amount of organic matter is frequently thought to be an important soil chemistry index. The information of soil organic matter was collected by the authors and their collaborators in the 1997 village-level survey, and the soil tests were performed by laboratories in China.

[7] According to a literature survey made by Putterman and Chiau (1994), there are about 12 Chinese agricultural production function studies, however, only one of them explicitly use organic manure as a separate input (Wiens, 1982).

[8] Yao and Carter (1996) also meet the similar problem in their analysis about the impact of land rights on the green manure planting. Besley (1995) just ignored the effects of price in this analysis about effects of property rights on African farmers' investment incentives.

[9] Actually, some studies ignore prices when encountering similar problem (e.g., Strauss and Ferris, 1994; David and Otsuka, 1994; Besley, 1995). If there is not a big expected effects on the performance of land rights variables there is no reason not to drop the price variable. Input demand and yield response equations are also estimated without price variables, parameter estimates of land rights variables are generally consistent with version with prices.

[10] For example, Burki (1969) found that yield of private plots averaged more than twice of that of the collectively controlled plots. Shaban (1987) found that yield of self-owned plots is generally 40 percent higher than that of sharecropped plots.

[11] Besley (1995) found even bigger increase of size of land rights coefficient, for example, from 0.02 to 0.11 and from 0.05 to 0.28.

[12] It is interesting to note that village budget expenditure, proportion of irrigation land and party membership have significant effects on length of tenure. The F-value of the test of instruments significance is 10.81 which shows that the test passes satisfactorily.

[13] In fact, there are some two variables, age and formal education level of household head, in my original specifications to control farm experience.

[14] We randomly select another 115 non-private plots to run the same regression, the results are basically consistent with what we found in column 3 of Table 6 even the significance of length of tenure decreases.