Property Rights, Land Misallocation and Agricultural Efficiency in China*

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November 2017

Abstract

This paper examines the impact of a property rights reform in rural China that allowed farmers to lease out their land. We find the reform led to increases in land rental activity in rural households. Consistent with a model of transaction costs in land markets, our results indicate that the formalization of leasing rights resulted in a redistribution of land toward more productive farmers. Consequently, the aggregate productivity of land increased significantly. We also find that the reform increased the responsiveness of land allocation across crops to changes in crop prices.

*We gratefully acknowledge funding from the ESRC-DFID. This paper has benefitted from comments from Santosh Anagol, S. Anukriti, Chang Tai-Hsieh, Rachel Heath, Melanie Khamis, Adriana Kugler, Annemie Maertens, Laura Schechter, and seminar participants at the Agricultural and Development Conference (at Yale University), Columbia University, Pennsylvania State University, Stanford University, University of Virginia Darden, University of Delaware, Wharton and the World Bank. All errors are our own.

1 Introduction

Growth in agricultural productivity has long been viewed as central to the process of structural transformation and economic growth (Gollin, Parente and Rogerson 2002, Ranis and Fei 1961). Yet labor productivity in agriculture remains remarkably low in most developing countries, and this can (at least mechanically) account for most of the overall differential in labor productivity between rich and poor countries (Caselli 2005, Restuccia, Yang and Zhu 2008). Research suggests that this phenomenon cannot be explained by low capital per worker (Chanda and Dalgaard 2008, Vollrath 2009, Lagakos and Waugh 2013), implying that residual factors, or total factor productivity, must be the major source of the productivity differential in agriculture.

Some recent studies suggest that the observed productivity differentials in agriculture may be a result of frictions that produce a misallocation of productive resources (Adamopoulos and Restuccia 2014, Restuccia and Santaeulalia-Llopis 2017). This idea extends an influential literature that emphasizes factor misallocation as a source of low productivity in the manufacturing sector (Chari 2011, Hsieh and Klenow 2009, Midrigan and Xu 2014, Restuccia and Rogerson 2008). The argument is supported by the stark differences in the inputs and scale of agricultural production in developing and developed countries (Foster and Rosenzweig 2012). These differences may reflect market failures or institutional frictions in developing countries that act as a constraint on the growth of more productive farmers.[1] Understanding which policies and institutions underlie these frictions, and quantifying their associated costs, is important for both researchers and policy-makers.

We contribute to this literature by leveraging a property rights reform in China. Specifically, we analyze the impact of the Rural Land Contracting Law (RLCL), a reform that gave farmers legal rights to lease their land while re-iterating existing protections for the security of land rights, on land allocation and efficiency in agricultural production. This occurred in a context where farmers do not have full ownership rights to their land, but rather only use rights granted by the local government. The RLCL provides a valuable opportunity to estimate the importance of land

[1] A possible alternative is that the differences do not reflect market failures in developing countries. For example, low wages in developing countries may not be caused by market failures and may correspond with labor-intensive, small-scale production being the most efficient market outcome.

market imperfections in generating misallocation and the potential for property rights reforms to improve outcomes in the agricultural sector.

In theory, well-defined property rights over land should facilitate efficiency-improving transactions. In practice, however, the extent to which property rights in land markets matter is unclear. First, there may be other market failures or constraints that prevent the efficient reallocation of land, and which may not (at least in the short run) be relieved by restoring the missing market for land. Second, the importance of formal rights has itself been questioned in the literature: some evidence on the role of property rights in agriculture suggests that informal institutions that adequately substitute for lack of formal land titles and tenure may arise (Besley 1995, Carter et al 1994, Brasselle, Gaspart and Platteau 2002). However, other papers suggest an important role for tenancy rights and tenure security in agricultural outcomes (Banerjee, Gertler and Ghatak 2002, Goldstein and Udry 2008). The impact of formalizing exchange rights therefore remains an open empirical question.

Our approach for addressing this question is to exploit variation across provinces in the timing of their implementation of the central reform that was announced in 2003.[2] We collected novel data on the timing of implementation in each province and use the staggered timing to identify the impacts of property rights. We combine this information with panel data on input decisions and output realizations of agricultural households collected from the Chinese Ministry of Agriculture (called the National Fixed Point Survey or NFP) from 2003 to 2010. In addition to the long panel dimension, this data set is somewhat rare among agricultural household surveys in its large sample size and broad geographic coverage.

We begin our analysis with difference-in-difference estimates of the impact of the reform. We find evidence of a significant increase in land rental activity following the reform, with the probability of new renting transactions increasing by about 10% and the area of land rented out increasing by 7%. At the village level, overall output and the productivity of land also increase significantly by about 7%.

[2]Deininger and Jin (2009) and Zhao (2014) examine the same property rights reform in China, but they focus on different outcomes (land reallocations by the government and labor market outcomes, respectively). Furthermore, their identification is based on a before-after 2003 comparison whereas we utilize the staggered nature of implementation across provinces.

While the previous set of results have the advantage of not requiring any assumptions on the agricultural production process, we are also interested in testing for reallocation of land across producers and quantifying the extent to which this may be responsible for the observed improvement in aggregate output and productivity. To examine whether the share of land within villages farmed by the more productive farms increases, while the share of land cultivated by less productive farms falls, we use a production function approach to estimate farmer TFP after controlling for a variety of inputs.[3] We find that the reform increased the amount of land farmed by relatively more productive farmers, while reducing the amount of land cultivated by relatively less productive farmers, consistent with the notion that reducing frictions in the land market should produce a more efficient allocation of land. The results on reallocation are very similar if we look for land reallocation along the gradient of marginal product of land or agricultural profits instead of TFP.

We also observe a corresponding reallocation of labor, which is a complementary input to land: the amount of hired labor increased on relatively more productive farms but decline on less productive farms, suggesting a within-village reallocation of labor. Interestingly, we do not find evidence of labor moving out of agriculture (within the village) or into migration (out of the local area). We apply a simple decomposition of aggregate productivity to find that nearly 85% of the observed increase in aggregate productivity can be attributed to input reallocations associated with the reform.

In addition to their effect on income and productivity, land market restrictions also hinder farmers' ability to respond to economic fluctuations. This is an important implication in the context of the agricultural sector, where agricultural households' profits and incomes are sensitive to price changes. We examine whether the reduction in land transaction costs due to the reform allowed farmers to respond better to changes in agricultural prices, an important source of risk in the agricultural sector.[4] We find that an increase in the price of a crop induces greater reallocation of land

[3]This builds on a large existing literature on agricultural production function estimations. See Gollin and Udry (2017) for an overview. A concurrent working paper by Adamopoulos, Brandt, Leight and Restuccia (2017) estimate farm-level production functions in China to examine the misallocation of land and capital. In addition to examining a later period in China, the approach in our paper is quite different in that we exploit a reform that aimed to improve the functioning of rural land markets.

[4]This relates to an existing literature in agricultural economics that estimates the response of yields to crop prices (see for example, Choi and Helmberger 1993, Houck and Gallagher 1976, Menz and Pardey 1983).

toward that crop in the post-reform period (relative to the pre-reform period). This result provides some insight into one way in which the reform has reduced frictions in the efficient allocation of land resources.

In the context of agriculture in developing countries, ownership and use rights over land are often poorly-defined and this plausibly affects the ability and incentives of farmers to transact in land. Our results establish both the importance of land misallocation as a source of productive inefficiency in the agricultural sector, as well as the positive role that well-defined property rights can have in ameliorating the problem.[5]

Our paper constitutes a distinct contribution to the literature on property rights in agriculture that has largely focused on the ability to leverage land as collateral or on the implications of land tenure for agricultural investments, but has paid relatively less attention to the importance of exchange rights in achieving a more efficient allocation of land. Studies of the relationship between exchange rights and efficiency in rural areas are Ravallion and van de Walle's (2003) examination of the 1993 Land Law in Vietnam which bundled selling rights with a titling system and Chen, Restuccia and Santaeulalia-Llopis' (2017) analysis of leasing behavior and efficiency in Ethiopia. The approaches of both papers are different from ours. In the absence of data on agricultural production and data prior to the reform or a control group, Ravallion and van de Walle (2003) use consumption outcomes to measure efficiency in a counterfactual exercise. In a concurrent working paper, Chen, Restuccia and Santaeulalia-Llopis (2017) demonstrate a positive relationship between land leasing and productivity, but in the absence of data prior to the leasing reform; their analysis requires the assumption that post-reform changes in observed leasing activity are exogenous to the outcomes of interest.

The paper proceeds as follows. Section 2 provides detailed institutional background on land tenure laws and reform in China. Section 3 presents a simple theoretical model that provides intuition for the empirical analysis. Section 4 presents the empirical analysis, and Section 5 concludes with a discussion of the results.

[5]Our study also contributes to an existing literature that documents sources of inefficiencies related to land allocation and agricultural production. Udry (1996) studies inefficiencies in the intra-household allocation of land in Burkina Faso; in contrast, we document inefficiencies in land allocation across agricultural households within villages.

2 Institutional Background

Beginning in 1979, the Household Production Responsibility System (HRS) was created to dismantle the existing collective organization of agricultural production and to give households control of farming decisions and output. After 1979, farmers had private use rights to agricultural plots but these land rights were relatively insecure as local governments could reassign plots until the late 1990s. In 1998, the Land Management Law granted farmers 30-year formal land contracts from their village governments, providing security of land tenure. This paper focuses on the property rights reform that occurred with the official announcement of the Rural Land Contracting Law (RLCL) in 2003. In addition to re-iterating the existing policy of 30-year contracts between village governments and farmers, the RLCL provides farmers the legal right to rent out and rent in land.[6] Prior to 2003, there were instances of informal land rental agreements, including contracts based on verbal agreements among family and neighbors. The 2003 reform offered legal security to both parties of a leasing contract.[7]

Regarding the RLCL, Li (2003) writes, "This landmark law represents the most important legal breakthrough for securing land rights for China's 210 million farm households since the adoption of the HRS." The RLCL makes no statements about inheritance rights and does not reverse a prior law's prohibition of using land rights as collateral. Thus, the main mechanisms of the RLCL are the decreased threat of expropriation and legal protections offered to rural households who lease land.

Summary statistics presented in Zhao (2014) suggest that a large drop in government-led land adjustments occurred starting 1998 (following the Land Management Law) but that there was very little change in government-led land readjustments occurring after 2003.[8] The share of villages engaging in major government-led land reallocations was under 4% from 2001 to 2006 and zero in

[6]The law outlines the legal protection granted to leasing rights, rules for leasing and transferring leases, and how to address land disputes in leasing contracts.

[7]In cases of disputes over rental contracts and private negotiation between the two parties fail, they can ask the village or town government to assist in the negotiations. If that fails, either party can initiate arbitration or a lawsuit in the local court system.

[8]We reprint Figure 1 from their paper in Appendix Figure A.1. This figure is based on data that were collected by the author and we do not have access to them. The main data of our analysis (NFP) do not have questions on perceptions about security or the occurrence of reallocations.

2007 and 2008.[9]

While the central government adopted the RLCL in 2003, it also stated in Article 64, "The standing committees of the people's congresses of the provinces, autonomous regions and municipalities directly under the Central Government may, in accordance with this Law and in light of the actual conditions of their administrative areas, work out measures for implementation of this Law."[10] This follows many other market reforms that started after 1978 where the central government issued general guidelines on the priorities, and local governments were encouraged to implement and to experiment within the guidelines (Xu, 2011). Thus, we use subsequent province-level variation in the implementation of the property rights reform. By the end of 2014, 24 provincial governments have made official announcements about the local implementation of RLCL.[11] According to a World Bank (2002) report on land tenure in China, local authorities are the major obstacle to the implementation of central initiatives over agricultural land tenure. In a report by Li (2003), a former Chinese representative for the Rural Development Institute also suggests that local capacity and cooperation are key to the successful implementation of the RLCL. Thus, we use the dates of the provincial-level implementation of RLCL as the relevant time in which agricultural households could exercise these new land rights.

Anecdotal evidence supports the idea that farmers responded to the reform by changing their leasing behavior and substantially increasing their income. After the law was implemented in the province of Ningxia in 2015, a newspaper article describes an interview with a farmer named Xueying Wang: "he rented out all 29 mu of his land to a large-scale farm at the price of 700 RMB per year. Thus, he can get 19,600 RMB per year from the land, and at the same time, his wife is working for that farm and she can earn 24,000 RMB per year... His income doubled compared to the past [before receiving the right to contract out land]" (Ningxia Daily 2015). This case also

[9] In later data collected by some of the authors of this paper (Liu, Wang and Wang) from 1930 households across 22 provinces in 2012, only 2.5% of households had experienced a government land reallocation in the past five years.

[10] We discuss a few articles of the central RLCL with Jilin province's law in 2005 to shed some light on the scope of changes at the provincial level. Provinces can add regulations; for example, Article 14 of Jilin's law states that the county-level and town-level governments must build a database registering the land leases, and publicize information on this leasing registry. The provincial law can also remove requirements stipulated at the central level; for example, Article 27 of the central RLCL states a requirement of a two-thirds vote to adjust contract terms between villagers and the local government in the case of natural disaster, but Jilin doesn't allow for re-adjustment in this scenario at all.

[11] Appendix Table A.1 provides the timing of implementation for each province in our data.

highlights the potential changes in the distribution of land within villages following the reform.

The number of people potentially affected by changes in rural land institutions in China is enormous. According to data from the Chinese Statistics Yearbooks, 768 million people were living in rural areas in China in 2003; this is 60% of the population. Correspondingly, agriculture remains an important source of employment, representing 49% of total employment.

3 Model

We outline a simple model to provide intuition for the analysis. Consider a village economy populated by a fixed number of farmers, producing an undifferentiated agricultural commodity (crop). The price of the crop, denoted by p, is assumed given (i.e. exogenous to production and consumption decisions in the village); this is a reasonable assumption given that each village is quite small relative to the market for the crop.[12]

We assume for simplicity that production depends only on the quantity of land (this assumption will be relaxed in the empirical analysis). Suppose the production function has the following form:

$$y = \phi l^{\alpha} \tag{1}$$

where y denotes the farmer's output, l denotes the land input, and ϕ denotes the total factor productivity (TFP) of the farmer. Each farmer has a fixed level of TFP, which is assumed to be a random draw from a distribution over the interval $[\underline{\phi}, \overline{\phi}]$. There are no fixed costs of production.

The total amount of land in the village is denoted by L. The endowment of land is assumed to be independent of TFP.[13] For simplicity, we assume that all farmers in the village are endowed with the same quantity of land. Each farmer decides whether or not to engage in farming the crop, and how much of her land endowment she will utilize with the remaining land endowment supplied to the market at the going land rental rate, denoted by r. The land market is local in the sense

[12] In addition, in Table 9, we also demonstrate that cash crop prices at the province-level in China are strongly correlated with U.S. prices, suggesting that farmers respond to global prices in these crops.

[13] This assumption is consistent with the findings of Adamopoulos et al (2017) and is also approximately borne out in our data. This assumption can be relaxed; our results can be explained by simply assuming that the distribution of land endowments is such that high TFP farmers are not cultivating more land than optimal in the pre-reform period.

that all land transactions are assumed to occur within the village. The rental rate r is therefore determined by supply and demand within the village.

To model the effects of land reform, we introduce land market frictions. Assume that farms that want to rent in land have to pay a transaction cost, which is modeled as a proportional tax, denoted by $t \in [0, 1]$, such that the effective rental price is $r(1 + t)$.[14],[15] The farmer is assumed to maximize net income (i.e. profit plus rental income).[16]

Appendix A derives the equilibrium in the economy. Figure 1 graphs the associated relationship between (own-cultivated) area and farmer TFP. The figure also shows two polar cases: When there are no frictions to trading land (and $t = 0$), own-cultivated land area is strictly increasing in TFP, but when $t = \infty$ each farmer is constrained to farm his own land endowment. The equilibrium in the intermediate case (with $0 < t < \infty$) lies in between the two polar cases.[17] The figure indicates that a reduction in the transaction cost will result in a reallocation of land from low-TFP farmers to high-TFP farmers. This simple prediction can be taken to the data to test for productivity-improving reallocations following the reform.[18]

The essential insight of the misallocation literature is that frictions in factor markets (such as the land transaction cost in our model) can reduce aggregate productivity by skewing the allocation of productive inputs away from the most productive individuals. Removing these frictions will therefore increase aggregate productivity even if no individual firm or producer becomes more

[14] In the model presented here, the transaction cost is assumed to be paid by the renter rather than the owner, but the tax can be shifted with no difference to the final outcome.

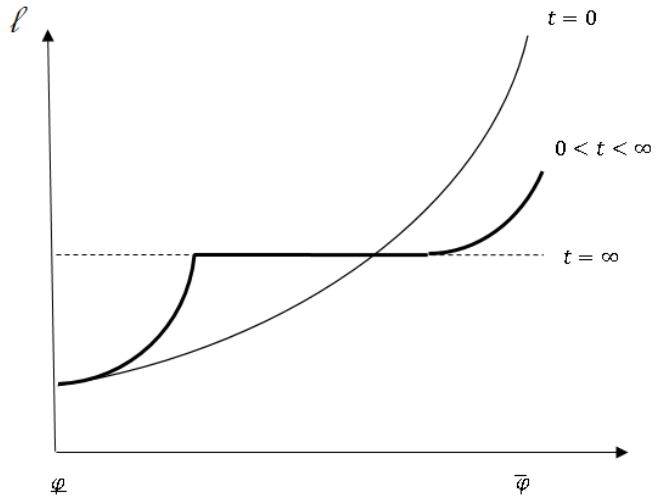
[15] The assumption of a proportional tax can also be motivated as follows: Consider a farmer who rents out an acre of land at the price r, to be paid at the end of the farming season. In the absence of secure leasing rights, there is some probability, say π, that she will not get repaid and will be unable to enforce her claim in the court system because leasing rights are not legally protected. Alternatively, if the main mechanism of the reform is a reduction in the fear of government reallocation, π can be thought of as the increased probability of expropriation associated with renting out land. This is similar to the idea that agricultural households fallow their land for shorter durations because of the concern that fallow land is more likely to be allocated to another household (Goldstein and Udry 2008). The farmer's expected rental income is then proportional to the rental price, and is given by $r(1 - \pi)$.

[16] We assume that household consumption and production decision are separable, so that each household acts as a profit-maximizing farm. Because land is not directly consumed by the household, this assumption is valid, but will fail if there are also imperfections in other markets (see Singh, Squire and Strauss 1986).

[17] The intuition for the intermediate case is that low-TFP farmers will rent out part of their endowment to high-TFP farmers who will consequently farm more than their endowment, while there will exist a middle range of TFP in which farmers will neither rent in nor rent out land.

[18] In theory, if pre-reform land endowments had been too highly skewed toward high-TFP farmers, it might even be the case that the reform would reallocate land towards low-TFP farmers. As we have noted earlier, however, this does not appear to be the case in the data.

Figure 1: The relationship between own-cultivated area and TFP for three different values of the transaction cost



productive (in a TFP sense). To formalize this point in the context of our model, Appendix A shows that land shares can be cast in the following general form:

$$s_i = \frac{\tau_i \theta_i}{\sum \tau_i \theta_i} \tag{2}$$

where $s_i = l_i/L$ denotes farmer i's share of village land and $\theta_i = \phi_i^{\frac{1}{1-\alpha}}$. Finally, $\tau_i = (r/MP_i)^{\frac{1}{1-\alpha}}$ can be interpreted as a wedge between the rental price r and farmer i's marginal product of land (MP_i).[19] Note that when the transaction cost is removed ($\tau_i = 1$), the marginal products are equalized, so that land shares are simply proportional to θ_i. This formulation mirrors that of Hsieh and Klenow (2009), in which producers are assumed to face idiosyncratic taxes on factor usage that result in a dispersion in marginal products. To see how these wedges affect aggregate productivity, consider the aggregate output of the economy:

$$\begin{aligned} Y &= \sum_i y_i = \sum_i \phi_i l_i^\alpha = (\sum_i \phi_i s_i^\alpha) L^\alpha \\ &\equiv \Phi L^\alpha \end{aligned} \tag{3}$$

[19] An analogous expression can be derived in the case of multiple inputs into production.

where $\Phi = \sum_i \phi_i s_i^{\alpha}$ can be interpreted as aggregate TFP. This formulation shows that aggregate productivity Φ depends not only on the individual TFPs, but also on how land is allocated vis-a-vis TFP, and as equation (2) above shows, this allocation is in turn influenced by the factor price wedges. It can now be verified that Φ increases when the transaction cost is removed, confirming the intuitive expectation that land reform will increase aggregate productivity, and hence aggregate output, even in the absence of any changes in individual TFPs (see Appendix A).

4 Data

The analysis combines agricultural outcomes and inputs from a household-level panel data set with a dataset that we assembled on the timing of provinces' implementation of the RLCL.

4.1 National Fixed Point Survey

Our primary data source is the National Fixed Point Survey (NFP), a panel survey collected by the Research Center of Rural Economy (RCRE) of the Chinese Ministry of Agriculture, beginning in 1986. We use annual waves of data between 2003 to 2010 for data comparability as the questions and the structure of the survey changed substantially in 2003. For the period of 2003-2010, our dataset covers more than 19,000 households in 399 villages from 32 provinces. NFP villages were selected for representativeness based on region, income, cropping pattern, population, and non-farm activities. The NFP data contain detailed information on household agricultural production, employment, and income.

Benjamin, Brandt and Giles (2005) demonstrate that the data are of high quality and provide a detailed overview of the data. The key advantages of the data for our analysis are the panel structure and the detailed information on agricultural inputs and outputs at the household-crop-year level. However, unlike some other data sets of agricultural production, we do not have any information broken down at the plot level and there are no measures of land quality. Finally, we do not observe the specific terms of land rental contracts.[20]

Summary statistics for the main outcome variables are presented in Table 1. The structure of

[20] In other words, we do not see the length of the contract or the payment terms.

the household survey is that some questions are asked at the household level regarding the past year, while questions on agricultural input and output are asked at the household-crop level. Panel A provides summary statistics on variables available in the NFP at the household-year level. The average household in the data cultivates 12.4 mu of land (or about 2 acres). The survey asks about new renting transactions over agricultural land in the past year.[21] About 14% of households engage in new land renting transactions, which includes either renting in or renting out land.[22] For the last years of the data, 2009 and 2010, we also have information about the amount of land rented out to individuals and to firms. In these years, the amount of land rented out to individuals is much greater (0.33 mu) than to firms (0.03 mu). Total household income (from all sources) is on average 29,000 RMB.[23]

We have a few measures of labor supply decisions of household members. Unlike most of the other variables that are asked at the household level, these labor supply questions are asked for each member of the household, where out of the 365 days of the year, they are asked the number of days that they worked off-farm (not in agriculture) in the same township, as a migrant worker and on-farm (in agriculture). We aggregate the individual-level measures for each household and year. Over half of the households in the sample had at least one individual engage in migration and 42% of households engaged in off-farm labor in the past year.

In order to examine the aggregate effects of the reform, we aggregate some measures from the household-level to the village-level. Panel B presents aggregate agricultural revenue and aggregate agricultural revenue divided by land. At the village level, the average revenue per year in the sample is 427041 RMB and 727 RMB per mu.

In the questions on agricultural production, the survey asks households to report all inputs and output at the household-crop level.[24] In addition to having information on output in terms of revenue, we also have the physical amount of output (as measured in kilograms). As shown in Panel

[21] Thus, if a household is renting in land but the contract began two years ago, this flow variable would not pick it up.

[22] Land leasing is not spatially concentrated; the NFP data indicate that 81% of village-year observations have some new household leasing activity in the sample period.

[23] This is approximately 3600 USD. We convert income and cost variables into real 2002 RMB using a province-level consumer price index from the Regional Economy Database.

[24] These refer to production on land that the household cultivates. If they rent out their land, the inputs and outputs on land they rent out and do not cultivate are not included.

C, on average, a household utilizes 4.7 mu of land per crop. This measure includes both their own land as well as land that they have rented in. They spend 86 RMB per crop per year on machine costs. Labor inputs, which includes household labor and hired labor, averages at 68 days per crop. Given the Cobb-Douglas estimation approach, we combine other agricultural inputs which individually contain many zero values. This includes chemical and organic fertilizer, pesticides, irrigation, small tools, agricultural covers, animals and other costs.

4.2 Data on the Timing of the Reform Implementation

We collected information on the local province-level implementation of the RLCL that was passed at the national level in 2003 from several different sources. The main source is PkuLaw, a database that provides comprehensive coverage of local laws and regulations in China. We use the following keywords to search in the database: "Tudi Chengbao (land contracting)", "Tudi Liuzhuan (land subcontracting)". For completeness, we also search several other law databases, including Xihu Law Library (www.law-lib.com), Beijing Zhongtian Nuoshida Technology Company Law Database (www.law-star.com) and Zhengbao Online Education Company's database (www.chinalawedu.com). After this initial search, we read through all of the legal documents found. For consistency across provinces, we discarded the ones that are issued by governments below the provincial-level since we focus on province-level variation. Next, we dropped documents that are issued by departments rather than by the provincial government directly (e.g. some documents are issued by lower-level provincial departments such as Jiangsu Department of Agriculture that discuss the implementation of the policy). Finally, we further filter out documents that are not about the implementation of the RLCL.[25] These multiple stages of filtering leave us with the final set of legal documents that allow us to codify the timing of local implementation of the 2003 RLCL for each province, summarized in Appendix Table A.1.

In Appendix Table A.2, we use province-level data from the Chinese Statistical Yearbooks to examine the question of why some provinces implemented the reform at different times than others. We estimate an equation where the sample is limited to the periods including the reform year and

[25] In other words, the keywords appear in the title or the main body, but the document is not about implementation of the RLCL.

the years prior, and the dependent variable is an indicator for the reform year. In particular, we examine whether variation in urban and rural income and in employment in different sectors predicts the timing of the reform. The results suggest that increases in urban income is strongly correlated with the province implementing the reform; a 10% increase in urban income corresponds with an 8.2% increase in the probability of reform and this estimate is significant at the 1% level.[26] However, with the inclusion of the year and province fixed effects, the relationship is no longer significant or even positive. Given that we are looking at the impact of the reform on agricultural outcomes, it is reassuring that rural income and agricultural employment are not significantly correlated with the timing. These results provide some reassurance against the idea that agricultural outcomes are directly driving the decision of the provincial government regarding the reform.

4.3 Crop Price Data

We collected provincial-level agricultural price indices from China Rural Statistics Yearbooks for the period 2003 to 2010 where the indices are set to 100 for the year 2002. Appendix Figure A.3 presents the average price indices across all provinces for each. Panel A shows the price indices (averaged across provinces) for each of the five staple crops and Panel B shows the corresponding price indices for each of the four cash crops for which we have price data.[27] The figures indicate strong trends in prices over time.[28] They also show there is more variation in the prices of cash crop than staple crops. This is likely because cash crop prices are driven by global market forces while the Chinese government may intervene to control the prices of staple crops.

[26]One possibility is that provincial leaders were hoping that the implementation of the reform would facilitate rural-to-urban mobility. While our results in Appendix Table 6 suggest this reform did not increase migration out of the rural areas, it may still be the case that the timing decisions were driven by this motive.

[27]There is no price index for hemp, and we do not assign a single price to categories in the NFP data that refer to several crops such as the "other staple crops" category.

[28]In the regressions, we will address this by controlling for linear crop-province-specific trends.

5 Estimating the Impact of the Property Rights Reform

5.1 Effects on Household-level Rental Activity

We begin by examining whether the implementation of the property rights law affected land renting activity. For this household level outcome, we estimate the following equation for each household h in province p and in year t:

$$y_{hpt} = \alpha + \beta_0 PostReform_{pt} + \beta_1 ReformYear_{pt} + \gamma_p t + \gamma_t + \gamma_h + \epsilon_{hpt} \quad (4)$$

where $PostReform$ is an indicator variable for the years following the implementation of the reform (not including the reform year itself) and $ReformYear$ equals one in the year that the reform was implemented in province p.[29] In addition to fixed effects for household and for calendar year, we allow for province time trends (denoted by $\gamma_p t$). The standard errors are clustered at the province level. This strategy exploits the panel nature of the data and examines the same households before and after the leasing reform, using the staggering of the implementation of the reform across provinces.

In Table 2, the outcome is an indicator for any land renting. The first column includes the full sample while the second column limits the sample to villages for which we have data both before and after the implementation of the reform.[30] We see a 1.4 to 1.5 percentage point increase in the probability of engaging in land rentals in villages after the implementation of the reform. Relative to the average rate of land renting, this is a 10% increase. This estimate is significant at the 5% level in the full sample and at the 10% level when the sample is restricted to villages for which we have data on both sides of implementation, respectively. This suggests that the property rights reform allowed households to adjust their land-holdings through renting.

To look at pre-reform and post-reform trends, we can also estimate a specification that uses the

[29] As shown in Appendix Table A.2, many of the reforms were implemented in October or November of the calendar year. Given that the reform tended to be implemented late in the year, we separate the effects of the reform year from the years after the implementation.

[30] We may not see households both before and after the reform for a variety of reasons mainly due to the exclusion of observations from provinces that reformed in 2003 and provinces that had not yet reformed by the end of the sample period. To a lesser extent, the drop in the both sides sample size is also driven by villages or households being added to the survey sample after the reform in their province, and villages or households attriting from the survey.

leads and lags around the implementation:

$$y_{hpt} = \alpha + \sum_{k=-2}^{3} \beta_k Reform_{pt,k} + \gamma_t + \gamma_p t + \gamma_h + \epsilon_{hpt} \tag{5}$$

where $Reform_{pt,k}$ is an indicator variable that indicates the period relative to the reform implementation in the province. Thus, $Reform_{pt,-2}$ refers to two years prior to the year of implementation and $Reform_{pt,2}$ refers to two years after implementation. The omitted category is $k = -1$. The sample here is restricted to the six waves around the implementation year in each province. Equation 5 takes advantage of the panel nature of the data to allow us to test the identification assumption that the timing of the implementation of the reform in each province is exogenous to our outcomes of interest.

Figure 2 displays the estimates corresponding to Equation 5.[31] We observe a shift in both the magnitude and significance of the coefficients after the implementation of the reform. Furthermore, there are no significant trends in these outcomes prior to the implementation. This provides support for the identification assumption that the timing of the implementation of the reform is not driven by changes in land rental activities in the province.

The estimated impact of the reform on the amount of leasing may be underestimated in the main variable used so far, which is an indicator for whether the household engaged in *new* leasing contracts. Thus, that measure may miss changes in the intensive margin of land leasing. We exploit the fact that the survey includes a question on the amount of land rented out to individuals in the 2009 and 2010 waves. Given that there are only two waves, these regressions exploit provinces that implement their reforms in 2009 or 2010. Table 3 shows that the reform led to a 7% increase in the amount of land rented to individuals, and this estimate is significant at the 1% level.[32]

[31] The corresponding table is in Appendix Table A.3.

[32] The dependent variable is transformed using the inverse hyperbolic sine (IHS) function. The IHS function is similar to a logarithmic transformation but is well defined for values of zero. Thus, we use it for continuous outcomes whose distribution includes preponderance of zeros and a long right tail. We use the logarithmic transformation for continuous variables without any zeros.

5.2 Estimation Concerns

A common concern with difference-in-difference estimates is that there are other changes happening at the same time that are driving the results. For this concern to be valid, the roll out of the other change across provinces would need to follow the implementation of the RLCL. The other important law change for rural households around this period is the reduction and elimination of the agricultural tax.[33] All the provinces in our sample began reducing this tax in 2004. Any aggregate change before versus after 2004 would be removed with the year fixed effects in our regressions. As an additional robustness check, we included the tax rate which declines at different rates across provinces starting in 2004 in the regressions and as shown in Appendix Table A.4, this inclusion has little effect on the magnitude and significance of the coefficients on the implementation of the RLCL.

Given that we are interested the reallocation of land within villages, there is a possible concern with an estimation strategy that uses a representative sample of households in the village rather than a village-level land census. We might be concerned that land rental transactions are occurring but that land is being transferred to agricultural firms that are not surveyed in the household-based survey. A similar concern is that land is being transferred to a very small number of households, and our sample covering 399 villages includes very few of the households that are amassing land. Both of these concerns would lead to underestimates in the effects of the property rights reform on our outcomes of interest.

We do two things to evaluate whether downward bias driven by the random sample is likely to be substantial. First, we examine the impact of leasing to agricultural firms by using the survey question on the amount of land rented out to firms in the 2009 and 2010 waves. Column 2 of Table 3 show a small (1.85%) negative effect on the amount of land rented to firms. Second, we examine whether the total village-level area of land reported under use by households in the sample declines. Appendix Table A.5 shows there is no significant change in the area of land under use in the survey sample. Both results provide reassurance that the downward bias in our estimates due to household sampling is unlikely to be substantial.

[33] See Wang and Shen (2014) for more background on the agricultural tax.

5.3 Effect on Aggregate Productivity and Output

We now examine the predictions of the model on the effect of the reform on aggregate agricultural output and productivity.[34] Aggregate output is defined as village-level aggregate revenue; in this section, we refer to village-level aggregate revenue per mu as aggregate productivity (this can be interpreted as aggregate yield). We estimate the following equation, where the unit of observation is village v in province p and year t:

$$y_{vpt} = \alpha + \beta_0 PostReform_{pt} + \beta_1 ReformYear_{pt} + \gamma_t + \gamma_p t + \gamma_v + \epsilon_{vpt} \tag{6}$$

and where the standard errors continue to be clustered at the province level. Table 4 presents the estimates where real village-level revenue and revenue per unit of land are in logarithms. The point estimate in column 1 indicates that land reform has increased aggregate output by approximately 7 percent (significant at the 5% level). Unsurprisingly, this is also mirrored in the aggregate productivity of land (column 2). These are significant gains, albeit more modest than the potential gains hypothesized in the previous literature (see for example, Restuccia and Santaeulalia-Llopis 2017).[35]

5.4 Constructing Total Factor Productivity and Marginal Product Measures

To test the model's predictions in terms of land reallocation, we first construct measures of total factor productivity (TFP) and the marginal product of land (MPL) using the detailed survey information on crop-specific inputs and output. We assume a Cobb-Douglas crop-specific production function that can be written in logs as follows:

$$y_{icvt} = \alpha_c \log L_{icvt} + \beta_c \log N_{icvt} + \gamma_c \log K_{icvt} + \delta_c \log M_{icvt} + \phi_{icvt} \tag{7}$$

where y_{icvt} denotes log (physical) output of farmer i growing crop c in village v in year t; L_{icvt}, N_{icvt}, K_{icvt} and M_{icvt} denote the area, labor days, machinery cost and all other input costs, respec-

[34] See Appendix Table A.6 for the impact of the reform on household-level income (rather than village-level revenue).

[35] However, Gollin and Udry (2017) argue that a significant proportion of the hypothesized gains stem from measurement errors and unobserved heterogeneity in land quality.

tively.[36] The logarithm of total factor productivity (TFP) is given by ϕ_{icvt}. Consistent estimation of the parameters of the production function depends on what we assume about unobserved TFP, because this is likely to be correlated with input decisions (Marschak and Andrews 1944). We assume that TFP can be decomposed into (i) a fixed farmer-crop component that captures the farmer's fixed ability to farm a given crop, (ii) a farmer-year component that captures time-varying shocks to productivity that are common to all crops grown by the farmer, (iii) a time-varying component that is common to all farmers in the village that are growing crop c (for example, weather shocks or pest infestations), and (iv) an idiosyncratic shock that is specific to the farmer and the crop in a given year:

$$\phi_{icvt} = \phi_{ic} + \phi_{it} + \phi_{cvt} + e_{icvt}. \tag{8}$$

Because farmers grow multiple crops in any given year, we can estimate the regression specification (Equation 7) jointly for all crops (i.e. we are estimating a single regression in which the coefficients on inputs are allowed to be crop-specific), while absorbing ϕ_{ic}, ϕ_{it} and ϕ_{cvt} by farmer-crop, farmer-year and village-crop-year fixed effects. The farmer-crop effect ϕ_{ic} absorbs all time-invariant productive characteristics such as farmer education and gender, in addition to capturing the farmer's crop-specific productive ability; the farmer-year effect ϕ_{it} absorbs changes in household composition, health shocks, rainfall shocks, etc; the village-crop-year component additionally absorbs shocks such as pest infestations which may be crop- and location-specific. Additionally, assuming that the idiosyncratic component of TFP, e_{icvt}, is unobserved by the farmer at the time that input decisions are made, the inclusion of these fixed effects addresses omitted variable bias arising from the dependence of input choices on the farmer-observed component of TFP.[37]

Appendix Table A.8 presents the estimated (crop-specific) production function coefficients.[38] On average across all crops (i.e. if we restrict elasticities to be equal across crops), the elasticity of output with respect to land is 0.47, which is slightly larger than estimates for China obtained

[36] Appendix Table A.7 shows that input intensity does not change significantly following the reform. This result isn't necessary for consistent estimates of the production function, but it is interesting to note that the reform doesn't lead to an increase in mechanization.

[37] Note that the inclusion of farmer-year and village-crop-year fixed effects also absorbs any changes in the village-level average TFP arising from the land reform, thus allowing us to consistently estimate the production function while using data on the entire sample period.

[38] See Appendix Figure A.4 for the distribution of TFP calculated from these production function estimates.

from aggregate data that range from 0.35 to 0.38 (Chow 1993, Cao and Birchenall 2013), although it should be noted that our estimates of elasticities exhibit substantial variation between crops.

In Appendix Table A.9, we assess the importance of selection due to entry and exit, by estimating the production function using a balanced sample of farmer-crop combinations that span the period 2003 to 2010. The production function coefficients are largely similar to those obtained before, indicating that selection driven by unobserved productivity shocks is not a serious problem.

In Appendix Table A.10, we examine the sensitivity of the estimates to a more stringent estimation strategy, in which, in addition to the inclusion of the fixed effects described above, the inputs are also instrumented by their lagged values (Arellano and Bover 1995). This specification further allows input choices to be correlated with the unobserved e_{icvt}. The coefficient estimates are generally similar to those obtained under the simpler specification, but are less precisely estimated and occasionally negative. More importantly for our purposes, the estimated TFP residuals are highly correlated with the estimated TFPs obtained from the simpler fixed effects specification, with the correlation coefficient being 0.993. In the analysis that follows, we therefore work with the TFP estimates derived from the simple fixed effects specification.

5.5 Evidence for Land Reallocation

The model presented in Section 3 leads us to expect that the reform should result in a reallocation of land towards high-TFP farmers. Figure 3 examines this hypothesis descriptively by graphing total farm area against farm TFP, 2 years prior to and 2 years after reform, where farm TFP is calculated by averaging TFP over the crops grown by the farmer.[39] In the pre-reform period, farm area correlates weakly with TFP, suggesting that the pre-reform regime may have been characterized by an inefficient allocation of land. After the reform, as predicted, high-TFP farmers (those in the top decile of the TFP distribution) cultivate more land following the reform with low-TFP farmers cultivating less land.[40]

We now establish this result more rigorously by testing for within-village land reallocations,

[39] To average TFP across crops, we use revenue TFP rather than physical TFP, where the former is obtained by multiplying physical TFP by the farmer-crop-specific price.

[40] The curves cross at approximately the 90th percentile of the TFP distribution.

using the following estimating equation:

$$l_{icvt} = \alpha + \sum_{j=1}^{5} \beta_j \phi_{ict}^j + \sum_{j=1}^{5} \delta_j (PostReform_{pt} \times \phi_{ict}^j) + \sum_{j=1}^{5} \theta_j (ReformYear_{pt} \times \phi_{ict}^j) + \eta_v + \eta_t + \epsilon_{ivct} \quad (9)$$

where ϕ_{ic}^j is an indicator for whether the TFP of farmer i growing crop c in year t is in quintile j of the TFP distribution of village v.[41] The dependent variable, l_{icvt}, is the logarithm of crop area. The regressions include village fixed effects and year fixed effects. As before, standard errors are clustered at the province level. In this regression, the δ coefficients capture the heterogeneous effects of the reform on crop area with respect to TFP.

Panel A of Figure 4 graphs the estimated δ coefficients, along with the associated 95% confidence intervals. The corresponding regression results are reported in Column 1 of Appendix Table A.11. The reform significantly reduces cultivated area, by approximately 13%, for those in the bottom two TFP quintiles. These reductions are matched by an increase in crop area in the top of the TFP distribution, with the majority of the increase occurring in the top quintile. These results accord well with the descriptive evidence of land reallocation presented in Figure 3.

A potential concern with the interpretation of these results is that measured TFP has a time-varying component which could be endogenous to the reform. Thus, the results reported earlier may be an artefact of compositional changes among the TFP quintiles, instead of reflecting an actual reallocation of land.[42] To rule out such compositional effects, we estimate the specification in equation 9, but this time using only the time-invariant component of TFP, ϕ_{ic}, to construct the TFP quintiles, as this component of TFP should not be affected by the reform. The results

[41] In the Chinese context, it is reasonable to assume that land is not traded across village boundaries, so that the village is the natural level at which the land market is defined. The quintiles are calculated with respect to the village TFP distribution aggregated across all years.

[42] For instance, if the reform increased the TFP of some farmers so as to move them from the fourth to the fifth quintile, and if these farmers had large amounts of land to begin with, this might increase the average crop area associated with farmers in the top quintile, even if no actual reallocation were to accompany the increase in TFP. Changes in measured TFP may also be triggered by increased land transactions: If the land transactions that occur after the reform systematically transfer either high or low quality plots from low to high TFP farmers, such transfers would have the effect of changing measured TFP (since land quality is unobserved to the econometrician and therefore enters into measured TFP).

are reported in column 2 of Appendix Table A.11 and presented in Panel B of Figure 4. The estimated effects retain similar magnitudes as before, suggesting that our results are not an artefact of compositional effects.

In addition to the total land cultivated, we examine whether the reform had heterogeneous effects by TFP on leasing behavior. Because the outcome variables, the amount of land rented out to individuals and firms, are asked at the household level, we return to household-level regressions. Furthermore, the key regressors are the interactions of the quintiles of the fixed component of TFP (ϕ_i), aggregated up from the household-crop level to the household level, with the standard reform indicators. Consistent with expectations on the gradient of the relationship, the results in column 1 of Table 5 show that households with low TFP are more likely to rent their land out to individuals after the reform than households with high TFP.[43] The difference between the interaction between the post reform year with the lowest quintile and the top quintile is statistically significant at the 5% level.[44] Overall, the results confirm the idea that the reform allowed land to move from low-TFP farmers to high-TFP farmers.

5.6 Land Reallocation Using Alternative Measures to TFP

Given that the identification of TFP requires a number of assumptions, we examine whether the results are robust to two alternative measures of productivity: Agricultural profits (per mu) and the marginal product of land, both measured at pre-reform levels.

First, we consider whether after the reform, the distribution of land moves towards farmers who had higher pre-reform agricultural profits per mu. While we have rich information on agricultural revenue and the cost of inputs at the household-crop level, a key obstacle to this approach is valuing labor that a household provides on their own land. We take a simple but standard approach by constructing village-level wage rates using information on the cost and number of days of hired labor.[45] Agricultural profits are then calculated by valuing family labor inputs at the market wage

[43]While high TFP farmers are ultimately cultivating more land (as shown in Figure 4), they also increase the amount of land that they are renting out. This is consistent with the idea that they are renting in more land than they rent out (and may be adjusting other characteristics of the land that they are cultivating).

[44]The interaction between post reform year with the lowest quintile and the second and fourth quintiles are statistically significant at the 10% and the 5% levels, respectively.

[45]This ignores the possibility of agency costs in hired labor that are not present in family labor (Eswaran and

rate. However, in nearly one-third of villages in our sample, zero households in the sample hire any labor in the pre-reform years. Thus, we lose a substantial share of the sample in this approach.

We estimate the equation 9 where we replace ϕ_{ic}^{j} with an indicator for whether the average pre-reform agricultural profits of farmer i growing crop c is in quintile j of the distribution in village v. The coefficients of δ_j and the corresponding 95% confidence intervals are presented in Figure 5.[46] There is a gradient in the magnitude of the coefficients across the quintiles suggesting that farmer-crop units with lower pre-reform agricultural profits cultivated less land after the reform while those in the higher quintiles gained land. However, it is important to note that none of the coefficient estimates are significant at the standard levels.

In our second alternative measure, we test whether land is reallocated along the gradient of marginal productivity (essentially, we would expect that land should be reallocated to those who are most productive at the margin). We calculate the revenue marginal product of land (averaged over pre-reform years) for each farmer-crop, and then categorize the latter into quintiles based on the within-village distribution of marginal products.[47] We then estimate equation 9 where ϕ_{ic}^{j} is now an indicator for whether the pre-reform marginal product of land of farmer i growing crop c is in quintile j of the distribution in village v.

The coefficient estimates of δ_j and 95% confidence intervals are graphed in Figure 6.[48] Farmers in the highest quintile of pre-reform marginal product of land gain the most land (12%) after the reform and this estimate is significant at the 90% level. Farmers in the lowest quintile cultivate 12% less land after the reform and this estimate is significant at the 5% level.

While the construction of the measures of pre-reform agricultural profitability and the pre-reform marginal product of land require different assumptions than the TFP measures, the main conclusions remain similar. Overall, we conclude that there is robust evidence of land being reallocated towards more productive farmers.

Kotwal 1986, Feder 1985).

[46] The corresponding regression table is in Column 1 of Appendix Table A.12.

[47] Under the Cobb-Douglas production function assumption, the marginal product of land equals the average product of land (i.e. output per unit of land) multiplied by the (crop-specific) elasticity of output with respect to land.

[48] Column 2 of Appendix Table A.12 presents the corresponding estimates.

5.7 Labor Effects

We now consider the effects of the reform on labor market outcomes. To start with, because labor is a complementary input to land, we would expect that the reallocation of land from low-TFP farmers to high-TFP farmers would reduce the labor demand of the former and increase the labor demand of the latter. This is indeed the case, as we show in Table 6, where we examine heterogeneity in the response to the reform by TFP quintiles with the dependent variables being the IHS function of hired labor days (column 1) and hired labor costs (column 2). The results show that farmers with the highest TFP within a village hire in 22% more days of labor after the reform and spend 48% more on hired labor after the reform. Farmers in the second highest TFP quintile use 9% more hired labor after the reform, spending 21% more on hired labor. All four coefficients are significant at the 1% level. In contrast, those in the bottom two quintiles of TFP hire significantly less labor after the reform. The anecdotal evidence presented in Section 2 suggests the increased demand for labor among high-TFP farmers may be met by in increases in wage labor supplied by low-TFP farmers.[49]

It is also interesting to examine whether there is an increase in local off-farm (i.e. non-agricultural) and migrant labor supply on the part of the low-TFP farmers. Table 6 presents estimates that examine heterogeneity by TFP quintiles with the dependent variables being the IHS function of off farm labor days (column 3) and the IHS function of migrant labor days in column 4.[50] There are no significant changes in the probability of migration or off-farm labor activities by TFP after the reform. The lack of evidence of any increases in migration following the property rights reform may be explained at least in part by the institutional barriers to migration in China.[51]

5.8 Decomposing the Productivity Gains from the Reform

The previous evidence suggests that land reallocation may be an important source of aggregate productivity gains following the reform. We now attempt to quantify the contribution of the

[49] There are no survey questions on labor supplied for agricultural wage work so we cannot test this directly.

[50] Note that unlike hiring labor inputs which are reported at the household-crop level, these are household-level regressions because migration is measured at the household level.

[51] See Kinnan, Wang and Wang (forthcoming) for an overview of the household registration (*hukou*) system in China.

reallocation channel to the observed increase in aggregate productivity. To do so, we consider the following decomposition of aggregate productivity suggested by Olley and Pakes (1996):

$$I_{vt} = \sum w_{ict}\phi_{ict} = E(\phi_{ict}|v,t) + \sum (w_{ict} - E(w_{ict}|v,t))(\phi_{ict} - E(\phi_{ict}|v,t)) \tag{10}$$

where the index I_{vt} denotes village-level aggregate TFP at time t, and is defined as the output-share weighted average of log TFPs, with w_{ict} denoting the real output-share of the i-th farmer-crop.[52] The aggregate index is decomposed into two components: A component that measures the productivity of the average farmer-crop, $E(\phi_{ict}|v,t)$, and a covariance term that measures the extent to which size (measured here by output) is correlated with TFP.[53] As Bartelsman, Haltiwanger and Scarpetta (2013) show, the Olley-Pakes covariance term is a reliable measure of the efficiency of resource allocation that varies systematically with changes in the economic regime. Our expectation is that land reform should result in an increase in the Olley-Pakes covariance, as land gets reallocated from low- to high-productivity farmers.

We can now estimate reform effects on the separate terms of the decomposition to understand the source of aggregate productivity growth. Table 7 reports the regression results. The point estimates indicate an aggregate TFP increase of approximately 9.3% (significant at the 1% level), which is consistent in magnitude with the observed increase in total output. There is a significant increase in the covariance term, which accounts for approximately 84% of the increase in aggregate TFP. The remaining increase in aggregate TFP is attributed to an increase in average productivity, although this effect is not statistically distinguishable from zero.[54] These results strongly suggest that the effects of land reform on aggregate productivity arise from input reallocations, in line with the predictions from the theoretical framework outlined in Section 3. To shed more light on the

[52] In order to aggregate TFP across crops, we convert physical TFPs by multiplying by the crop-specific price.

[53] The "covariance" term in this decomposition is really N times the covariance between output shares and TFP, where N is the number of household-crops. That is, the decomposition can be seen to be a simple rewriting of the expression for the covariance between output shares and TFP.

[54] This shift can also be seen in Appendix Figure A.4.

reallocational flows, we apply a decomposition of covariance term:

$$\begin{aligned} cov^{OP} &\equiv \sum (w_{ict} - E(w_{ict}|v,t))(\phi_{ict} - E(\phi_{ict}|v,t)) \\ &= N * cov(w_{ict}, \phi_{ict}) \\ &= N * E[cov(w_{ict}, \phi_{ict}|c)] + N * cov[E(w_{ict}|c), E(\phi_{ict}|c)] \end{aligned} \tag{11}$$

where, to avoid notational clutter, we have now suppressed the conditioning on v and t. The number of household-crops is denoted by N. The equation above shows that the Olley-Pakes covariance term can be decomposed into within-crop and across-crop components.[55]

Table 8 reports the results from regressing these components on the reform indicators. The average values of the covariance components are reported at the bottom of the table. Column 1 reiterates the results for the full covariance term from the prior table, and columns 2 and 3 display results for the within-crop and across-crop components, respectively. The point estimates suggest that across-crop reallocation is almost twice as important as within-crop reallocation.[56] This may not be surprising given that in our sample, across-crop covariance is on average much smaller than within-crop covariance (shown in the bottom row), signaling a distortion in the (aggregate) mix of crops. It appears therefore that an important source of productivity gain from the reform arises from a correction of this distortion.

6 Responses to Price Changes

Land reform may not only correct the allocation of land in a static sense, but may also increase the responsiveness of land allocation to productivity shocks. In this section, we consider relative price changes (across different crops) as a particular type of shock. The idea that the land reform may have increased farmers' ability to respond to such shocks is also suggested by our finding that there is more across-crop reallocation following the reform. We examine this hypothesis by examining

[55] This decomposition is sometimes referred to as the law of total covariance.

[56] This result stands in contrast with findings from the firm literature, where within-industry reallocation tends to dominate (e.g. Davis and Haltiwanger 1999, Foster, Haltiwanger and Krizan 2001), but the present setting differs not only in that we are studying the agricultural sector which may exhibit fundamentally different patterns of reallocation from the manufacturing sector, but also in that we are arguably studying a transition between steady states.

the effect of crop price changes on the allocation of land across crops before and after the reform.

Specifically, we estimate the following equation for a crop c in household h, village v, province p and year t:

$$Y_{hcvpt} = \alpha + \beta_0 Price_{cp,t-1} * PostReform_{pt} + \beta_1 Price_{cp,t-1} * ReformYear_{pt} + \beta_2 PostReform_{pt} + \beta_3 ReformYear_{pt} + \beta_4 Price_{cp,t-1} + \beta_5 OtherPrice_{cp,t-1} * PostReform_{pt} + \beta_6 OtherPrice_{cp,t-1} * ReformYear_{pt} + \beta_7 OtherPrice_{cp,t-1} + \nu_{cp} t + \gamma_t + \gamma_{vc} + \epsilon_{hcvpt} \quad (12)$$

The lagged province-level crop price index is given by $Price_{cp,t-1}$. This variable is a provincial level crop-specific price index where each crop price in 2002 is set as 1. We use a one-year lag for multiple reasons. Agricultural decisions are often months in advance of harvest in which case the relevant price on which farmers can make planting decisions is from the prior year. This also sidesteps the issue that contemporaneous prices may reflect endogenous agricultural production decisions. We also include an aggregate index of prices in all of the other crops (excluding crop c), $OtherPrice_{c,t-1}$, and its interactions with the timing of the reform. The regressions also include year fixed effects, province-crop time trends and household fixed effects. All of the regressions are clustered at the province level. The outcomes here are those that are measured at the household-crop-year level by the survey.

We also estimate the equation with the leads and lags around the implementation of the reform:

$$Y_{vcpt} = \alpha + \sum_{k=-2}^{3} (\beta_k Price_{cp,t-1} * Reform_{pt,k} + \eta_k Reform_{pt,k}) + \delta_1 Price_{cp,t-1} + \sum_{k=-2}^{3} (\theta_k OtherPrice_{cp,t-1} * Reform_{pt,k} + \mu_k OtherPrice_{cp,t-1}) + \delta_2 Price_{cp,t-1} + \nu_{cp} t + \gamma_t + \gamma_h + \epsilon_{hcpt} \quad (13)$$

where $Reform_{p,t+k}$ is an indicator variable that indicates the period relative to the reform implementation in the province. In these regressions, the sample is restricted to the six waves around the implementation of the reform. The reference year is the one prior to the reform implementation ($t = -1$).

A key concern with these regressions is whether local agricultural prices are exogenous to the reform. To address this, we present all of our crop-level estimates for both the full sample and the cash crop only sample. The all crop sample offers the advantage of presenting a full picture of the agricultural portfolio and decision-making of agricultural households. However, there may be some concerns about staple crops in this analysis. First, if the Chinese government sometimes intervenes in these markets, agricultural production decisions in these crops may be less likely to be driven by market dynamics and market prices (Deng 2009). Second, we may have some concerns that the timing of the reform at the provincial level responds to local economic conditions, which are largely defined by output in staple crops. Third, we may be concerned about the reverse, that crop prices are driven by the reform. Given that we are exploiting variation in prices of nine different crops that are not that highly correlated with each other, it seems unlikely that the results are driven by the endogeneity of prices to the reform.

However, we address this concern by demonstrating that cash crop prices are likely to be exogenous to the timing of the reform by estimating the relationship between crop prices in Chinese provinces and in the United States. In Table 9, the dependent variable in column 1 is the price of the four cash crops in Chinese provinces for which we have price data (oilseed, sugar, cotton, and tobacco). The dependent variable in column 2 is the price of the five staple crops. The results in column 1 indicate that price movements for cash crops in China move closely with changes in U.S. prices, suggesting that much of the variation in these prices is driven by global markets rather than by agricultural investment decisions of households in China. In contrast, the Chinese prices for staple crops do not move that closely with U.S. prices. Thus, we look at the estimates of Equations 12 and 13 for a sub-sample of only cash crops, which are more plausibly exogenous, in addition to the full sample of all crops.

The all crops sample includes both staple crops, which are corn, potato, rice, soybean and wheat, and cash crops.[57] For cash crops, we focus on four available in the data, cotton, sugar, oilseed, and tobacco. We exclude fruits and vegetables products, which are also cash crops, from the analysis because the NFP data lumps production questions on all fruits into one single category

[57] We follow the Chinese Ministry of Agriculture's definition of what constitutes a staple crop versus a cash crop.

and all vegetables together so we are unable to match these broad categories to a single agricultural price. We also do not have price data for hemp, so we exclude this from the crop-level analysis.[58]

6.1 Results on Price Changes

In Table 10, we estimate equation 12 where the outcomes are different measures of land used for cultivation of cash crops. The dependent variable in columns 1 and 2 is the inverse hyperbolic sine function of the land cultivated for each crop, while it is an indicator for any land cultivated for each crop in columns 3 and 4. In both the all crops sample (column 1) and the cash crops sample (column 2), we see that the reform leads to more land under cultivation of a specific crop in areas with positive changes in prices of that crop in the years after the reform is implemented.[59] In the sample including all crops, a standard deviation increase in the price of a crop (0.45) corresponds with a 1.7 percent increase in the area in the village allocated to that crop after the reform relative to before the reform. The estimate is significant at the 5% level. In columns 3, we also see a 1.2 percent increase in the probability that any land in the village is used for production in that crop corresponding to a standard deviation change in crop price, and these estimates are significant at the 5% level. Column 2 and 4 show that the magnitude of responses to prices is similar for the sample of cash crops as for all crops and these estimates are significant at the 10% level.

In all of the specifications, the impact of price changes in the year of implementation (β_1) is positive but not significantly different than in the years prior. Furthermore, the magnitudes of the estimates are much smaller as compared with the estimates for the following years. Finally, the coefficients on lagged price are positive, indicating that there was reallocation of land towards crops experiencing price increases prior to the reform.[60] However, the interactions discussed above show that the price response increased following the protection of property rights.

In the estimates of equation 13 presented in Appendix Table A.13, we see the sign and the significance of the coefficients shift immediately following the implementation of the reform for

[58] As shown by the number of observations in Appendix Table A.8, there is much less activity in hemp relative to all the other crops.

[59] This is given by the coefficient β_0 in Equation 12.

[60] These estimates are significant at the 10% level or less for the all crop sample, and not significant at the standard levels in the cash crop sample.

both the all crops sample and the cash crops sample. These results suggest that by allowing land to be legally rented across villagers, households are better able to optimize the amount of land devoted to the production of different crops in response to price changes. Furthermore, the similarity of the estimates and significance of the coefficients between the full sample and the cash crop sample in Table 10 and Appendix Table A.13 suggest that it is unlikely that an endogenous relationship between crop prices and the timing of the reform is driving the results.

7 Conclusion

Despite a unique history and set of land institutions, agricultural production in China is typical of a number of developing countries in many important aspects. The median farm is small (approximately 1.3 acres), and is largely operated using household labor. Therefore, this is an instructive setting in which to study the effects of easing land market frictions.

Our paper emphasizes the importance of property rights institutions for the efficient allocation of land across farmers and of labor across sectors and space. By exploiting provincial-level variation in the implementation of a central reform in China that formalized leasing rights, we are able to evaluate the impact of the rural land reform. We find that the reform increases leasing transactions and led to increases in agricultural output of over 7%. We argue that these gains can be attributed to a better allocation of land resources. While this is in line with theoretical predictions, empirical evidence has been scant. For example, Besley (1995) finds that rental and sale rights have no significant effect on agricultural investments in Ghana.

While our estimates of the effect of the reform on output and aggregate productivity are economically significant, they are considerably more modest than those implied by other studies. Adamopoulos, Brandt, Leight and Restuccia's (2017) study of misallocation in Chinese agriculture suggests that moving to an efficient allocation of land and capital would increase village-level productivity by 50%, while Restuccia and Santaeulalia-Llopis' (2017) study of misallocation in Malawi implies potential efficiency gains of more than 300%. One potential explanation for this discrepancy is that the RLCL has not succeeded in entirely removing all frictions in the land market in China, so that substantial gains remain yet to be realized. At the same time, it is also possible

that the diagnostic measures of misallocation used in the literature tend to overstate the extent of misallocation, at least when they are applied to the agricultural sector, a point that is emphasized by Gollin and Udry (2017).[61]

In many developing countries, much emphasis continues to be placed on land structures with communal ownership or on policies that aim for equality in the distribution of land across farmers rather than on allowing free exchange in land markets. Indeed, households still do not have the right to sell property in China.[62] Our research demonstrates that households cannot fully solve the contracting problem in informal ways and that legal protections for exchange rights are important for the efficient allocation of resources, including land and labor. An important related question, that we leave for future research, is the potential trade-off between efficiency and equity accompanying such changes in institutions.

[61] See also Bils, Klenow and Ruane (2017) and Rotemberg and White (2017) who show, in the context of manufacturing data, that measurement error and data inconsistencies tend to inflate the importance of misallocation.

[62] Similarly, the law does not allow for leasing or sales rights over grazing land in Mongolia.

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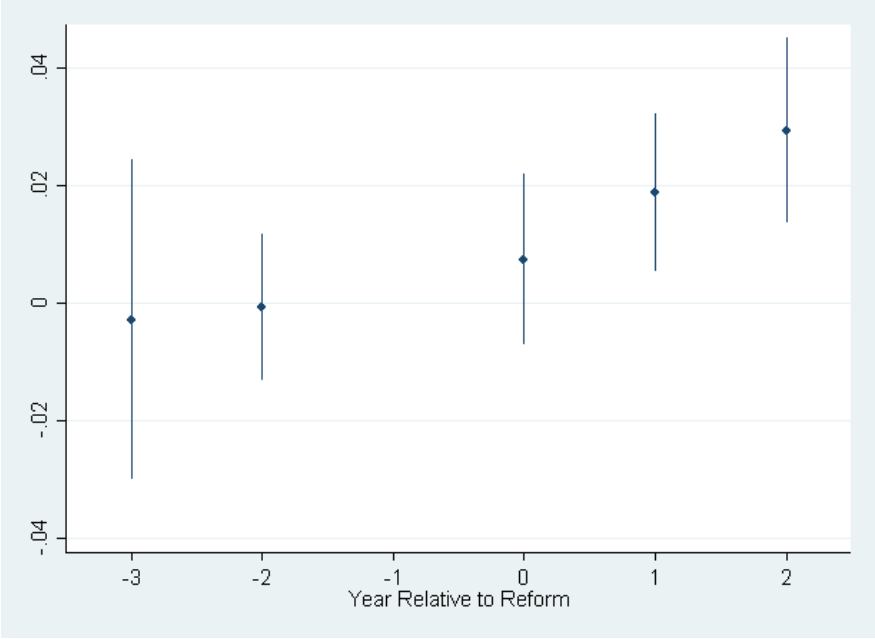
Figure 2: Coefficients of Impact of Reform Implementation on Land Renting

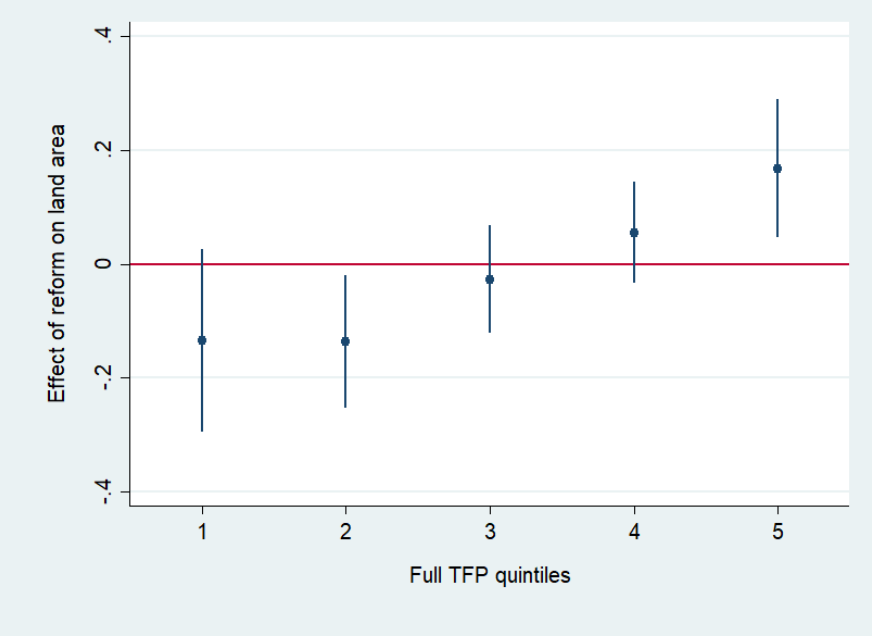


Notes: The dots give the coefficients from the regression specified in equation 5. The lines around the dots give the 95% confidence interval. The omitted category is the year prior to the reform ($t = -1$).

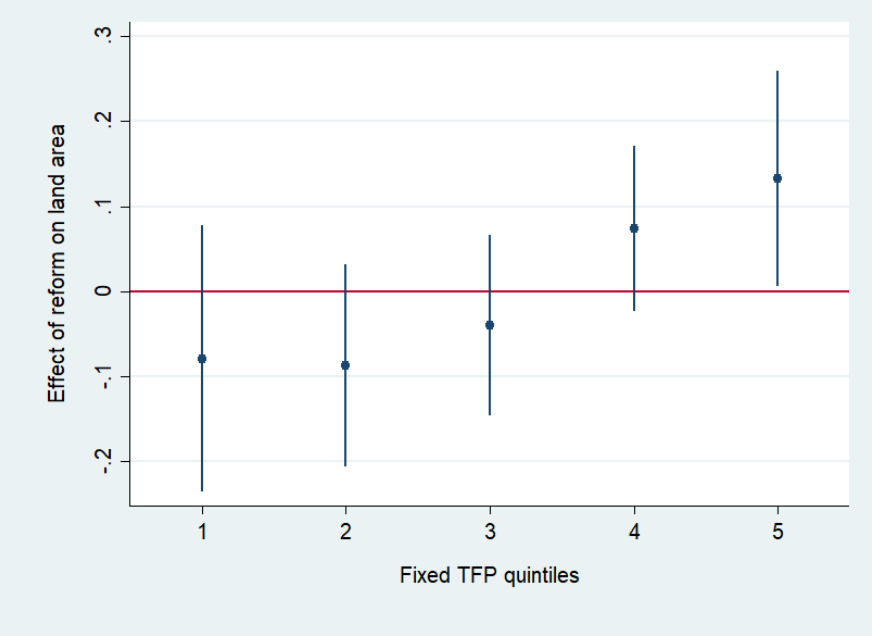
Figure 3: Distribution of Area by TFP Before and After the Reform

Figure 4: Coefficients on TFP Quintiles × Post Reform

(a) Full TFP

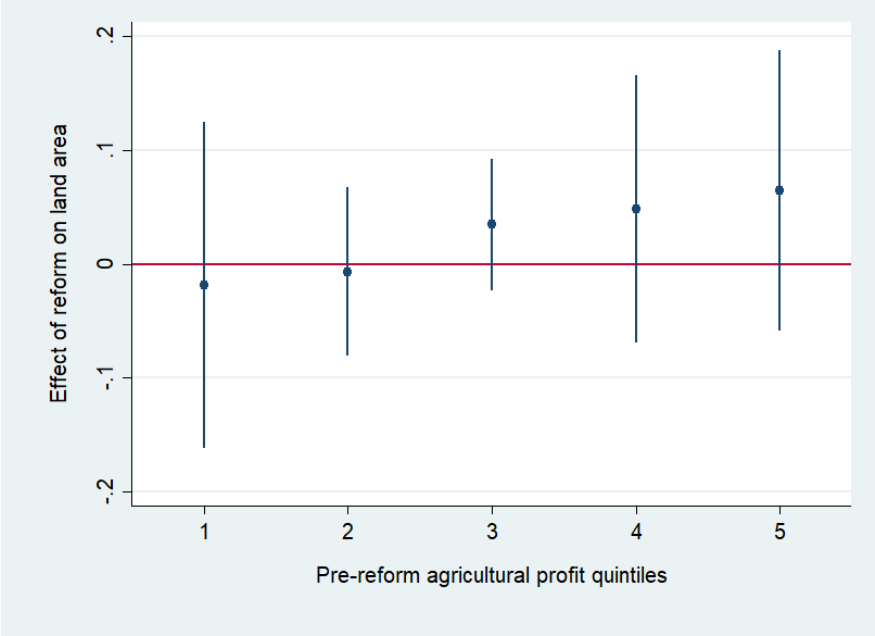


(b) Fixed TFP



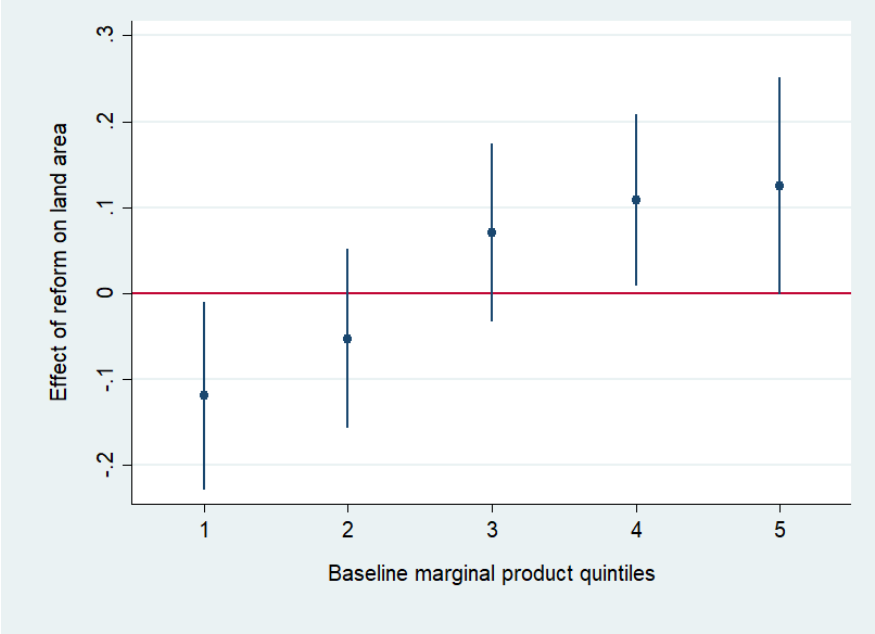
Notes: The dots give the coefficients from the regression specified in equation 9. The lines around the dots give the 95% confidence interval.

Figure 5: Coefficients on Agricultural Profit Quintiles × Post Reform



Notes: The dots give the coefficients from the regression specified in equation 9. The lines around the dots give the 95% confidence interval.

Figure 6: Coefficients on MPL Quintiles × Post Reform



Notes: The dots give the coefficients from the regression specified in equation 9. The lines around the dots give the 95% confidence interval.

Table 1: Summary Statistics

	Mean	Std Dev	Observations
Panel A: Variables by Household-Year			
Area (mu)	12.37	330.5	157315
Any New Land Renting	0.142	0.349	157315
Rental Transactions to Individuals (mu)	0.329	2.433	41577
Rental Transactions to Firms (mu)	0.0280	0.347	41577
Total Income	28821.2	82331.1	156395
Any Migration	0.552	0.497	156441
Number of Migrant Work Days	233.7	295.5	156441
Any Off Farm Work	0.420	0.493	156441
Number of Off Farm Work Days	126.3	225.9	156441
Panel B: Variables by Village-Year			
Aggregate Revenue	427041.4	407526.1	2235
Aggregate Revenue per mu	727.3	596.9	2235
Panel C: Variables by Household-Crop-Year			
Output	6242.9	1558191.8	412603
Area (mu)	4.717	203.9	412603
Machine Inputs (RMB)	85.74	529.1	412603
Labor Inputs (days)	68.10	4790.3	412603
Other Inputs (RMB)	672.0	74541.3	412603

Notes: Income and expenditures are in real 2002 renminbi. Renting transaction is referring to changes in renting out area (mu) in a given village-year. Panel B presents variables that we aggregate to the village level. Panel C presents information that is collected at the crop level.

Table 2: Impact of Property Rights Reform on Renting

	Full Sample	Both Sides
	(1)	(2)
Post Reform Year	0.0151**	0.0144*
	(0.00715)	(0.00813)
Reform Year	0.00657	0.00195
	(0.00561)	(0.00480)
Observations	157315	100588

Notes: Each observation is a household-year. The dependent variable is an indicator for any land renting. The regressions include indicators for calendar year, household fixed effects, province time trends and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 3: Impact of Property Rights Reform on Rentals to Individuals and Firms

	New Rentals to Individuals	New Rentals to Firms
	(1)	(2)
Post Reform Year	0.0680***	-0.0108
	(0.0186)	(0.00657)
Reform Year	0.0392***	-0.00831**
	(0.00929)	(0.00328)
Observations	41577	41577

Notes: Each observation is a household-year. The dependent variable is the IHS function of land rented out (in mu) to an individual in column 1 and to a firm in column 2. The sample includes only the 2009 and 2010 waves. The regressions include an indicator for calendar year, household fixed effects and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 4: Impact of Property Rights Reform on Aggregate Revenue

	Aggregate Revenue	Aggregate Revenue per Mu
	(1)	(2)
Post Reform Year	0.0723**	0.0698*
	(0.0350)	(0.0349)
Reform Year	0.00724	0.0543*
	(0.0336)	(0.0302)
Observations	2233	2233

Notes: The dependent variables are in logarithms. The unit of observation is a village-year. All regressions include village fixed effects, year fixed effects, province time trends and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 5: Impact of Property Rights Reform on Rentals to Individuals and Firms by TFP

	New Rentals to Individuals	New Rentals to Firms
	(1)	(2)
Post Reform Year × Fixed TFP Quintile 1	0.161***	-0.0238***
	(0.0397)	(0.00856)
Post Reform Year × Fixed TFP Quintile 2	0.0740**	-0.00915
	(0.0340)	(0.00664)
Post Reform Year × Fixed TFP Quintile 3	0.0999***	-0.00264
	(0.0273)	(0.00645)
Post Reform Year × Fixed TFP Quintile 4	0.0918***	-0.00570
	(0.0223)	(0.00851)
Post Reform Year × Fixed TFP Quintile 5	0.0764***	-0.00473
	(0.0211)	(0.00693)
Observations	41577	41577

Notes: Each observation is a household-year. The dependent variable is the IHS function of land rented out (in mu) to an individual in column 1 and to a firm in column 2. The sample includes only the 2009 and 2010 waves. The regressions include an indicator for calendar year, household fixed effects, reform year interacted with the TFP quintiles and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 6: Impact of Property Rights Reform on Hiring Labor and Labor Supplied to Migration and Off-Farm Activities by TFP

	Hired Labor Days (1)	Hired Labor Costs (2)	Migration Labor Days (3)	Off-Farm Labor Days (4)
Post Reform Year × Quintile 1	-0.103***	-0.253***	-0.0152	-0.0722
	(0.0263)	(0.0571)	(0.0730)	(0.129)
Post Reform Year × Quintile 2	-0.0789***	-0.198***	-0.00742	-0.0968
	(0.0244)	(0.0568)	(0.0898)	(0.123)
Post Reform Year × Quintile 3	-0.0000260	0.00434	-0.103	-0.0800
	(0.0197)	(0.0470)	(0.0845)	(0.104)
Post Reform Year × Quintile 4	0.0902***	0.214***	-0.0789	-0.0239
	(0.0185)	(0.0460)	(0.0671)	(0.129)
Post Reform Year × Quintile 5	0.216***	0.476***	-0.0293	0.0908
	(0.0249)	(0.0630)	(0.103)	(0.163)
Observations	251190	251190	156441	156441
Mean Dep. Var.	0.178	0.390	3.585	2.494

Notes: In columns 1 and 2, each observation is a household-crop-year. In columns 3 and 4, each observation is a household-year. The dependent variable is the IHS function of the number of days of hired labor in column 1, the IHS of the expenditures on hired labor in column 2, the IHS of household days spent working in migration in column 3 and the IHS of the household days spent working in local off-farm activities in column 4. The quintiles refer to the fixed TFP quintiles. The regressions include indicators for calendar year, household fixed effects, reform year interacted with the fixed TFP quintiles and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 7: Decomposition of the Impact of Property Rights Reform on TFP

	Aggregate TFP (1)	Covariance (2)	Average TFP (3)
Post Reform Year	0.0934***	0.0776***	0.0157
	(0.0242)	(0.0254)	(0.0216)
Reform Year	0.0389*	0.0287	0.0102
	(0.0225)	(0.0205)	(0.0195)
Observations	2233	2233	2233
Mean Dep. Var.	0.644	0.160	0.484

Notes: The unit of observation is a village-year. All regressions include village fixed effects, year fixed effects, province time trends and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 8: Decomposition of the Covariance Term into Within Crop and Across Crop Components

	Overall	Within Crop	Across Crop
	(1)	(2)	(3)
Post Reform Year	0.0776***	0.0275*	0.0501*
	(0.0254)	(0.0158)	(0.0250)
Reform Year	0.0287	0.00724	0.0215
	(0.0205)	(0.00984)	(0.0185)
Observations	2233	2233	2233
Mean Dep. Var.	0.160	0.131	0.0290

Notes: The dependent variables are measures of the covariance between output and TFP. The unit of observation is a village-year. All regressions include village fixed effects, year fixed effects, province time trends and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table 9: Relationship between Chinese Provincial and U.S. Crop Prices

	Cash Crops	Staple Crops
	(1)	(2)
U.S. Price	0.504***	-0.00324
	(0.0579)	(0.0180)
Observations	592	749

Notes: Each observation is a province-crop-year. The dependent variable is the crop price in a Chinese province. The regressions include crop fixed effects and time trends, province fixed effects and time trends, indicators for calendar year and a constant term. Standard errors clustered at the province level are in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

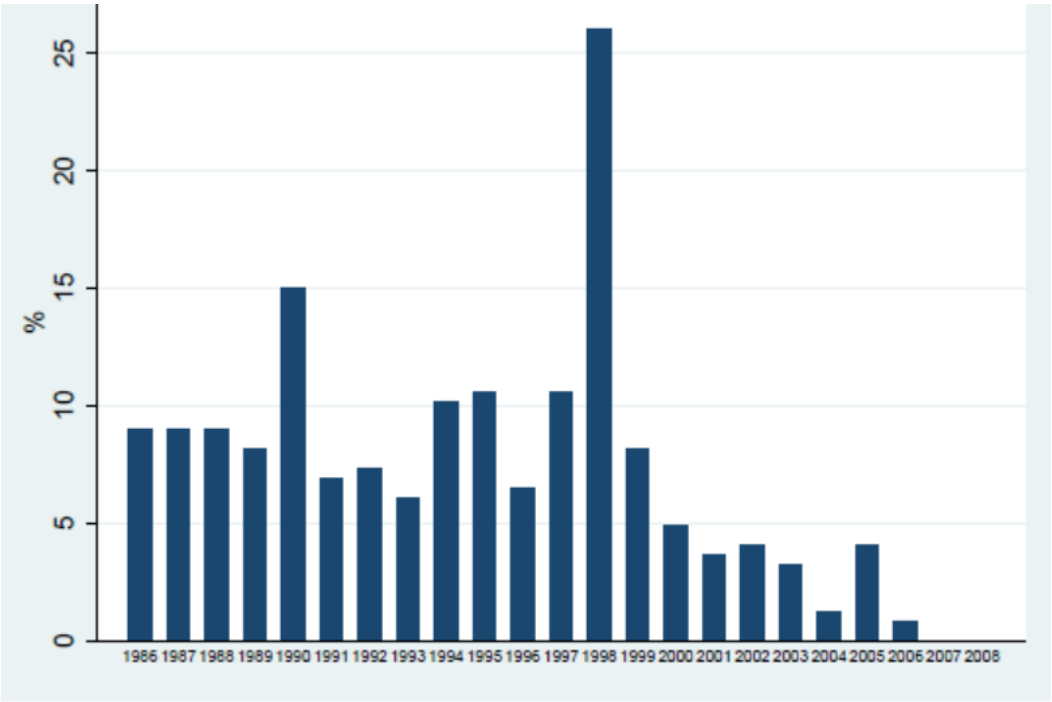
Table 10: Impact of Prices and Property Rights Reform on Land Allocation

	IHS Area		I(Any Area)	
	All Crops	Cash Crops	All Crops	Cash Crops
	(1)	(2)	(3)	(4)
Lagged Price X Post Reform	0.0386**	0.0392*	0.0275**	0.0263*
	(0.0160)	(0.0222)	(0.0105)	(0.0138)
Lagged Price X Reform Year	0.0128	0.0121	0.00984	0.00848
	(0.00935)	(0.0110)	(0.00623)	(0.00737)
Lagged Price	0.0357*	0.0292	0.0186**	0.0174
	(0.0193)	(0.0257)	(0.00700)	(0.0105)
Post Reform	0.0311	0.0138	-0.00971	0.000767
	(0.0299)	(0.0434)	(0.0225)	(0.0241)
Reform Year	0.0231	-0.0410	-0.00238	-0.0120
	(0.0302)	(0.0277)	(0.0210)	(0.0200)
Observations	741498	299443	741498	299443

Notes: Each observation is a household-crop-year. The regressions include indicators for reform time and for calendar year, province-crop time trends, village-crop fixed effects and a constant term. Standard errors clustered at the province level are in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

8 Appendix for Online Publication

Figure A.1: Major Government Land Reallocations over Time



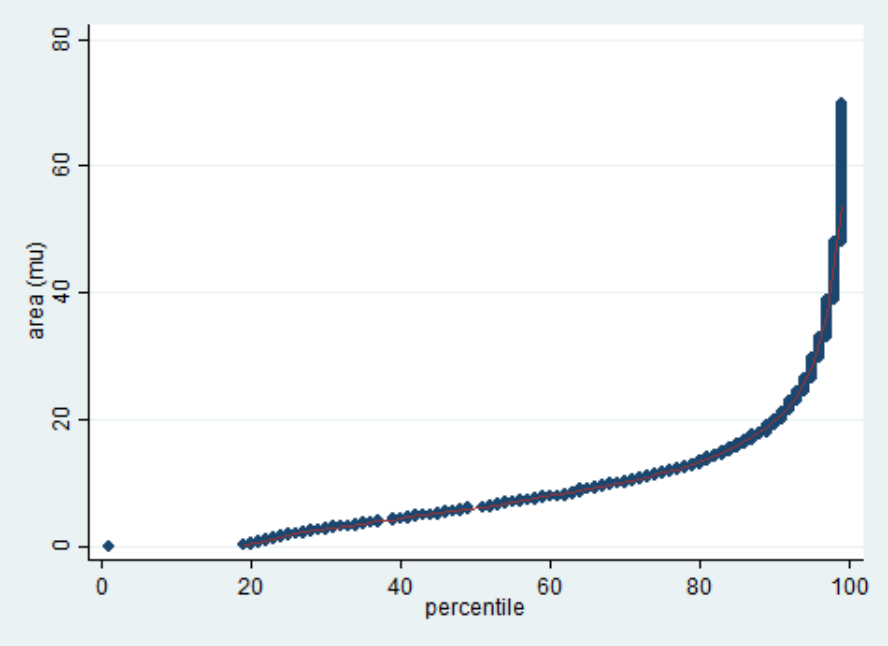
Note: Reprinted from Figure 1 of Zhao (2013).

Table A.1: Rural Land Contracting Law Announcement by Province

Province	Year	Document Name	Issue Date	Effective D
Shanghai	2003	Hu Fu Fa (2003) No. 29	04/25/2003	04/25/2003
Hunan	2004	Hunan Province People's Congress Standing Committee (2004) No. 35	07/30/2004	10/01/2004
Shandong	2004	Shandong Province People's Congress Standing Committee (2004) No. 37	07/30/2004	10/01/2004
Anhui	2005	Anhui Province People's Congress Standing Committee (2005) No. 57	06/17/2005	10/01/2005
Fujian	2005	Fujian Province People's Congress Standing Committee (Min Chang (2005) No. 18)	09/30/2005	11/01/2005
Jiangsu	2004	Jiangsu Province Government Order (2003) No. 21	12/18/2003	02/01/2004
Jilin	2005	Jilin Province People's Congress Standing Committee (2005) No. 29	01/20/2005	03/01/2005
Liaoning	2005	Liaoning Province People's Congress Standing Committee (2005) No. 28	01/28/2005	04/01/2005
Shanxi	2005	Shanxi Province People's Congress Standing Committee (2004) No. 117	09/25/2004	01/01/2005
Tianjin	2005	Jin Zheng Fa (2005) No. 009	02/05/2005	02/05/2005
Xinjiang	2005	Xinjiang People's Congress Standing Committee (2005) No.24	07/29/2005	10/01/2005
Gansu	2006	Gansu Province People's Congress Standing Committee (Ganzheng Ban Fa (2006) No. 92)	08/03/2006	08/03/2006
Guangxi	2006	Gui Zheng Ban Fa (2006) No. 141	11/14/2006	11/14/2006
Hainan	2006	Hainan Province People's Congress Standing Committee (2006) No.44	07/28/2006	10/01/2006
Sichuan	2008	Sichuan Province People's Congress Standing Committee (2007) No.110	11/29/2007	03/01/2008
Yunnan	2006	Yunnan Province People's Congress Standing Committee (2006) No. 41	07/28/2006	09/01/2006
Chongqing	2007	Chongqing Municipality People's Congress Standing Committee (2007) No. 6	04/02/2007	07/01/2007
Jiangxi	2007	Jiangxi Province People's Congress Standing Committee (2007 No. 102	07/27/2007	10/01/2007
Shaanxi	2007	Shaanxi Province People's Congress Standing Committee (2006) No. 59	09/28/2006	01/01/2007
Zhejiang	2007	Zhejiang Province People's Congress Standing Committee (2006) No. 59	09/30/2006	01/01/2007
Inner Mongolia	2009	Inner Mongolia People's Congress Standing Committee (2009) No. 10	07/30/2009	10/01/2009
Qinghai	2010	Qinghai Province People's Congress Standing Committee (2009) No. 15	11/10/2009	03/01/2010

Notes: Provinces not listed here (Beijing, Guangdong, Guangzhou, Hebei, Heilongjiang, Henan, Hubei, Ningxia and Tibet) either made their announcements after our sample period or have not made them at the time we collected these data.

Figure A.2: Distribution of Household Land Area



Note: Kernel density function using epanechnikov.

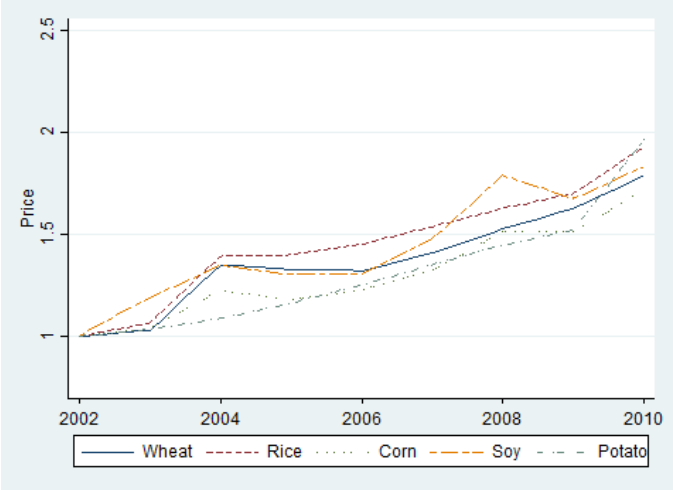
Table A.2: Determinants of Provincial Reform Timing

	(1)	(2)
Log Rural Income	-0.0227	1.125
	(0.233)	(2.565)
Log Urban Income	0.816***	-0.329
	(0.193)	(1.589)
Log Agricultural Employment	-0.0113	0.264
	(0.117)	(0.400)
Log Industrial Employment	-0.234	-0.246
	(0.186)	(0.521)
Log Service Employment	0.275	0.304
	(0.312)	(0.681)
Observations	145	145
Year and Province FE	No	Yes

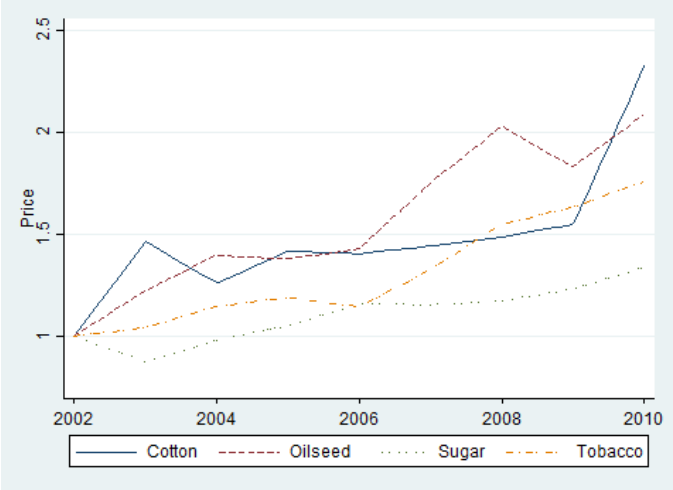
Notes: Each observation is a province-year. The dependent variable equals one in the reform year. The sample is limited to pre-reform years and the year of reform implementation. The regressions include a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Figure A.3: Average Price Indices of Crops

(a) Staple Crops

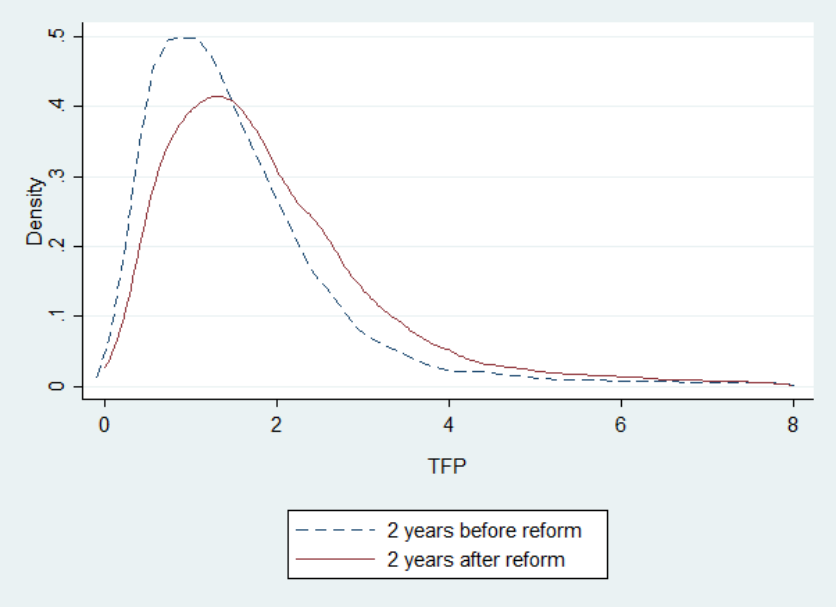


(b) Cash Crops



Note: The figure presents the average prices across provinces by year and by crop.

Figure A.4: Distribution of TFP



Note: Kernel density function using epanechnikov.

Table A.3: Impact of Property Rights Reform on Renting with Leads and Lags

	Full Sample	Both Sides
	(1)	(2)
Leasing Reform$_{t-3}$	-0.00335	-0.00287
	(0.0127)	(0.0131)
Leasing Reform$_{t-2}$	0.00103	-0.000882
	(0.00562)	(0.00597)
Leasing Reform$_{t}$	0.00817	0.00738
	(0.00684)	(0.00700)
Leasing Reform$_{t+1}$	0.0210***	0.0186***
	(0.00607)	(0.00645)
Leasing Reform$_{t+2}$	0.0293***	0.0293***
	(0.00743)	(0.00753)
Observations	73585	66148

Notes: Each observation is a household-year. The dependent variable is an indicator for any land renting. The regressions include indicators for calendar year, household fixed effects, province time trends and a constant term. The sample is restricted to the six years around the reform. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.4: Impact of Property Rights Reform on Renting Controlling for Agricultural Tax Changes

	Full Sample	Both Sides
	(1)	(2)
Post Reform Year	0.0153**	0.0150*
	(0.00709)	(0.00807)
Reform Year	0.00672	0.00213
	(0.00555)	(0.00483)
Agricultural Tax	-0.162	-0.311
	(0.232)	(0.268)
Observations	157315	100588

Notes: Each observation is a household-year. The dependent variable is an indicator for any land renting. The regressions include indicators for calendar year, household fixed effects, province time trends and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.5: Impact of Property Rights Reform on Village-Level Land Area

	Full Sample	Both Sides
	(1)	(2)
Post Reform Year	0.00504	-0.0217
	(0.0563)	(0.0446)
Reform Year	0.00599	-0.0327
	(0.0501)	(0.0392)
Observations	2572	1819

Notes: Each observation is a village-year. The outcomes are transformed by the IHS function. The regressions include indicators for calendar year, province time trends, village fixed effects and a constant term. Income is in real 2002 RMB. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.6: Impact of Property Rights Reform on Household Income

	Full Sample	Both Sides
	(1)	(2)
Post Reform Year	0.0382*	0.0396
	(0.0216)	(0.0233)
Reform Year	0.0157	0.0275*
	(0.0153)	(0.0158)
Observations	156395	100306

Notes: Each observation is a household-year. The outcomes are transformed by the IHS function. The regressions include indicators for calendar year, province time trends, household fixed effects and a constant term. Income is in real 2002 RMB. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.7: Impact of Property Rights Reform on Agricultural Inputs (per mu)

	Labor Inputs	Machine Inputs	Other Inputs
	(1)	(2)	(3)
Post Reform Year	0.0587	0.00866	0.0397
	(0.0366)	(0.0852)	(0.0654)
Reform Year	0.0119	-0.0332	0.00676
	(0.0321)	(0.0474)	(0.0422)
Observations	157315	157315	157315

Notes: Each observation is a household-year. The dependent variable is the IHS function of the input divided by area. The regressions include indicators for calendar year, province time trends, household fixed effects and a constant term. Standard errors clustered at the province level are in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.8: Production Function Estimates by Crop

	Area	Labor	Machinery	Other	Obs
Wheat	0.631***	0.122***	0.020***	0.097***	46,010
	(0.021)	(0.010)	(0.003)	(0.009)	
Rice	0.644***	0.119***	0.011***	0.086***	62,161
	(0.016)	(0.009)	(0.002)	(0.009)	
Corn	0.657***	0.148***	0.012***	0.079***	75,709
	(0.017)	(0.010)	(0.002)	(0.006)	
Soybean	0.569***	0.226***	0.014***	0.046***	31,823
	(0.013)	(0.011)	(0.004)	(0.004)	
Potato	0.520***	0.184***	0.027***	0.048***	30,804
	(0.018)	(0.011)	(0.006)	(0.006)	
Other grains	0.597***	0.198***	0.026***	0.094***	40,804
	(0.023)	(0.019)	(0.007)	(0.011)	
Cotton	0.835***	0.083***	-0.006	0.034***	10,363
	(0.024)	(0.019)	(0.005)	(0.013)	
Oilseed	0.598***	0.186***	0.012***	0.051***	40,897
	(0.014)	(0.010)	(0.003)	(0.004)	
Sugar	0.743***	0.141***	0.020**	0.128***	2,897
	(0.074)	(0.059)	(0.009)	(0.037)	
Hemp	0.578***	0.141	-0.244	-0.075*	468
	(0.118)	(0.122)	(0.153)	(0.045)	
Tobacco Leaf	0.516***	0.146***	0.022*	0.295***	1906
	(0.092)	(0.046)	(0.012)	(0.057)	
Other cash	0.254***	0.414***	-0.026	0.054**	5248
	(0.045)	(0.036)	(0.026)	(0.018)	
Vegetables	0.243***	0.281***	0.052***	0.076***	72,984
	(0.021)	(0.010)	(0.005)	(0.004)	
Other farm	0.385***	0.276***	0.042***	0.054***	11,865
	(0.023)	(0.021)	(0.012)	(0.009)	
Fruit	0.241***	0.370***	0.013**	0.135	18,259
	(0.025)	(0.018)	(0.006)	(0.009)	
Other orchard	0.368***	0.436***	0.037	0.107***	5517
	(0.068)	(0.044)	(0.072)	(0.017)	
Total	0.475***	0.239***	0.019***	0.075***	457,715
	(0.009)	(0.005)	(0.001)	(0.002)	

Notes: Each row presents the production function coefficient estimates for a particular crop. Standard errors are in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.9: Production Function Estimates by Crop (Balanced Panel)

	Area	Labor	Machinery	Other Inputs	Observations
Wheat	0.582***	0.150***	0.020***	0.068***	10,991
	(0.037)	(0.017)	(0.004)	(0.020)	
Rice	0.641***	0.118***	0.015***	0.083***	12,759
	(0.030)	(0.016)	(0.003)	(0.016)	
Corn	0.594***	0.175***	0.008**	0.084***	15,781
	(0.048)	(0.023)	(0.004)	(0.014)	
Soybean	0.581***	0.224***	0.009	0.034***	4,262
	(0.029)	(0.026)	(0.008)	(0.010)	
Potato	0.410***	0.217***	0.003	0.054***	3,759
	(0.064)	(0.032)	(0.015)	(0.017)	
Other grains	0.607***	0.178**	0.034**	0.064*	529
	(0.088)	(0.078)	(0.016)	(0.037)	
Cotton	0.922***	0.076	-0.012	-0.040	1,454
	(0.060)	(0.048)	(0.011)	(0.029)	
Oilseed	0.613***	0.147***	0.015***	0.068***	7,905
	(0.023)	(0.020)	(0.005)	(0.009)	
Sugar	0.817***	-0.071	0.024*	0.207**	405
	(0.136)	(0.098)	(0.014)	(0.098)	
Tobacco leaf	0.848***	0.010	0.031	0.161	169
	(0.233)	(0.149)	(0.024)	(0.195)	
Other cash	0.194*	0.420***	-0.028	0.050*	499
	(0.102)	(0.072)	(0.038)	(0.026)	
Vegetables	0.204***	0.292***	0.072***	0.066***	13,622
	(0.043)	(0.020)	(0.014)	(0.006)	
Other Farm	0.309***	0.059	0.071	0.031	795
	(0.067)	(0.051)	(0.056)	(0.027)	
Fruit	0.153***	0.371***	0.008	0.168***	1,743
	(0.059)	(0.044)	(0.012)	(0.025)	
Other orchard	0.233	0.383***	-0.050	0.075***	1,033
	(0.155)	(0.075)	(0.087)	(0.021)	
Total	0.417***	0.243***	0.018***	0.070***	75,706
	(0.025)	(0.013)	(0.002)	(0.005)	

Notes: Each row presents the production function coefficient estimates for a particular crop. The sample is limited to observations in which the household farms the crop in every year. Standard errors are in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.10: Production Function Estimates by Crop Instrumented with Lagged Values

	Area	Labor	Machinery	Other Inputs	Observations
Wheat	0.587***	0.113***	0.017**	0.129***	46,010
	(0.033)	(0.022)	(0.007)	(0.018)	
Rice	0.641***	0.095***	0.008	0.116***	62,161
	(0.027)	(0.021)	(0.005)	(0.018)	
Corn	0.670***	0.117***	-0.002	0.081***	75,709
	(0.022)	(0.018)	(0.005)	(0.010)	
Soybean	0.604***	0.270***	0.015	0.059***	31,823
	(0.028)	(0.027)	(0.010)	(0.011)	
Potato	0.459***	0.205***	0.014	0.039***	30,804
	(0.026)	(0.024)	(0.015)	(0.012)	
Other grains	0.536***	0.128**	0.051***	0.167***	40,804
	(0.068)	(0.055)	(0.018)	(0.034)	
Cotton	0.772***	0.001	0.016	-0.006	10,363
	(0.060)	(0.047)	(0.013)	(0.026)	
Oilseed	0.655***	0.180***	0.014*	0.055***	40,897
	(0.025)	(0.022)	(0.008)	(0.010)	
Sugar	1.034***	-0.315**	-0.009	0.611***	2,897
	(0.184)	(0.129)	(0.019)	(0.086)	
Hemp	2.726	0.845*	-0.033	-1.084	468
	(1.707)	(0.502)	(0.028)	(0.942)	
Tobacco Leaf	0.493***	0.030	0.179***	0.470*	1906
	(0.110)	(0.171)	(0.068)	(0.252)	
Other cash	-0.041	0.499***	0.009	-0.020	5248
	(0.145)	(0.082)	(0.009)	(0.036)	
Vegetables	0.192***	0.249***	0.070***	0.064***	72,984
	(0.015)	(0.017)	(0.022)	(0.008)	
Other farm	0.447***	0.253***	0.020*	0.044*	11,865
	(0.052)	(0.042)	(0.012)	(0.025)	
Fruit	0.229***	0.309***	-0.005	0.173***	18,259
	(0.063)	(0.036)	(0.046)	(0.018)	
Other orchard	0.452***	0.569***		0.005	5517
	(0.088)	(0.062)		(0.023)	
Total	0.477***	0.207***	0.012***	0.077***	185989
	(0.007)	(0.008)	(0.003)	(0.004)	

Notes: Each row presents the production function coefficient estimates for a particular crop. Each input is instrumented with its lagged value. Standard errors are in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.11: Impact of Property Rights Reform on Log Area by TFP

	Full TFP	Fixed TFP
	(1)	(2)
Post Reform Year × Full TFP Quintile 1	-0.135*	
	(0.0783)	
Post Reform Year × Full TFP Quintile 2	-0.136**	
	(0.0572)	
Post Reform Year × Full TFP Quintile 3	-0.0271	
	(0.0465)	
Post Reform Year × Full TFP Quintile 4	0.0555	
	(0.0437)	
Post Reform Year × Full TFP Quintile 5	0.168***	
	(0.0594)	
Post Reform Year × Fixed TFP Quintile 1		-0.0791
		(0.0767)
Post Reform Year × Fixed TFP Quintile 2		-0.0876
		(0.0582)
Post Reform Year × Fixed TFP Quintile 3		-0.0399
		(0.0520)
Post Reform Year × Fixed TFP Quintile 4		0.0740
		(0.0479)
Post Reform Year × Fixed TFP Quintile 5		0.133**
		(0.0621)
Observations	251406	251406

Notes: The dependent variable is log area. The unit of observation is a household-crop-year. All regressions include the TFP quintiles, a Reform Year indicator interacted with the TFP quintiles, village fixed effects, year fixed effects, and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.12: Impact of Property Rights Reform on Log Area by Alternative Measures

	MPL	Profits/Area
	(1)	(2)
Post Reform Year × MPL Quintile 1	-0.119**	
	(0.0533)	
Post Reform Year × MPL Quintile 2	-0.0525	
	(0.0512)	
Post Reform Year × MPL Quintile 3	0.0704	
	(0.0506)	
Post Reform Year × MPL Quintile 4	0.109**	
	(0.0488)	
Post Reform Year × MPL Quintile 5	0.125*	
	(0.0618)	
Post Reform Year × Profits Quintile 1		-0.0186
		(0.0690)
Post Reform Year × Profits Quintile 2		-0.00670
		(0.0358)
Post Reform Year × Profits Quintile 3		0.0345
		(0.0279)
Post Reform Year × Profits Quintile 4		0.0480
		(0.0566)
Post Reform Year × Profits Quintile 5		0.0642
		(0.0594)
Observations	235817	274174

Notes: The dependent variable is log area. The unit of observation is a household-crop-year. The quintiles in Column 1 refer to pre-reform average MPL. The quintiles in Column 2 refer to pre-reform average agricultural profits per mu. The regressions include the quintile fixed effects, a Reform Year indicator interacted with the quintiles, village fixed effects, year fixed effects, and a constant term. Standard errors clustered at province level are reported in parentheses. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

Table A.13: Impact of Price Changes and Property Rights Reform on Land Allocation with Leads and Lags

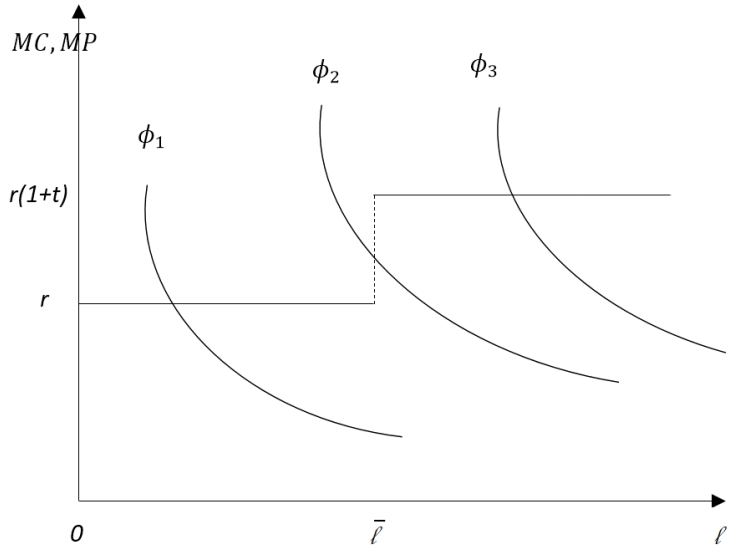
	IHS Area		I(Any Area)	
	All Crops	Cash Crops Only	All Crops	Cash Crops Only
	(1)	(2)	(3)	(4)
Lagged Price X Reform$_{t-3}$	-0.0319	-0.0555*	-0.0150	-0.0282
	(0.0223)	(0.0276)	(0.0162)	(0.0203)
Lagged Price X Reform$_{t-2}$	-0.00722	0.00138	-0.00440	-0.0121
	(0.0143)	(0.0169)	(0.00984)	(0.0116)
Lagged Price X Reform$_{t}$	0.0428***	0.0362***	0.0247***	0.0197**
	(0.00979)	(0.00951)	(0.00748)	(0.00703)
Lagged Price X Reform$_{t+1}$	0.0515***	0.0367**	0.0353***	0.0260**
	(0.0108)	(0.0145)	(0.00801)	(0.00952)
Lagged Price X Reform$_{t+2}$	0.0710***	0.0701***	0.0430***	0.0392***
	(0.0215)	(0.0179)	(0.0140)	(0.0118)
Observations	488326	195151	488326	195151

Notes: Each observation is a household-crop-year. The regressions include indicators for reform time and for calendar year, province-crop time trends, village-crop fixed effects, an index of other crop prices and its interactions with the leads and lags of the reform, and a constant term. *, **, *** denote significance at the 10%, 5% and 1% levels, respectively.

A Extended Model

We first describe the equilibrium in the intermediate case ($0 < t < \infty$) of the village economy. It is intuitive that the size of each farm (i.e. cultivated land area) will depend on the farmer's TFP. Figure A.5 graphs the marginal cost and marginal product of land, for low-, medium- and high-TFP farmers, denoted by ϕ_1, ϕ_2 and ϕ_3 respectively. The kink in the marginal cost occurs when farmers need more land than their own endowment (and thus need to rent in land from others).

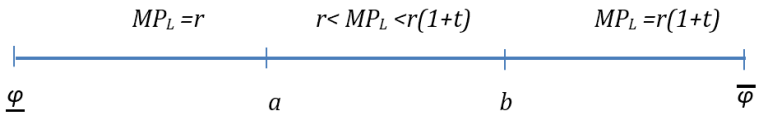
Figure A.5: Marginal Cost and Product of Land for Farmers with Varying TFP



As the figure implies, an equilibrium will feature three categories of farmers, based on their level of TFP, as depicted in Figure A.6: More specifically, we have farmers in category A for whom $\phi \in (\underline{\phi}, a)$. These farmers will supply some of their land to the market and use the rest in their own farm (but will not rent in any land). These farmers are not land-constrained: Their optimal farm size is small enough that they can meet its land needs with their endowment. Thus, these farms are using only household land up to the point that its marginal product (denoted by MP_L in the figure above) equals its opportunity cost, r.

Category B farmers are defined by $\phi \in (a, b)$, those with TFP above the level a would ideally like to operate larger farms that utilize more land than they are endowed with. Once the land

Figure A.6: Thresholds Defining Three Types



endowment has been exhausted, however, the opportunity cost of land increases discontinuously because of the transaction cost. Because of this jump, some farmers will not find it profitable to rent in land. For these farms, the marginal product is greater than r, but is less than $r(1+t)$, implying that they would have rented in land in the absence of a transaction cost.

Finally, in category C, we have the farmers who are productive enough that they find it worthwhile to rent in land in spite of the transaction cost. Their TFP lies in the interval $(b, \overline{\phi})$. Farmers in this category rent in land until its marginal product equals its marginal cost $r(1+t)$.

We now derive aggregate (village-level) TFP. Recall that aggregate output is given by:

$$Y = \sum_i y_i = \sum_i \phi_i s_i^{\alpha} L^{\alpha} = \Phi L^{\alpha} \tag{14}$$

where L denotes the total quantity of land in the village (which is assumed fixed), and s_i denotes the land share cultivated by farmer i, i.e. l_i/L. Equilibrium land shares can be derived from the first-order conditions for profit maximization:

$$\alpha \phi_i l_i^{\alpha-1} = r_i \tag{15}$$

where r_i denotes the equilibrium marginal value of land for farmer i. For farmers who are at a corner solution, r_i is defined to equal the marginal product of land. The first-order condition can be rewritten to solve for l_i:

$$l_i = (\frac{\alpha}{r})^{\frac{1}{1-\alpha}} \tau_i \theta_i \tag{16}$$

where τ_i is defined as $(\frac{r}{r_i})^{\frac{1}{1-\alpha}}$ and we have defined $\theta_i = \phi_i^{\frac{1}{1-\alpha}}$. Adding over all farmers in the village, we have:

$$L = (\frac{\alpha}{r})^{\frac{1}{1-\alpha}} \sum_i \tau_i \theta_i \tag{17}$$

Farmer i's land share is therefore given by:

$$s_i = \frac{\tau_i \theta_i}{\sum_i \tau_i \theta_i} \tag{18}$$

Thus, aggregate TFP simplifies to:

$$\Phi = \sum_i \frac{\tau_i^\alpha \theta_i}{(\sum_i \tau_i \theta_i)^\alpha} \tag{19}$$

Finally, note that because $\tau_i \leq 1$ for all i and $\alpha < 1$, it follows that

$$\Phi = \sum_i \frac{\tau_i^\alpha \theta_i}{(\sum_i \tau_i \theta_i)^\alpha} \leq \sum_i \frac{\tau_i \theta_i}{(\sum_i \tau_i^\alpha \theta_i)^\alpha} = [\sum_i \tau_i \theta_i]^{1-\alpha} \tag{20}$$

$$\leq [\sum_i \theta_i]^{1-\alpha} = \Phi(t=0) \tag{21}$$

which confirms the intuitive expectation that land reform will increase aggregate productivity, and hence aggregate output.