How Much Expropriation Hazard Is Too Much? The Effect of Land Reallocation on Organic Fertilizer Usage in Rural China

Ying Bai, James Kung, and Yang Zhao

ABSTRACT. *In China, land is reallocated on either a full-scale or a partial basis. By employing a unique farm survey that deliberately draws a distinction between full-scale and partial land reallocations, and by decomposing their respective expropriation risk effects, we find that the significantly negative effect of expropriation risk on organic fertilizer usage is driven solely by full-scale reallocation. Consistent with this finding, a reduction in the predicted expropriation hazard rate by half leads to a sizable increase of 491% in organic fertilizer usage in villages with a history of full-scale reallocation, and has an estimated productivity effect of 19.1%.* (JEL O12, Q15)

I. INTRODUCTION

The thesis that property rights protection is crucial for economic growth is now a widely accepted premise (Acemoglu, Johnson, and Robinson 2001; Acemoglu and Robinson 2012; Banerjee, Gertler, and Ghatak 2002; Besley 1995; Besley and Ghatak 2009; Brasselle, Gaspart, and Platteau 2002; DeLong and Shleifer 1992; Demsetz 1967; Engerman and Sokoloff 2005; Goldstein and Udry 2008; Jones 1987; North 1990; North and Thomas 1973). An important mechanism linking property rights protection and economic performance lies presumably in the *investment* that the protection of rights encourages. To the extent that the state has historically been the one to expropriate the fruits of private investments, any reduction in the degree of such expropriation is thus conducive to economic growth, as North and Weingast (1989) and others have persuasively demonstrated. The situation becomes vastly more complicated, however, if the state is not the source of the "grabbing hand" but is instead somewhat constrained by ideology to reform property rights in a direction that is likely to induce investments.

The story that we have in mind is Chinese agriculture. Although China had already broken up its collective farms and divided them among the farm households to be farmed on an individual basis (agricultural decollectivization) since the early 1980s, land has remained to this day "collectively" owned (by the well-defined communities of villagers). Given that members of a village community enjoy equal rights (bestowed at birth and through marriage) of using the common arable resource, land is subject to periodic reallocations in response to demographic change, for example, births, deaths, and marriages (Brandt et al. 2002; Kung 1995, 2000; Yao 2004), and more recently to broader changes in the structure of the village economy—most notably rural-urban migration (Bai et al. 2012). To many observers, this practice, one that results arguably from the absence of transfer rights, amounts to expropriation risk, given that a farmer cannot duly anticipate when land will be reallocated next and, when it does occur, is likely unable to retain any of

Land Economics • August 2014 • 90 (3): 434–457
ISSN 0023-7639; E-ISSN 1543-8325

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the plots he or she currently cultivates. Rational farmers, under this circumstance, will refrain from undertaking any long-term investments in their plots. For this reason, farmers in China have allegedly applied less organic nutrients to their plots than is arguably required to keep the soil fertile over the long run (Johnson 1995; Prosterman, Hanstad, and Li 1996; Wen 1995; Zhou and Liu 1994). Empirical studies linking expropriation risk generated by land reallocations and their long-term investment and productivity consequences have however remained few and far between.

By employing a dataset constructed from a rural household survey in northeast China, Jacoby, Li, and Rozelle (2002) and Li, Rozelle, and Brandt (1998) quantify the effect of expropriation risk brought about by land reallocations on organic fertilizer use, and find that heightened expropriation risk significantly reduces organic fertilizer applications. Given that land reallocations in China are far from homogeneous and that their heterogeneities may affect tenure security differently, our goal is to extend Jacoby, Li, and Rozelle's (2002) study by examining if the two general types of land reallocations adopted in China's villages—full-scale and partial—may have any significantly differential impact on organic fertilizer usage. Our hypothesis is premised on the observation that, unlike reallocations conducted on a villagewide basis, only those households that have experienced demographic change—typically a small percentage of the village community—are affected in a partial reallocation and, more importantly, only a tiny fraction of their entire plot collection is affected (Kung and Bai 2011).

To make this distinction requires us to divide the households into those that have been subjected to full-scale reallocation and those that have experienced partial reallocation, and to gain insights into the set of institutional rules governing especially the partial reallocation. A unique rural farm survey conducted among some 2,000 rural households in nearly 100 villages across six Chinese provinces in 2003 provides us with all the aforementioned information required for making this analysis possible.

With the conceptual aid of a simple theoretical model, we test with data the hypothesis that, while expropriation risk reduces organic fertilizer usage, the hazard induced by full-scale reallocation has a significantly larger effect than that associated with partial land readjustments. We proceed with our empirical analysis in two steps. First, we predict the expropriation risk that confronts a household by employing a hazard analysis based on both tenure duration (as measured by the number of years between the last reallocation for a household and the survey year of 2003) and a number of household characteristics that do not vary with tenure duration.[1] Given that the risk factors associated with the two types of land reallocation are unlikely to be identical, we employ a "competing risk" model to estimate the effects of the two types of expropriation hazard on organic fertilizer usage in the second step of our analysis. Doing so reveals the novel finding that, while expropriation risk does have a significantly negative effect on plot-specific investment (which confirms Jacoby, Li, and Rozelle's [2002] finding), the result is in fact driven solely by full-scale reallocation, once we include the two cause-specific hazard rates in the estimations.

Against this important finding, a question of even greater fundamental significance is whether the difference in hazard between the two types of land reallocations is economically significant. Evidence suggests it is. First, our analysis robustly finds that the elasticity of organic fertilizer usage in response to a decrease in the predicted hazard rate is substantially larger in villages with a history of full-scale reallocations. For instance, whereas a 50% reduction in the predicted expropriation hazard rate leads to an average increase in organic fertilizer usage of 79.2% when evaluated at the mean, the effect for full-scale reallocations is a massive 491%, compared to a mere 6% for partial reallocations. This result

[1] This strategy follows that of Jacoby, Li, and Rozelle (2002), who employ plot characteristics to estimate hazard risk. Lacking the plot-level data we analyze hazard risks based upon household characteristics instead. Neither set of characteristics varies with tenure duration.

is supported by a large number of scientific field experiments unequivocally demonstrating that organic fertilizer applications have the virtuous effect of boosting grain yields.[2] More important perhaps is that increased application of organic fertilizer has the estimated effect of raising grain yields by 3.1% on average, and a substantial 19.1% in villages with a history of full-scale reallocations but a negligible 0.2% in those that adopted partial reallocations.

But since collecting and applying animal manure is not only time-consuming but also labor-intensive, and, together with the increase in chemical fertilizer supply and rising opportunity costs of labor, Chinese agriculture has witnessed a steep monotonic decline in organic fertilizer usage in the last quarter of the century since the individualization of farm production. Portch and Jin (2006) has found, for example, that the ratio of organic to total fertilizer usage in China has decreased from 0.44 in 1980 to 0.25 in 2005. Conversely, by 2007 nitrogen fertilizer consumption reached a hefty 32.6 million tons, an increase of 191% from 1981, and is the main cause behind the growing problem of soil acidification (Guo et al. 2010). These various lines of evidence collectively suggest that the significantly negative relationship between the insecurity of tenure induced by full-scale land reallocations and organic fertilizer application rates is economically meaningful. Moreover, to the extent that full-scale reallocations are the sole cause of tenure insecurity, the policy of prohibiting them appears to make good economic sense.[3]

II. FULL-SCALE AND PARTIAL LAND REALLOCATIONS: STYLIZED DIFFERENCES AND IMPLICATIONS FOR TENURE SECURITY

Two Modes of Land Reallocation

As befits a common property regime, under which members of a village community (where membership is defined by birth and marriage) are guaranteed cultivation rights, the majority of villages have reallocated land in response to demographic change, in spite of government policy urging villages to ban such acts for the sake of maintaining tenure security (Brandt et al. 2002; Kueh 1985; Kung 2000; Kung and Bai 2011; Liu, Carter, and Yao 1998). Our own survey, for example, finds that 86.5% of the rural households have readjusted their landholdings since around the early 1980s when agricultural decollectivization was completed; only 13.5% of the households indicated that they had never reallocated land at the time when this survey was conducted (in 2003, Table 1). It is this periodic reshuffling of farm plots among village households in response to demographic and possibly broader changes of the village economy (e.g., rural-urban migration) that led to allegations of tenure insecurity being the culprit behind low organic fertilizer application (Jacoby, Li, and Rozelle 2002; Li, Rozelle, and Brandt 1998; Li, Rozelle, and Huang 2000; Prosterman, Hanstad, and Li 1996; Wen 1995). Using survey data from northeast China, Jacoby, Li, and Rozelle (2002) find that higher expropriation risk does significantly reduce organic fertilizer application.

In China, land reallocations are far more nuanced than the term suggests. Depending on the type (or mode) of reallocation a village adopts, and through the different effects that each has on the extent to which (1) the number of farm households and (2) the proportion of a household's overall landholdings as well as the number of plots are affected, there could be far reaching implications for tenure security. In some instances, for example, the existing land allocations will be completely reshuffled, to the extent that households are unable to retain any of the plots they previously cultivated (a mode the Chinese have

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[2] According to these farm studies, organic fertilizer (e.g., farmyard manure) has the virtuous effect of retaining moisture in the soil and increasing the contents of β-glucosidase and alkaline phosphatases (Fan et al. 2005; Liu, et al. 2010); the result is higher crop yields (Ibrahim et al. 2000; Haq et al. 2011; Jala and Goel 2006; Lee et al. 2006; Pan et al. 2009; Pandey and Singh 2010; Rautaray, Ghosh, and Mittra 2003; Singh, Pandey, and Singh 2011; Supparattanapan et al. 2009).

[3] The Chinese government has long been concerned about tenure insecurity created by land reallocations. In 1998 it explicitly prohibited villages from reallocating land by the Revised Land Management Law (Standing Committee of the National People's Congress 1998).

TABLE 1
Provincial Distribution of the Patterns (Types) of Land Reallocations

		(1) No LR	(2) PLR Only		(3) FLR Only		(4) Both PLR and FLR		
Province	Number	%	%	Frequency	%	Frequency	%	Frequency of PLR	Frequency of FLR
Households									
Hunan	351	9.4	35.9	2.55	34.8	3.21	19.9	3.24	2.37
Zhejiang	354	18.4	32.2	1.98	33.3	2.25	16.1	1.49	1.23
Fujian	351	—	—	—	94.6	3.91	5.4	2.00	3.00
Sichuan	352	35.5	49.1	1.95	13.1	1.02	2.3	2.63	1.00
Anhui	351	—	—	—	79.2	1.33	20.8	1.56	1.49
Heilongjiang	349	17.8	32.1	1.00	50.1	1.01	—	—	—
Total	2,108	13.5	24.9	1.90	50.8	2.38	10.8	2.14	1.81
Villages									
Total	95	0	41.0	3.33	29.5	2.21	29.5	4.04	1.89

Note: LR, land reallocation; PLR, partial land reallocation; FLR, full-scale land reallocation.

dubbed *daluan chongfen,* meaning large, or full-scale, land reallocation). Conversely, in other instances, only a small percentage of the households—specifically those affected by family demographic change—and accordingly farm plots would be affected in the process. The Chinese call this particular mode of reallocation *xiao tiaozheng,* meaning partial, or small-scale, reallocation (Jiang and Chen 1997).

Before we provide a qualitative account of the differences between the two modes of land reallocations as they are conducted in China, we want to point out that, contrary to popular beliefs, the mode of land reallocation is not randomly chosen; moreover, seldom are they uniformly conducted across villages. Inside China, scholars widely believe that villages would randomize between partial and full-scale land reallocations, depending on the extent of mismatch between land and labor across farm households. Where the mismatch is minimal, a partial reallocation would suffice, but where greater realignments are deemed necessary, a large-scale reallocation would be called for—hence the popular saying of "land would be reallocated partially once every three years and thoroughly once every five years" (*sannian yi xiaotiao, wunian yi datiao*). This cannot be further from the truth. In addition to showing that the vast majority of farm households in China have experienced land reallocations, Table 1 also shows, importantly, that an overwhelming majority, 75.7%, have in fact followed only a *single* mode of reallocation in a period of more or less 20 years since decollectivization (24.9% in the case of partial reallocation and 50.8% in the instance of full-scale reallocation). Only 10.8% of all the surveyed households have experienced both types of reallocation. This bimodal distribution of land reallocation is demonstrated in Figure 1 using kernel density (against the normal density distribution) to estimate the ratio of full-scale to overall land reallocations.[4] As can easily be seen, most of the surveyed households engaged in either partial (left-hand side of the graph) or large-scale reallocations (right-hand side of the graph), but not both.

Indeed, recent studies have explained why Chinese villages (or the majority of them) tend to follow a single mode of land reallocation. For example, Kung and Bai (2011) show that villages characterized by complex terrain and topographies (using the number of plots as proxy) tend to reallocate land on a partial basis, primarily because the transaction costs of "mapping" a large number of smaller and variegated plots among *all* households are

[4] The kernel density estimator is defined as $\hat{f}(x) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{h}\phi\left(\frac{x_i - x}{h}\right)$, where $\phi(\cdot)$ is the standard normal density function.

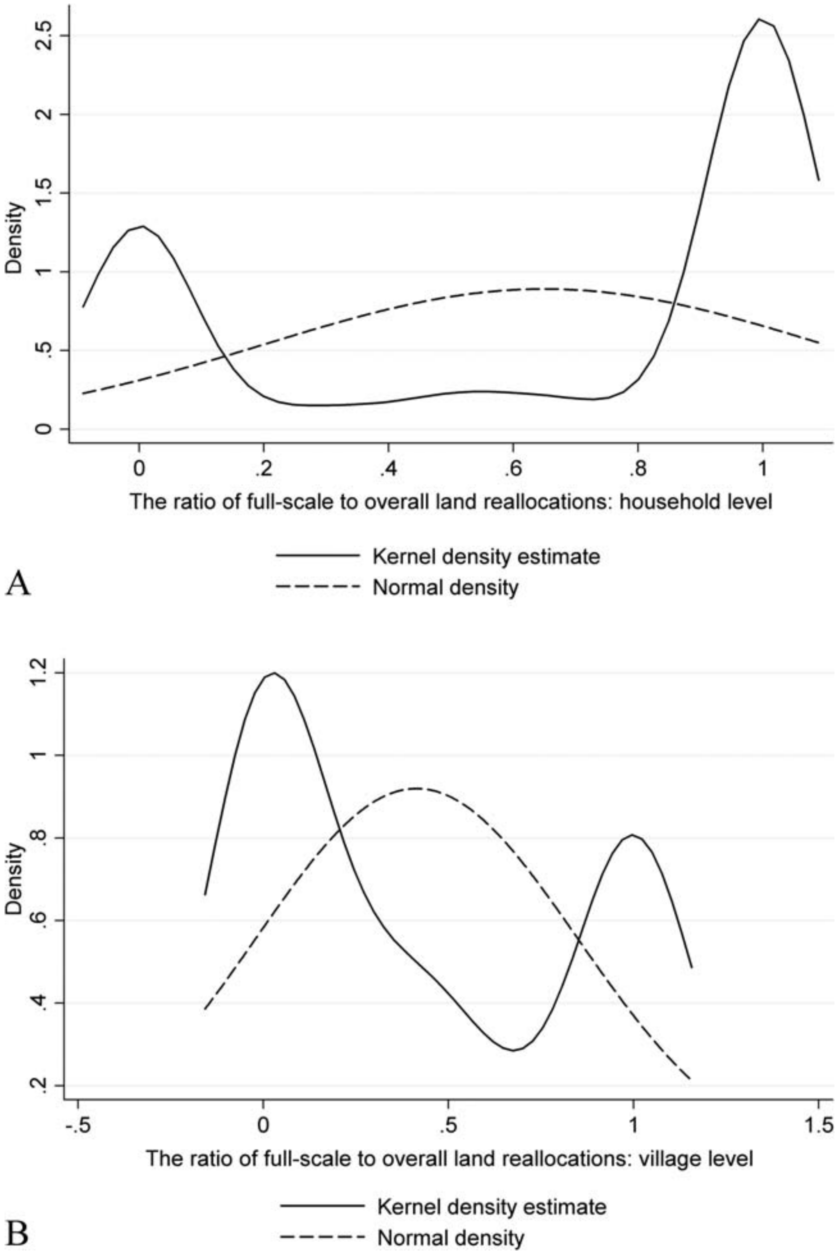

FIGURE 1
Kernel Density Estimate of the Ratio of Full-Scale to Overall Land Reallocations: (A) Household Level, (B) Village Level (Kernel Density Estimator Defined as $\hat{f}(x) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{h}\phi\left(\frac{x_i - x}{h}\right)$, Where $\phi(\cdot)$ Is the Standard Normal Density Function)

likely formidable in these villages.[5] Conversely, the costs of "matching" a large number of households to the transferred plots would be prohibitive in the larger villages should they resort to reallocating land on a partial basis, hence their long-held preference for full-scale reallocation.[6] But what are in fact the institutional differences between the two in terms of the effect they have on the number of households, the size of their landholdings, and not the least, the number of farm plots affected? Answers to these questions would help to shed light on the possible implications the two different modes of land reallocation may have for tenure security.

Stylized differences between Full-Scale and Partial Reallocation and Their Implications for Tenure Insecurity

In a full-scale reallocation, typically the existing holdings will be redistributed from scratch among virtually all eligible households of a village community, with the exact plot(s) to which a household is entitled determined by drawing a lottery. Given that in this type of reallocation the overwhelming majority of the affected households are unable to retain any of the plots they previously farmed—regardless of whether they have experienced a demographic change (e.g., 78.6%, Kung and Bai 2011: 1515), any plot-specific investments they made previously are subject to premature confiscation; the expected outcome is heightened tenure insecurity. In contrast, as it is common knowledge that in a partial reallocation only households that have experienced demographic change (due to births, deaths, and marriages) would be affected, households that have not recently experienced such changes would have no reason to feel insecure about their land ownership. To test if that is indeed the case, we construct a dummy variable to indicate whether households are able to retain any of their previously farmed plots after the most recent full-scale reallocation, and regress it on whether a household had experienced demographic change before the reallocation. Reported in Table 2, the pertinent results reveal, consistently, the lack of a significant relationship between the two across estimations with varying degrees of control.

In addition, a partial reallocation is likely to impact less negatively upon tenure security also because even for the few households destined to transfer some of their land to the others, the whole process is governed by a set of prevailing rules; the effect is enhanced certainty. Table 3, which provides a summary of the principles governing partial reallocation as laid down by the village officials, confirms our understanding that typically land is reallocated from households having experienced a decrease in membership (and hence with "surplus" land) to households that have expanded in size.

Table 4 lays out more specifically the precise methods that villages employ in reallocating the household plots on a piecemeal basis. Going by our survey it appears that the most popular method of transferring land in a partial reallocation is to transfer the entire (boundary-demarcated) plot among the demographically affected households (46.9%). Given the mean plot size averages about 1.21 mu,[7] and assuming that either all plots are of equal size or the different-sized plots are somewhat standardized according to differences in quality, a household transferring land out in a partial land reallocation loses an average of 16.7% of its previously cultivated land; this stands in stark contrast to the situation in which a household loses all of its land in the event of a full-scale reallocation.

[5] Mapping costs, which include the costs of resurveying the land and recalculating the village population eligible for land redistribution, are prohibitively high in these villages, because land of varying quality or grades (for which there are too many) was divided up in a largely egalitarian manner upon decollectivization. Since resurveying the land will not be necessary for partial reallocation, mapping costs can be eliminated entirely in villages choosing not to reallocate land comprehensively.

[6] Matching costs, which apply to both types of land reallocation, are incurred in the process of dividing up and combining farm plots for reallocation through, for example, a lottery system.

[7] One Chinese mu is equal to 0.16 U.S. acre or 0.0667 hectare. This is obtained by dividing the mean size of land (7.24 mu) by the average number of plots a household had (5.96) prior to a partial reallocation.

TABLE 2
Population Change and Plots Retention under Full-Scale Land Reallocation

Dependent Variable: No land retained during the past land reallocation (= 1), otherwise (= 0)	(1)	(2)	(3)	(4)	(5)	(6)
Population change (dummy)	− 0.013	0.016	0.017			
	(0.024)	(0.023)	(0.024)			
Population increase (dummy)				− 0.005	0.048	0.053
				(0.035)	(0.034)	(0.035)
Population decrease (dummy)				− 0.018	− 0.004	− 0.006
				(0.029)	(0.027)	(0.027)
ln(Household size)			− 0.016			− 0.032
			(0.036)			(0.037)
ln(Household arable lands)			0.004			0.011
			(0.032)			(0.032)
ln(Household plots)			0.018			0.015
			(0.026)			(0.026)
Village dummies		Yes	Yes		Yes	Yes
Observations	1,243	1,243	1,234	1,243	1,243	1,234
R-squared	0.00	0.26	0.26	0.00	0.26	0.26

Note: Dependent variable: No land retained during the past land reallocation, = 1; otherwise, = 0. We regress whether a household was able to retain any land during the most recent full-scale land reallocation on population change and household characteristics. Robust standard errors in parentheses. Constant term and village dummies are included but not reported.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 3
Methods Employed in Partial Land Reallocation at the Village Level

Rule	%
Part of the land of the affected households is to be reallocated.	12.70
Increase the land of households with an increase in household size while reducing the land of those with a decrease.	77.78
Parcels of land would be transferred from households with above-average entitled quantity to those with below-average quantity.	7.94
Other	7.94

Note: 63 out of 67 officials whose villages have experienced partial land reallocations answered this question.

The smaller villages (3.98 mu as compared with 7.24 mu) and villages with more complex topographies (7.97 plots as compared with 5.96) tend to reallocate land in a somewhat different manner (34.9%). In these villages, a household obligated to transfer its land to another household ends up surrendering a small fraction of a number of its plots (instead of entire plots) to the recipients. While without knowing the exact fraction of the plots to be surrendered we are unable to calculate the percentage of land a shrinking household is required to relinquish, one can still confidently conclude that the land-losing households retain the bulk of their plots after a partial reallocation.[8] If we imagine that some villages have never reallocated land on a full-scale basis, and that farm households in these villages adhere strictly to the embedded rules of partial reallocation, we would expect that tenure is likely significantly more secure in these villages than in those where full-scale reallocation predominates.

III. TESTABLE HYPOTHESIS: THE MODEL

In Section II we deduced the hypothesis that tenure is distinctly insecure only under full-scale but not under partial land realloca-

[8] We can perform a back-of-an-envelope calculation as follows. Given the mean plot size of 0.49 mu (3.98 mu/7.97 plots) and that the number of plots affected is 2.6, a household will have to transfer 1.27 mu or 31% of its land if it had to give entire plots away. Assuming that a "fraction" means 20%, the overall percentage of land that this household is required to give up is a mere 6% of its entire holdings.

TABLE 4
Methods Employed in Partial Land Reallocation at the Household Level

Method	Number of Households Involved	Number of Plots Reallocated	Number of Plots before the Reallocation	Size of Land before the Reallocation (mu)[a]
Transferred out				
One entire plot	129	1.00	5.96	7.24
		(0.00)	(3.99)	(8.77)
A small part of several plots	96	2.60	7.97	3.98
		(1.80)	(5.32)	(2.18)
Other	50		6.12	4.36
			(4.08)	(5.01)
Transferred in				
One whole plot transferred from another household	122	1.00	4.40	6.10
		(0.00)	(3.26)	(7.38)
Several plots transferred from another household	60	2.38	7.28	3.02
		(1.09)	(6.51)	(2.40)
Several plots transferred from several households	70	3.16	5.88	4.04
		(1.79)	(5.34)	(4.90)
Other	23		3.95	6.43
			(1.96)	(8.26)

Note: Standard deviation in parentheses.
[a] 1 mu is equal to 0.1647 acre or 0.0667 hectare.

tion. In this section we derive from the above intuition a formal model, developed from Jacoby, Li, and Rozelle (2002), for testing the hypothesis. Our model is essentially a standard investment model that features the risk of land expropriation, in that village leaders may expropriate a household's plots for reallocation at some random time s. The survival function of a household able to retain its plots until time t can be denoted by $S(t) = \Pr(s \geq t)$, and the corresponding hazard function is defined as $h(t) = -\dot{S}(t)/S(t)$, which represents the instantaneous probability of losing a plot (or plots) for a given duration (t). For a farm household, the value of the output obtained from farming the land is given by the neoclassical production function $F(k(t))$, where $k(t)$ stands for the stock of organic fertilizer. A household's investment in fertilizing the soil at time t is represented by $x(t)$ with cost $c \cdot x(t)$. The net yield that it obtains in each period can then be defined as $R(t) = F(k(t)) - cx(t)$. With this setup, all that a household needs to do is to decide on the quantity of fertilizer to use over time that would maximize the expected discounted returns on land as specified in equation [1].

$$\begin{aligned} &\text{Max} \int_0^{\infty} e^{-rt} S(t) R(t) dt \\ &\text{s.t.} \\ &\dot{k}(t) = -\delta k(t) + x(t) \\ &x(t) \geq 0, k(0) = k_0 . \end{aligned} \quad [1]$$

The constraints reflect the assumption that organic fertilizer will be depleted at a constant rate δ and that the farmer needs to decide whether to replenish the stock of organic fertilizer (namely, $x(t) > 0$) or not (namely, $x(t) = 0$). The first-order necessary condition can now be derived as

$$F_k = c(\delta + r + h(t)), \quad [2]$$

$$x(t) = \delta k(t) + \frac{c}{F_{kk}} \dot{h}(t), \quad [3]$$

where $F_{kk} < 0$ is determined by the concavity of the neoclassical production function (F). What equation [3] implies is that organic fertilizer usage is determined by $\dot{h}(t)$, namely, how the hazard of land reallocation changes in accordance with plot tenure. For instance, $\dot{h}(t) > 0$ implies that the hazard of land reallocation increases over time; with $F_{kk} < 0$, farmers will invest less than necessary ($\delta k(t)$).

From equations [2] and [3] we can derive the organic fertilizer usage $x^*(t) = x^*(h(t),\dot{h}(t),r,\delta,c)$. The standard investment model without expropriation risk can be regarded as a special case whereby $S(t) = 1$ and $h(t) = 0$. The optimal amount of organic fertilizer to use under this condition would then be $\tilde{x}^*(t) = \tilde{x}^*(r,\delta,c)$. With expropriation hazards, however, $h(t) = g(t)\theta$, where $g(t)$ is a function of time and θ represents the exogenously given frequency of expropriation. Differentiating fertilizer usage with respect to the exogenous change in tenure security (θ) yields the following result:

$$\frac{dX^*(t)}{d\theta} = \frac{c}{F_{kk}}[\delta g(t) + \dot{g}(t)].$$

Assuming that a household holds N plots, and that land is reallocated on a full-scale basis, $X^*_{\mathrm{F}}(t) = Nx^*(h(t),\dot{h}(t),r,\delta,c)$. But where land is reallocated on a partial basis, only a small proportion of the households (we denote the ratio of affected to total households by P) would be affected, and only a fraction (ρ) of all plots reallocated. The overall organic fertilizer usage for a household under the partial reallocation regime can thus be written as $X^*_{\mathrm{P}}(t) = \rho PNx^* + (1-\rho P)N\tilde{x}^*$.[9] With the use of comparative statics we can then differentiate the effect of an exogenous difference in tenure security on organic fertilizer usage as follows:

$$\frac{dX^*_{\mathrm{F}}(t)}{d\theta} = \frac{cN}{F_{kk}}[\delta g(t) + \dot{g}(t)], \qquad [4]$$

$$\frac{dX^*_{\mathrm{P}}(t)}{d\theta} = \rho P\frac{cN}{F_{kk}}[\delta g(t) + \dot{g}(t)]. \qquad [5]$$

To recap, unlike in a full-scale reallocation, where all households in a village will be affected, in the event of a partial readjustment only those having experienced a change in family demographics will be involved. Moreover, unlike in a full-scale reallocation, where the prospects for the overwhelming majority to retain any of their existing plots are slim, in partial reallocation only a small fraction of the affected household's portfolio is reallocated. We now summarize our hypothesis in Table 5 alongside that of Jacoby, Li, and Rozelle (2002), who postulate that expropriation risk in general has a negative effect on long-term investment (column 1). By distinguishing full-scale from partial reallocation and by expecting the former to lead to greater tenure insecurity, we hypothesize that only full-scale but not partial land reallocations have a distinctly significant and negative effect on investment incentive (column 2). Stated differently, expropriation risks associated with partial land reallocations should have no significant effect on long-term specific investment.

TABLE 5
Hypothesis Testing: The Effect of Expropriation Risk on Investment Incentive

	Jacoby, Li, and Rozelle (2002)	This Study
Expropriation risk	Negative	Negative
Expropriation risk caused by full-scale land reallocation	Negative	Negative
Expropriation risk caused by partial land reallocation	Negative	Less negative/zero

IV. DATA, VARIABLES, AND ESTIMATION STRATEGY

Data

The data used for analysis in this paper were collected from a survey designed specifically to document the patterns of land reallocation behavior and, equally important, farm investment behavior in rural China. In order to form a long-term perspective on land reallocation behaviors and to distinguish our study from most other surveys of land tenure in rural China, we deliberately drew a distinction between large-scale and partial land reallocations. Specifically, we collected information on the type of reallocation—large-scale

[9] $X^*_{\mathrm{P}}(t) = \rho PNx^* + (1-\rho)PN\tilde{x}^* + (1-P)N\tilde{x}^*$.

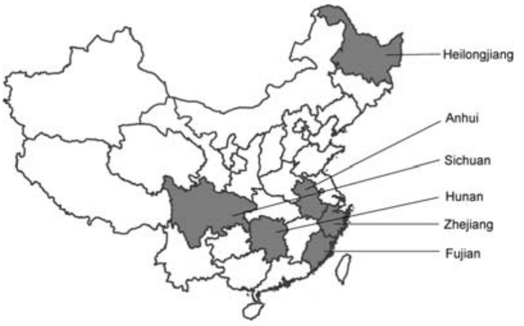

FIGURE 2
The Six Surveyed Provinces

versus partial—that a village adopted *each* time since decollectivization (ca. 1978–2003) and the specific year in which a village reallocated land. Additionally, we also enumerated the reason(s) underlying the most recent reallocation, the procedure thus entailed, and so forth.

The survey was organized by the Development Research Center (DRC)—a high-powered research and policy arm under China's State Council—in 2003 in six Chinese provinces selected on the basis of their geographical representation. Zhejiang and Fujian provinces were, for instance, selected to represent provinces in the rapidly developing southeastern coastal seaboard area, whereas Hunan and Anhui provinces, in central China, were selected to represent the country's "grain basket" and also locations with rampant out-migration activities. To cover the southwest and the northeast, Sichuan and Heilongjiang provinces were chosen. The geographical locations of these provinces are shown in Figure 2.

Two counties were selected in turn from each of the six selected provinces. To ensure that the selected counties were broadly representative of a province, counties were ranked in terms of their per capita GDP, and those clustered around the mean were selected randomly. Then four townships were chosen from each county. Instead of picking only the "average performers," one of each from the higher- and lower-income categories were selected alongside the two middle-ranked townships. Altogether, 48 townships were selected, after which two villages, based on the same consideration (of income level) as that taken in choosing counties, were selected from each township for inclusion in the survey, giving 96 villages in 48 townships in 12 counties in a total of six provinces. Finally, 22 farm households were selected randomly from the village roster for the household survey, resulting in 2,108 household observations available for analysis.

Estimation Strategy and Variables of Interest

Most studies assume that land reallocation has negative implications for tenure security, yet few have actually examined it. Using plot-level characteristics collected from a village survey in northeast China, Jacoby, Li, and Rozelle (2002) and Li, Rozelle, and Brandt (1998) examine the impact of past land reallocations (or tenure duration) on plot-specific investment, using organic fertilizers as a proxy measure. Li, Rozelle, and Brandt (1998) find that tenure duration, a proxy for tenure security, has a positive effect on organic fertilizer usage.[10] But using backward-looking data (on past reallocations) to project forward-looking expropriation risk has its limitations. While a longer duration may imply a more secure tenure, it may also suggest that the plot is becoming due for reallocation and thus tenure of the plot is less secure. In this context, the relationship between tenure duration and expropriation risk is at best ambiguous. By applying a hazard analysis of individual plot tenure, Jacoby, Li, and Rozelle (2002) deal with this problem more effectively. They do so by first predicting the expropriation hazards (due to land reallocation), followed by estimating the effect of such hazards on organic fertilizer usage. This way they do not have to rely on the assumed but ambiguous relationship between past reallocations or tenure duration and tenure insecurity.

Like Jacoby, Li, and Rozelle (2002) we proceed with our empirical analysis in two stages. First, we similarly predict the expro-

[10] The underlying assumption here is that the longer a household has held on to a plot the more secure the tenure.

priation risk that confronts a household by employing a hazard analysis based upon the tenure duration—measured by the number of years between the last reallocation for a household and the survey year of 2003. Given that a longer duration may imply either a less secure tenure or, equally, a more secure one, we also predict the expropriation risk using variables that do not vary with tenure duration, as Jacoby, Li, and Rozelle (2002) have done. Lacking the data on plot characteristics, however, we employ household-level characteristics instead. Based on these first-stage results we then move on to the second stage to estimate the effect of predicted expropriation risk on organic fertilizer usage—our dependent variable. As we are able to distinguish a full-scale from a partial reallocation, we are able to extend Jacoby, Li, and Rozelle's (2002) study by comparing the differences in the effects of expropriation risk between the two types of land reallocation on farm investment behavior.

In the hazard analysis the variable of interest is the duration or specifically the length of time that a household has held on to its contracted plots between the last reallocation it experienced and 2003. Our observations will thus consist of a cross section of durations, $t_1, t_2, \ldots t_n$. We begin by estimating a standard parametric model of duration, assuming that a household's contracted plots will be expropriated at some random point in time s. Given this assumption, the probability that household i will be able to retain its land until time t_i can be denoted by the survival function $S(t_i) = \Pr(s \geq t_i)$, and the hazard function (in the standard Weibull form) can be written as

$$h(t_i) = \alpha \theta_i t_i^{\alpha - 1},$$

where α represents duration dependence. Specifically, $\alpha > 1$ implies a rising hazard rate over time, $\alpha = 1$ implies a constant hazard rate over time, and $\alpha < 1$ implies a falling hazard rate over time. The rise in hazard rate over time implies that the longer the tenure duration the more likely land is due for reallocation. We define the hazard rate θ_i as $\exp(x_i \beta)$.

As our key independent variable, the expropriation risk parameter can now be written as

$$\theta_i = \exp(x_i \beta + \varepsilon_v), \qquad [6]$$

where θ_i is the hazard rate, which does not vary over the tenure duration. We employ its log-term to be our explanatory variable. Expropriation risk is likely endogenous, however, as some omitted variables may be correlated with both expropriation risk and organic fertilizer usage. For instance, upon observing that some households have failed to fully utilize their land, village leaders may decide to reallocate land more frequently among households. To instrument expropriation risk, we follow Jacoby, Li, and Rozelle's strategy (2002) by including a set of village dummies in equation [6], but without doing the same for organic fertilizer usage.[11] In addition, we include all other independent variables in equation [7] (to be introduced below). Moreover, owing to the left-censoring nature of organic fertilizer usage, we employ the tobit model to estimate the effect of expropriation risk. The fertilizer demand equation can be written as

$$y_i = \delta \log(\hat{\theta}_i) + x_i \gamma + \varepsilon_i. \qquad [7]$$

While it is interesting to assess the overall effect of the predicted expropriation risk due to land reallocations on organic fertilizer usage, our specific goal is to compare the difference in the effects of such risks between full-scale and partial land reallocations on organic fertilizer usage. To do this, we use the ratio of full-scale to overall land reallocations at the village level to proxy for the probability (F) of another full-scale land reallocation occurring (in the event of another land reallocation occurring); $1 - F$ is then the probability of another partial land reallocation occurring. Denoting by $\log(\hat{\theta}_i)$ the hazard of land reallocation, we are now able to distinguish between the two types of expropriation risk, namely, $F_i \log(\hat{\theta}_i)$ as due to full-scale reallocation and $(1 - F_i)\log(\hat{\theta}_i)$ as due to partial

[11] Jacoby, Li, and Rozelle (2002) include the set of village dummies in equation [1]—hazard analysis, but not in equation [2]—the estimation of fertilizer demand.

reallocation. The fertilizer demand equation can now be written as

$$y_i = \delta_1 F_i \log(\hat{\theta}_i) + \delta_2(1 - F_i)\log(\hat{\theta}_i) + x_i\gamma + \varepsilon_i. \quad [8]$$

To check the robustness of our results, we further define the two alternative measures of land reallocation at both the village and household levels. That is, we assign the value of 1 to a household/village if it had experienced a full-scale reallocation, and 0 otherwise. Our remaining independent variables (x_i) for the hazard analysis include a vector of household and individual characteristics ($\mathbf{X}_h$) that range from household size, age, and education of the household head to the share of labor force in a household, the share of female members in that labor force, and not the least, the share of that labor force working off the farm. While the survey failed to enumerate the kind of plot-specific characteristics such as those employed by Jacoby, Li, and Rozelle (2002), it does contain detailed information on the number of plots farmed by a household and overall farm size, which serve as useful controls in the analysis. We summarize the descriptive statistics of all the variables in Table 6.

V. EMPIRICAL TESTING

Hazard Analysis

We first predict the hazard rate before estimating its impact on organic fertilizer usage. Figure 3[12] reports the frequency distribution of tenure duration in the full sample of 2,107 households, which reveals a bimodal distribution with the peaks centered at five and eight years. The number of households that were able to hold on to their plots for five years is 481 (or 23.85%), while 360 (or 17.85%) were able to hold on to theirs for eight years. As 14% never experienced a reallocation since decollectivization, there are quite a few observations with as long a duration as 19 to 22 years. This is consistent with Jacoby, Li, and Rozelle's (2002) 1996 survey finding that 25.1% of the plots in northeast China had not been reallocated since decollectivization.

The results of the hazard analysis are reported in Table 7. In the baseline estimate in which we do not control for the village dummies, household size and number of plots are significantly correlated with expropriation risk (column 1). In fact, the effect of household size on the estimated hazard rate is significant across estimations regardless of whether we control for the full set of 95 village dummies or not (columns 1 through 4). Its positive coefficient suggests that the larger households are always more likely to be affected by land reallocation. The same is found for number of plots; those with more plots are also positively correlated with greater hazard risks after accounting for the effect of the village dummies. The share of nonfarm labor force, while negatively significant in the regression in which land characteristics are not controlled for (column 2), loses its significance in the full model (column 4). The duration dependence $\log(\alpha)$ is significantly positive throughout the estimations, suggesting rising hazards over time. In other words, the longer a household has held on to its plots the less secure it feels about the tenure, a finding that contrasts sharply with that of Li, Rozelle, and Brandt (1998) and suggests that one should not analyze hazard risks based solely on the parameter of tenure duration.

Based on the estimates of specification [4] we can obtain a predicted expropriation hazard rate using the formula $\hat{h}(t) = \hat{\alpha}\hat{\theta}_i t^{\hat{\alpha}-1}$. As this predicted expropriation hazard rate does not vary with land tenure, it enables us to confidently predict a forward-looking expropriation risk. With the mean hazard rate estimated at 0.347 and the mean length of time a household has held on to its plots at 7.55 years, a household has a 34.7% chance of experiencing a land reallocation in the future. Not all households face the same rate of expropriation risk, however. For that reason it would be useful to compute the probabilistic distribution of the differing odds of experiencing land reallocation within a specified time period

[12] The x axis measures the duration or, specifically, the length of time (year) a household has held on to its plots; the left y axis groups the number of households having held on to their plots for the same duration together, whereas the right y axis represents the number of households having held on to their plots for the same duration as a percentage of the total number of households.

TABLE 6
Summary Statistics of Variables

	Number of Observations	Mean	Std. Dev.	Min.	Max.
Organic fertilizer per mu	1,980	925.40	1,360.80	0.00	6,000.00
Duration of land reallocation	2,107	7.55	5.74	1	23
Full-scale land reallocation, household	2,108	0.62	0.49	0	1
Full-scale land reallocation, village	2,086	0.59	0.49	0	1
Ratio of full-scale to overall land reallocation	2,086	0.41	0.43	0	1
ln(Household size)	2,108	1.33	0.37	0.00	2.40
Age of household head	2,106	46.78	11.27	20.00	86.00
Education of household head	2,106	2.61	0.83	1.00	6.00
Female ratio	2,108	0.49	0.16	0.00	1.00
Labor ratio	2,108	0.65	0.26	0.00	1.00
Nonfarm labor ratio	2,108	0.23	0.23	0.00	1.00
ln(Household arable lands)	2,091	1.36	0.99	− 1.61	4.80
ln(Household plots)	2,088	1.39	0.76	0.00	4.28
Policy	2,111	0.14	0.35	0	1
Equality consideration	2,111	0.75	0.43	0	1

(t_0) as $1 - S_i(t_0)$.[13] We illustrate this with the aid of Figure 4, in which we plot the cumulative probabilities of the percentage of farm households experiencing land reallocation within a 5-year window and a 10-year window. Within the first 5 years after the last reallocation, for example, about 24.5% of the households are likely spared another land reallocation, but none of the households would be spared a future reallocation within the 10-year frame (the cumulative probability equals 0, lower left-hand side of panel). Indeed, the probability of a household's experiencing an additional reallocation increases monotonically with duration. Within the 5-year period after a reallocation, for instance, about 32% of the households have a 50% or more chance of experiencing yet another reallocation.[14] The odds are higher, at 69%, for the longer time frame of 10 years. At the other end of the spectrum, while a mere 8.5% of the households are almost certain that they would experience yet another reallocation within the next 5 years, the same percentage increases to 41.9 for the longer window of 10 years.

[13] This exercise also serves to check the robustness of our claim that the hazard rate rises over time.

[14] 32% is obtained by adding together the last four dots on the 5-year line.

Estimating the Effect of Predicted Hazard Rates on Organic Fertilizer Investment

We now turn to estimating the effect of predicted hazard rates on organic fertilizer usage. The results, reported in Table 8, show that the predicted expropriation risk is significantly negative in the baseline estimate (column 1). Specifically, the marginal effect of hazard rate ($\log \hat{\theta}$) on organic fertilizer usage (log-term) is -0.568 (-0.841*0.675), which implies that a 1% decrease in the hazard rate ($\hat{\alpha}\hat{\theta}_i t^{\hat{\alpha}-1}$) will lead to a 0.568% increase in organic fertilizer usage. Evaluating this effect at the mean, a 10% and a 50% reduction in the hazard rate triggered by land reallocation lead to, respectively, a 9.3% and a 79.2% increase in organic fertilizer usage. This result is consistent with that of Jacoby, Li, and Rozelle (2002) and supports the general idea that tenure insecurity will reduce long-term plot-specific investment.

Once we divide expropriation risk into two types, namely, $F * \log \hat{\theta}$ and $(1-F) * \log \hat{\theta}$, more interesting results emerge. First, the interaction term between the full-scale land reallocation ratio and expropriation hazard exhibits a negative effect on organic fertilizer usage and is significant at the 1% level. In terms of magnitude, the effect of the hazard rate caused by full-scale reallocation is about

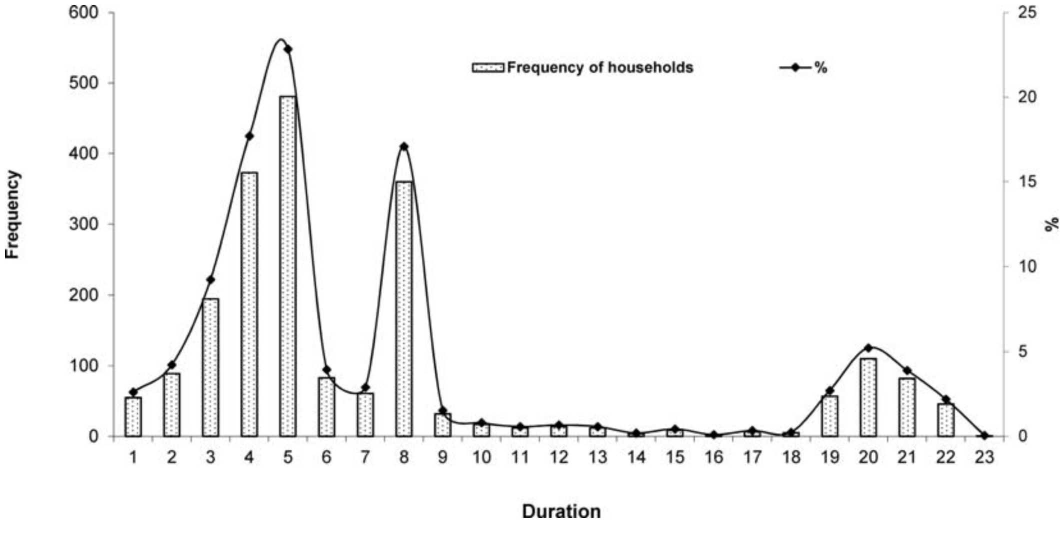

FIGURE 3
Tenure and Frequencies of Households

TABLE 7
Hazard Analysis of Household Tenure

		Village Fixed Effects		
	(1)	(2)	(3)	(4)
Duration dependence log(α)	0.399***	0.876***	0.894***	0.894***
	(0.016)	(0.018)	(0.018)	(0.018)
ln(Household size)	0.329***	0.220***	0.243***	0.221***
	(0.066)	(0.070)	(0.080)	(0.083)
Age of household head	−0.000	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Education of household head	0.002	0.044	0.034	0.035
	(0.029)	(0.031)	(0.031)	(0.031)
Female ratio	−0.008	0.154		0.172
	(0.144)	(0.155)		(0.155)
Labor ratio	0.014	0.144		0.008
	(0.095)	(0.099)		(0.101)
Nonfarm labor ratio	−0.117	−0.252**		−0.119
	(0.108)	(0.118)		(0.118)
ln(Household arable lands)	−0.035		−0.106	−0.102
	(0.025)		(0.068)	(0.069)
ln(Household plots)	−0.205***		0.114**	0.110**
	(0.029)		(0.055)	(0.055)
Village dummies	No	Yes	Yes	Yes
Number of observations	2,084	2,105	2,084	2,084

Note: Constant term and village dummies are included but not reported.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

−1.748 (−2.563*0.682), whereas the effect of the hazard rate caused by partial reallocation is merely −0.057 (−0.084*0.682). Assuming that the hazard rate decreases by 10%, organic fertilizer usage would increase by approximately 31% where past land reallocations were made on a full-scale basis, but less than 1% (0.9%) where land was readjusted only partially (and is statistically insignificant). If the hazard rate decreases even further,

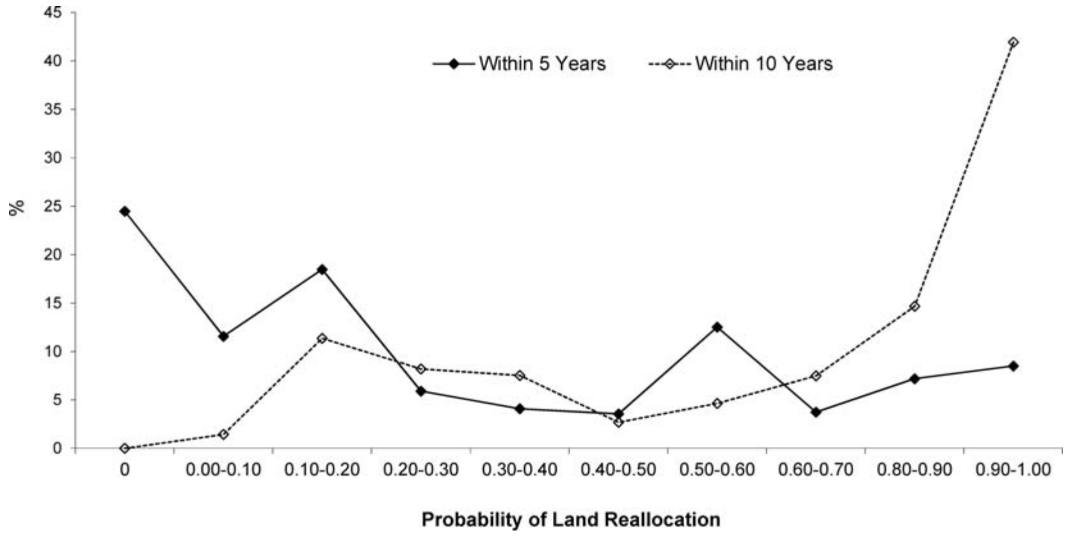

FIGURE 4
Percentage of Farm Households Faced with Various Probabilities of Land Reallocation within the Next 5 and 10 Years

say by half, the elasticity of organic fertilizer usage becomes a massive 491% under full-scale reallocations but a mere 6.0% (and is statistically insignificant) under partial reallocations.

A more important question concerns the likely impact of increased organic fertilizer usage on agricultural productivity. While we are unable to estimate the effect of the hazard rate on grain yields directly using our own survey data (as these data contain no information on agricultural output), it is possible to do so indirectly based on estimates provided by others.[15] Based on the previous finding that a reduction in the hazard rate by half leads to an increase in organic fertilizer usage by 79.2%, or 366.5 kg, and against the Ministry of Agriculture's (1984) estimate that the optimal usage of organic matters per mu of land is about 2,500 kg, we arrive at the estimate that the average effect of a reduced hazard rate on agricultural productivity is approximately 3.1% (0.147*21%), and that the productivity effect in the case of full-scale reallocations is significantly larger: 19.1% (against a negligible 0.2% for partial reallocations).[16]

To check whether the measure "the ratio of full-scale to overall land reallocations" is a robust proxy for land reallocation type (column 2), we employ an alternative measure: a dummy variable that is assigned a value of 1 if a household/village has never experienced full-scale land reallocation (columns 3 and 4). Regardless of which proxy we use, the results consistently show that, while expropriation risks do reduce organic fertilizer usage, the magnitude is much smaller for those associated with partial reallocation. But using the more parsimonious measure—namely, the ra-

[15] For instance, we can base our calculation on the finding of a 20-year fertilization trial experiment comparing the grain productivity between plots fertilized with both chemical fertilizers and pig manure in one instance and those fertilized with only chemical fertilizers in the other, in the Tai Lake region (Eastern China), which reveals that productivity in the former instance is higher by 21% (Pan et al. 2009).

[16] 366.5 kg of organic fertilizer amount to approximately 14.7% of the optimal usage of 2,500 kg. Applying the same procedure to the productivity estimates of Jacoby, Li, and Rozelle (2002) yields a similar result. Specifically, a reduction in the hazard rate by half would lead to an increase in yield by 5% on average and 30.5% in the case of full-scale reallocation (against 0.4% for partial reallocation).

TABLE 8
Effect of Expropriation Risk on Organic Fertilizer Usage

	(1)	(2)[a]	(3)[b]	(4)[c]
$\log(\hat{\theta})$	−0.841***			
	(0.087)			
$F*\log(\hat{\theta})$		−2.563***	−1.079***	−1.407***
		(0.270)	(0.168)	(0.192)
$(1-F)*\log(\hat{\theta})$		−0.084	−0.593***	−0.322**
		(0.126)	(0.167)	(0.152)
ln(Household size)	0.910**	0.824**	0.855**	0.853**
	(0.368)	(0.389)	(0.389)	(0.411)
Age of household head	0.041***	0.038***	0.041***	0.040***
	(0.012)	(0.014)	(0.010)	(0.012)
Education of household head	0.101	0.086	0.106	0.090
	(0.172)	(0.147)	(0.162)	(0.143)
Female ratio	−1.248	−0.984	−1.221	−1.127
	(0.936)	(0.978)	(0.876)	(0.843)
Labor ratio	0.447	0.827	0.545	0.656
	(0.676)	(0.523)	(0.654)	(0.627)
Nonfarm labor ratio	−2.649***	−2.856***	−2.696***	−2.621***
	(0.661)	(0.770)	(0.579)	(0.639)
ln(Household arable lands)	0.031	0.205	0.026	0.073
	(0.138)	(0.157)	(0.157)	(0.140)
ln(Household plots)	1.379***	1.085***	1.397***	1.281***
	(0.169)	(0.201)	(0.188)	(0.184)
Proportion working factor	0.675	0.682	0.681	0.675
Number of observations	1,974	1,953	1,953	1,974

Note: $\log(\hat{\theta})$ is the predicted hazard rate in log-term; $F*\log(\hat{\theta})$ denotes the predicted hazard rate associated with full-scale reallocation, whereas $(1-F)*\log(\hat{\theta})$ denotes the predicted hazard rate associated with partial reallocation. Coefficients are reported. Marginal effects can be calculated by multiplying the coefficients with the proportion working factor. Constant term is included but not reported.

[a] F is measured by the ratio of full-scale reallocations to all land reallocations.

[b] F is measured by whether a household experienced full-scale reallocation.

[c] F is measured by whether a village experienced full-scale reallocation.

* Significant at 10%; ** significant at 5%; *** significant at 1%.

tio of full-scale to overall land reallocations—to proxy for future land reallocation type (column 2) leads to an even stronger conclusion: tenure insecurity is caused only by full-scale land reallocations. Expropriation risk due to partial land reallocations is statistically insignificant.

Other variables bearing upon this decisive difference include household size, age of the household head, the share of off-farm labor, and the degree of land fragmentation (proxied by the number of plots). Given that the thorough spreading of organic nutrients on fields is an onerous task, larger families enjoy a comparative advantage over their smaller counterparts in this labor-intensive endeavor. Likewise, the positive coefficient of the age of the household head suggests that the more experienced, older farmers care more about the soil fertility of their contracted plots; this concurs with the reality that the opportunities for off-farm employment decline with age. Consistently, the negative coefficient of the off-farm labor variable suggests that households engaged disproportionately in off-farm work are less likely to invest more in their land. In terms of magnitude, a 1% increase in this ratio will likely reduce organic fertilizer usage by approximately 2.856 percentage points (column 2), which is substantial. Finally, to the extent that households managing a larger collection of smaller plots tend to be more specialized in farming, chances are that they are more likely to apply more organic fertilizer to their plots.

Robustness Checks: Alternative Instruments

In our baseline estimates we include the set of village dummies only in the hazard equation but not in the equation of organic fertilizer usage. This identification strategy relies on the variation in land management policy across the villages. However, these instruments would be invalid if there are other unobserved village-specific factors, which may then lead to a spurious correlation between organic fertilizer usage and predicted expropriation risk (Jacoby, Li, and Rozelle 2002). For instance, in villages where the soil is infertile, village leaders may be inclined to suppress land reallocations in order to encourage farmers to invest in the fertility of their assigned plots. Conversely, to the extent that the social cost of land reallocations is likely to be far smaller in villages well served by public infrastructure such as irrigation, individual fertilizing behavior would be far less a concern to the village leaders and farmers alike, and accordingly there would be fewer incentives for the community at large to forgo land reallocations. To test the robustness of our previous results we include two additional instruments that correlate directly with a village's land management policy for identifying the causal effects of expropriation risk on organic fertilizer usage.

The first of these additional instruments pertains to what may be considered a "policy shock" that helps remove the otherwise endogenous nature of land reallocations. The reason is that agricultural decollectivization was completed in 1984, when farm households across China were given a contractual arrangement meant to last 15 years before ending in 1998. To impart confidence among the farmers in the Household Responsibility System (that it will continue to be the primary unit of farm organization), the Chinese government extended the existing tenure for another 30 years, from 1998. In compliance with this policy, some village authorities received explicit instructions from their township supervisors to thoroughly reallocate land among those who, as in the instance of decollectivization, were eligible for equal land use rights, in anticipation that full-scale reallocation would be prohibited for 30 years to come. In this context, the village officials were asked to indicate in the survey "if they had been explicitly instructed to implement full-scale land reallocations in 1998." For those who answered "yes" to this question and did as instructed, we consider land reallocation in that year *exogenous,* which we exploit as our new instrument.[17] About 14% of the surveyed households indicated that they had been instructed to reallocate land on a full-scale basis in 1998. We consider this instrument appropriate because it correlates directly with land reallocations but not with organic fertilizer usage except through the effect of land reallocations.

We consider yet another instrument, namely, whether a village assigns greater weight to an egalitarian ideology.[18] The underlying assumption here is that land reallocations would be conducted more frequently in villages that stress more heavily the egalitarian ethos. To measure this variation, we construct a variable based on whether a village had assigned land based on a household's laboring capacity (using the age of full-time laborers as a criterion) in addition to sheer household size when it decollectivized its land holdings some two decades ago. We assume that a village tends to be more egalitarian if it decollectivized its land based only upon household size, the corollary of which is that land reallocations would be conducted more frequently, and vice versa. Granted, village ideology is a collective choice variable, but, once historically settled upon, it should have no direct effect on households' investment decision. To control for the possible region-specific effects we include the provincial dummies in these regressions. In the light of the new instruments we can rewrite our estimation strategy as

[17] We should continue to bear in mind the fact that the Chinese (central) government has banned full-scale land reallocations otherwise (see, e.g., the revised Land Management Law of 1998 and Rural Land Contract Law of 2002), and that, despite such repeated policy attempts, 5.5% of the rural households surveyed nationally in 2005 were found to have ignored such policies and continued to reallocate land thoroughly (Kung and Bai 2011).

[18] Due to the low standard of living, egalitarianism—manifested in the equal sharing of food entitlements—is arguably a distinguished hallmark of China's collective agriculture. Depending in part on how close to subsistence villages were when they decollectivized agriculture, some were likely more egalitarian than others—variations of which are now manifested in the criteria by which land was divided among farm households as Kung (1994) has observed.

TABLE 9
Robustness Check: Alternative Instruments

	Hazard Analysis (1)	The Effects of Expropriation Risk on Organic Fertilizer Usage					
		(2.1)[a]	(2.2)[b]	(2.3)[c]	(2.4)[a]	(2.5)[b]	(2.6)[c]
$F*\log(\hat{\theta})$		− 1.680***	− 1.232**	− 1.130**	− 3.737***	− 3.070***	− 2.838***
		(0.614)	(0.550)	(0.552)	(0.642)	(0.511)	(0.575)
$(1-F)*\log(\hat{\theta})$		− 0.551	− 0.721	− 0.800*	− 0.663*	− 0.648	− 0.790*
		(0.456)	(0.457)	(0.433)	(0.380)	(0.469)	(0.417)
ln(Household size)	0.350***	0.451	0.505	0.510	1.759***	1.864***	1.853***
	(0.068)	(0.392)	(0.416)	(0.470)	(0.432)	(0.431)	(0.397)
Age of household head	− 0.001	0.048***	0.048***	0.048***	0.045***	0.044***	0.046***
	(0.002)	(0.014)	(0.015)	(0.012)	(0.013)	(0.012)	(0.014)
Education of household head	0.007	0.117	0.109	0.109	0.175	0.163	0.165
	(0.029)	(0.198)	(0.180)	(0.181)	(0.164)	(0.170)	(0.187)
Female ratio	− 0.043	− 0.745	− 0.790	− 0.804	− 1.468**	− 1.484**	− 1.488*
	(0.144)	(0.707)	(0.836)	(0.902)	(0.689)	(0.740)	(0.802)
Labor ratio	0.013	0.574	0.571	0.572	0.694	0.685	0.704
	(0.095)	(0.603)	(0.566)	(0.532)	(0.550)	(0.600)	(0.469)
Nonfarm labor ratio	− 0.083	− 1.909***	− 1.906***	− 1.909***	− 2.589***	− 2.560***	− 2.579***
	(0.108)	(0.606)	(0.727)	(0.652)	(0.539)	(0.601)	(0.516)
ln(Household arable lands)	− 0.097***	0.019	− 0.025	− 0.035	− 0.119	− 0.177	− 0.213
	(0.029)	(0.150)	(0.150)	(0.132)	(0.243)	(0.250)	(0.259)
ln(Household plots)	− 0.197***	1.760***	1.769***	1.778***	0.463*	0.431**	0.490**
	(0.031)	(0.179)	(0.154)	(0.191)	(0.237)	(0.215)	(0.206)
ln(Total village households)	0.009	1.854***	1.847***	1.838***	0.643***	0.661***	0.634***
	(0.035)	(0.237)	(0.216)	(0.269)	(0.236)	(0.213)	(0.235)
Village equality consideration	1.183***						
	(0.079)						
Policy (1998)	0.417***						
	(0.063)						
Duration dependence $\log(\alpha)$	0.484***						
	(0.017)						
Proportion working factor		0.681	0.680	0.680	0.694	0.694	0.694
Province dummies					Yes	Yes	Yes
Number of observations	2,063	1,953	1,953	1.953	1,953	1,953	1,953

Note: $\log(\hat{\theta})$ is the predicted hazard rate in log-term; $F*\log(\hat{\theta})$ denotes the predicted hazard rate associated with full-scale reallocation, whereas $(1-F)*\log(\hat{\theta})$ denotes the predicted hazard rate associated with partial reallocation. Coefficients are reported. Marginal effects can be calculated by multiplying the coefficients with the proportion working factor. Constant term is included but not reported.
[a] F is measured by the ratio of full-scale reallocations to all land reallocations.
[b] F is measured by whether a household experienced full-scale reallocation.
[c] F is measured by whether a village experienced full-scale reallocation.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

$$\lambda_i = \exp(x_i\beta + \phi_1 Policy_i + \phi_2 Egalitarian_i), \quad [9]$$

$$y_i = \delta_1 F_i \log(\hat{\theta}_i) + \delta_2(1-F_i)\log(\hat{\theta}_i) + x_i\gamma + \varepsilon_i. \quad [10]$$

We first report the results of the hazard analysis (equation [9]) in column (1) of Table 9. Of foremost importance is that the two new instruments significantly affect the hazard rate (at the 1% level of significance). As expected, the positive coefficient of the "policy shock" variable suggests that the villagers who were instructed to reallocate land in 1998 did experience greater expropriation risk. By the same token, farm households in the more egalitarian villages similarly perceived greater expropriation risks. Consistent with previous estimates, the duration dependence $\log(\alpha)$ continues to be significant and positive, suggesting rising hazards over time.

In columns (2.1)–(2.3) of Table 9 we present the estimation results of equation [10], which are strikingly similar to those of the baseline estimations (Table 8). The pertinent results point to the consistent finding that expropriation risk arising from full-scale reallocation has a significant effect of depressing organic fertilizer usage. While the expropriation risk associated with partial reallocation is also significantly negative in two of the three specifications (columns 2.2 and 2.3), it is significant at only the 10% level and with a much smaller magnitude. Inclusion of the provincial dummies does not alter this conclusion (columns 2.4–2.6). On the whole, these findings lend further support to our hypothesis regarding the differential effects of the two types of land reallocation on plot-specific investment behavior.

To check if our instruments of policy shock and village ideology are valid, it is necessary to ensure that they do not have any direct effects on organic fertilizer usage. To ensure that village ideology does not have any direct significant effect on organic fertilizer usage, we use the policy shock to instrument hazard rate, followed by adding village egalitarian ideology to the model as the exogenous regressor. Our instrument of village egalitarian ideology would be rendered invalid if it has a significant effect on organic fertilizer usage. This method can be regarded as an easy-to-interpret version of the overidentification test. The second step of this instrumental variable (IV) regression can be written as

$$y_i = \delta_1 F_i \log(\hat{\theta}_i) + \delta_2 (1 - F_i) \log(\hat{\theta}_i) + x_i \gamma + \phi_1 Egalitarian_i + \varepsilon_i. \quad [11]$$

We report the results of this check in columns (1), (3), and (5) of Table 10. As the results clearly show, village egalitarian ideology has an *insignificant* direct effect on organic fertilizer usage. By the same token, to ensure that policy shock does not have any direct significant effect on organic fertilizer usage, we employ it to be the exogenous regressor and use village egalitarian ideology as the instrument instead. Reported in columns (2), (4), and (6), the results similarly show that policy shock does not bear significantly upon organic fertilizer usage.

Competing Expropriation Risks of Two Kinds of Land Reallocations

Up to this point of the analysis we have assumed that for each village there exists a hazard function of land reallocation, and that a village chooses a particular type of land reallocation that it finds appropriate. Given these assumptions, our empirical strategy is to estimate an expropriation hazard first, then interact this hazard function with the particular type of land reallocation chosen. The rationale underlying this approach is that for the majority of villages, the type of land reallocation remains relatively stable over time (as can be seen from Figure 1 and Table 1); this allows us to use the history of land reallocation type to proxy for the possible type of future land reallocation.

In this penultimate section we relax the above assumptions, because the risk factors for the two types of reallocation are not identical. This is especially the case for partial land reallocation, which is driven by explicit household-specific demographics. For this reason a "competing risk" model would be a more appropriate specification.[19] Specifically, we assume that the surveyed households would experience one of two "failure" types—either full-scale or partial reallocation but not both—and that between the two potential "failure times" (viz. the time to full-scale reallocation ($t_1^F, t_2^F, \ldots, t_n^F$) vis-à-vis the time to partial reallocation ($t_1^P, t_2^P, \ldots, t_n^P$)) we can observe only the shorter of the two ($t_1, t_2, \ldots, t_n$).We then denote the hazard rate for full-scale reallocation by $h^F(t)$ and that for partial reallocation by $h^P(t)$. The total hazard rate ($h(t)$), that is, the probability that any of the two events will occur, is equal to $h^F(t) + h^P(t)$. According to Pintilie (2006), we can take turns to identify $h^F(t)$ by treating partial land reallocation as censored, and to identify $h^P(t)$ by treating full-scale land reallocation as censored.

While essentially we are employing the same method of hazard analysis to identify the two hazard rates, the specific hazard functions (in the standard Weibull form) can be written as

$$h^F(t) = \alpha^F \theta_i^F t^{\alpha^F - 1},$$
$$h^P(t) = \alpha^P \theta_i^P t^{\alpha^P - 1},$$

and the expropriation risk parameters for the two kinds of land reallocation now become

[19] We thank an anonymous reviewer for this suggestion.

TABLE 10
Checking the Validity of Instruments

	The Effects of Expropriation Risk on Organic Fertilizer Usage					
	(1)[a]	(2)[a]	(3)[b]	(4)[b]	(5)[c]	(6)[c]
$F*\log(\hat{\theta})$	−3.936***	−3.117***	−3.260***	−2.455***	−3.062***	−2.166**
	(0.734)	(0.947)	(0.572)	(0.827)	(0.536)	(0.977)
$(1-F)*\log(\hat{\theta})$	−0.810	0.009	−0.790*	0.016	−0.938**	−0.042
	(0.527)	(0.802)	(0.440)	(0.784)	(0.447)	(1.040)
ln(Household size)	1.807***	1.520***	1.914***	1.632***	1.909***	1.595***
	(0.370)	(0.531)	(0.405)	(0.387)	(0.350)	(0.559)
Age of household head	0.045***	0.045***	0.043***	0.044***	0.045***	0.046***
	(0.013)	(0.013)	(0.010)	(0.014)	(0.013)	(0.010)
Education of household head	0.167	0.161	0.155	0.150	0.156	0.150
	(0.150)	(0.189)	(0.166)	(0.150)	(0.157)	(0.140)
Female ratio	−1.495*	−1.460	−1.511**	−1.477	−1.517*	−1.478*
	(0.799)	(0.923)	(0.712)	(0.909)	(0.781)	(0.869)
Labor ratio	0.683	0.672	0.673	0.663	0.691	0.680
	(0.595)	(0.519)	(0.498)	(0.492)	(0.486)	(0.551)
Nonfarm labor ratio	−2.579***	−2.512***	−2.550***	−2.483***	−2.569***	−2.495***
	(0.706)	(0.592)	(0.674)	(0.700)	(0.770)	(0.644)
ln(Household arable lands)	−0.095	−0.016	−0.155	−0.077	−0.189	−0.102
	(0.251)	(0.297)	(0.322)	(0.309)	(0.251)	(0.324)
LN(Household plots)	0.408*	0.570**	0.376	0.535**	0.429*	0.605**
	(0.247)	(0.278)	(0.288)	(0.250)	(0.224)	(0.257)
ln(Total village households)	0.646**	0.639**	0.664**	0.657***	0.639***	0.630***
	(0.287)	(0.281)	(0.276)	(0.215)	(0.238)	(0.214)
Village equality consideration	0.342		0.336		0.374	
	(0.330)		(0.498)		(0.343)	
Policy (1998)		−0.969		−0.952		−1.060
		(1.058)		(0.937)		(1.270)
Proportion working factor	0.694	0.694	0.694	0.694	0.694	0.694
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,953	1,953	1,974	1,974	1,953	1,953

Note: $\log(\hat{\theta})$ is the predicted hazard rate in log-term; $F*\log(\hat{\theta})$ denotes the predicted hazard rate associated with full-scale reallocation, whereas $(1-F)*\log(\hat{\theta})$ denotes the predicted hazard rate associated with partial reallocation. Coefficients are reported. Marginal effects can be calculated by multiplying the coefficients with the proportion working factor. Constant term is included but not reported.
[a] F is measured by the ratio of full-scale reallocations to all land reallocations.
[b] F is measured by whether a household experienced full-scale reallocation.
[c] F is measured by whether a village experienced full-scale reallocation.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

$$\theta_i^F = \exp(x_i\beta^F + \phi_1^F Policy_i + \phi_2^F Egalitarian_i + \varepsilon_v^F),$$
$$\theta_i^P = \exp(x_i\beta^P + \phi_1^P Policy_i + \phi_2^P Egalitarian_i + \varepsilon_v^P), \quad [12]$$

where θ_i^F and θ_i^P are the respective hazard rates for full-scale and partial land reallocation—rates that do not vary with tenure duration. This allows us to rewrite the fertilizer demand equation as

$$y_i = \delta_1 \log(\hat{\theta}_i^F) + \delta_2 \log(\hat{\theta}_i^P) + x_i\gamma + \varepsilon_i. \quad [13]$$

The results of the hazard analysis (equation 12) for both full-scale and partial land reallocations (on the village level) are reported in columns (1) and (2) of Table 11. The duration dependence $\log(\alpha)$ is significantly positive throughout the estimations regardless of the type of reallocation, suggesting rising hazards over time. For full-scale reallocation, α^F is about 1.433 (exp(0.360)), and for partial reallocation α^P is about 2.283 (exp(0.718)). Our two instrumental variables—policy shock and village egalitarian ideology—are positively and significantly correlated with the hazard rate of full-scale reallocation. The more egalitarian villages are indeed less likely to reallocate their lands on a partial basis. This finding, while significant only at the 10% level, is consistent with the finding that villages that assign more weight to efficiency tend to reallocate land on a partial basis (Kung and Bai 2011).

TABLE 11
Effect of Expropriation Risk on Organic Fertilizer Usage: Robustness Checks

	Hazard Analysis			Hazard Analysis		
	Full-Scale LR (1)	Partial LR (2)	Fertilizer Demand (3)	Full-Scale LR (4)	Partial LR (5)	Fertilizer Demand (6)
$\log(\hat{\theta})$: full-scale LR			−0.993***			−0.994***
			(0.288)			(0.291)
$\log(\hat{\theta})$: partial LR			0.079			0.090
			(0.259)			(0.331)
ln(Household size)	0.456***	0.139	0.765*	0.454***	0.154	0.762
	(0.087)	(0.111)	(0.436)	(0.088)	(0.107)	(0.472)
Age of household head	−0.002	0.000	0.048***	−0.004	0.003	0.046***
	(0.003)	(0.003)	(0.011)	(0.003)	(0.003)	(0.012)
Education of household head	−0.021	0.055	0.084	−0.026	0.056	0.078
	(0.037)	(0.047)	(0.189)	(0.038)	(0.045)	(0.187)
Female ratio	−0.433**	0.543**	−1.304	−0.441**	0.482**	−1.313
	(0.185)	(0.231)	(1.014)	(0.189)	(0.224)	(1.078)
Labor ratio	−0.047	0.120	0.499	−0.017	0.069	0.532
	(0.120)	(0.156)	(0.577)	(0.123)	(0.150)	(0.500)
Nonfarm labor ratio	−0.145	−0.038	−2.023***	−0.134	−0.082	−2.007***
	(0.138)	(0.173)	(0.707)	(0.140)	(0.167)	(0.725)
ln(Household arable lands)	0.004	−0.230***	−0.128	0.017	−0.227***	−0.113
	(0.038)	(0.047)	(0.165)	(0.039)	(0.046)	(0.163)
ln(Household plots)	−0.507***	0.277***	1.535***	−0.582***	0.334***	1.452***
	(0.041)	(0.050)	(0.248)	(0.042)	(0.049)	(0.282)
ln(Total village households)	0.034	−0.001	1.838***	0.082*	−0.066	1.892***
	(0.044)	(0.056)	(0.222)	(0.046)	(0.054)	(0.194)
Policy (1998)	1.021***	−0.381***		1.019***	−0.332***	
	(0.088)	(0.091)		(0.088)	(0.089)	
Village equality consideration	0.989***	1.646***		0.990***	1.477***	
	(0.101)	(0.133)		(0.102)	(0.128)	
Duration dependence $\log(\alpha)$	0.360***	0.718***		0.400***	0.624***	
	(0.022)	(0.053)		(0.022)	(0.025)	
Proportion working factor			0.681			0.681
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	2,063	2,063	1,953	2,063	2,063	1,953

Note: We first use a competing risk model to estimate the effects of various dependent variables on the risks associated with full-scale and partial land reallocations in columns (1), (2), (4), and (5), and then predict the hazard rates separately for full-scale and partial reallocations. In columns (3) and (6), we use a tobit model to estimate the effect of predict hazard rates on organic fertilizer usage. Coefficients are reported. Marginal effects can be calculated by multiplying the coefficients with the proportion working factor. Constant term is included but not reported. LR, land reallocation.

* Significant at 10%; ** significant at 5%; *** significant at 1%.

We can now reestimate the effects of hazard rates, which are predicted from the competing risk model, on organic fertilizer usage. Reported in column (3) of Table 11, the results continue to lend support to our hypothesis, namely, that although the expropriation risk caused by full-scale reallocation significantly decreases organic fertilizer usage, the expropriation risk associated with partial reallocation is statistically insignificant. In terms of magnitude, the marginal effect of hazard rate ($\log \hat{\theta}^F$) on organic fertilizer usage (log-term) is −0.676 (−0.993*0.681), which implies that a 1% increase in the hazard rate ($\hat{\alpha}\hat{\theta}_i t^{\hat{\alpha}-1}$) will lead to a 0.676% decrease in organic fertilizer usage (column 6). To check the robustness of our results, we conduct the same hazard analysis (equation [12]) for the two types of land reallocation at the household level and find the same results (columns 4–6 of Table 11).

VI. CONCLUSION

Despite the individualization of farming, property rights to land in rural China have to this day remained collectivized; what has been devolved to the farm households are use and income rights, but not transfer rights. While this invigorated work incentives and boosted farm productivity and output growth initially, it remains incomplete from the standpoint of private property rights. The common property nature of land rights has obligated the periodic reallocation of land among members of the village community—a practice that allegedly exposes the farmers to expropriation risk and discourages them from investing in the land for the long term. Empirical studies that employ plot characteristics to predict hazard risk convincingly bear out the negative relationship between land reallocations and organic fertilizer usage.

Premised on the facts that (1) land reallocation in China is far from homogeneous, (2) the majority of villages tend to adopt a single mode of reallocation rather than randomize between the two, and (3) one mode of reallocation may have radically different implications for tenure security from the other, we extend Jacoby, Li, and Rozelle's (2002) study to analyze the predicted hazard rates of both full-scale and partial reallocations on organic fertilizer usage—the most popular form of plot-specific investment undertaken by farm households in rural China.

By employing a unique farm survey that deliberately draws a distinction between these two modes of land reallocations, we are able to decompose the effect of expropriation risk by the mode of reallocation with which it is associated, thereby providing a fresh perspective from which to understand the relationship between land tenure security and farm investment behavior in the specific Chinese context. While we found that expropriation risk created by land reallocations on the whole does have a negative and significant effect on farm investment behavior, we showed, importantly, that this negative relationship is driven solely by full-scale reallocation; partial reallocation, which involves only a small percentage of the households and a tiny fraction of the existing plots, does not bear significantly upon organic fertilizer usage. This nuanced finding has important policy implications for the Chinese government's continuing concerns over tenure insecurity, as clearly articulated in the 2002 Rural Contracting Law, which explicitly prohibits full-scale land reallocations but sanctions partial reallocations under certain circumstances.[20] Consistent with the above finding, our estimations indeed find that a reduction in the hazard rate by half has had a sharply different effect between these two types of land reallocation on organic fertilizer usage (491% versus 6%) and, accordingly, crop yields (19.1% versus 0.2%). While the intuition underlying the spirit of this law is that full-scale land reallocations are likely to hurt tenure security more so than partial land reallocations, our findings concerning the effects of reduced hazard rates on organic fertilizer usage and agricultural productivity provide the precise and much-needed empirical evidence for substantiating this claim.

Acknowledgments

We thank two anonymous reviewers whose suggestions on earlier drafts have helped improve this article substantially. We alone are responsible for any remaining errors.

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[20] Exception applies in the event of a natural disaster or "other special circumstances" that cause serious damage to the contracted land, as long as the decision to reallocate land is approved by two-thirds of the village representatives (Article 27 of the Rural Contracting Law [Ninth National Party Congress of the Communist Party 2002]).

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