NBER WORKING PAPER SERIES

MISALLOCATION IN INDIAN AGRICULTURE

Marijn A. Bolhuis
Swapnika R. Rachapalli
Diego Restuccia

Working Paper 29363
http://www.nber.org/papers/w29363

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 2021

We thank Murat Celik, Joseph Cummins, Doug Gollin, Steven Helfand, Serdar Ozkan, Xiaodong Zhu, and seminar participants at the University of Toronto, Oxford, UC Riverside, and Bristol for useful comments and suggestions. All errors are our own. Bolhuis acknowledges the support from the Ontario Trillium Foundation and thanks the Department of Economics and the Centre for the Study of African Economies at the University of Oxford for their hospitality while writing this paper. Restuccia acknowledges the support from the Canada Research Chairs program and the Bank of Canada Fellowship program. The views expressed herein are those of the authors only and do not necessarily represent the views of the Bank of Canada and the IMF, its Executive Board, IMF management, or the National Bureau of Economic Research.

Misallocation in Indian Agriculture
Marijn A. Bolhuis, Swapnika R. Rachapalli, and Diego Restuccia
NBER Working Paper No. 29363
October 2021
JEL No. O11,O13,O4

ABSTRACT

We exploit substantial variation in land-market institutions across Indian states and detailed micro household-level panel data to assess the effect of distortions in land rental markets on agricultural productivity. We provide empirical evidence that states with more rental-market activity feature less misallocation and reallocate land more efficiently over time. We develop a model of heterogeneous farms and land rentals to estimate land-market distortions in each state. Land rentals have substantial positive effects on agricultural productivity: an efficient reallocation of land increases agricultural productivity by 38 percent on average and by more than 50 percent in states with highly distorted rental markets. Both farm and state-level land market distortions are quantitatively important, with state-level wedges accounting for a significant fraction of rental market participation differences across states. Land market distortions contribute about one-third to the large differences in agricultural total factor productivity across Indian states.

Marijn A. Bolhuis
International Monetary Fund
mbolhuis@imf.org

Swapnika R. Rachapalli
Princeton University
sr1356@princeton.edu

Diego Restuccia
Department of Economics
University of Toronto
150 St. George Street
Toronto, ON M5S 3G7
CANADA
and NBER
diego.restuccia@utoronto.ca

1 Introduction

Low productivity in agriculture is a key contributor to the large income differences between rich and poor countries (Gollin et al., 2002; Restuccia et al., 2008). While the evidence suggests that poor countries are characterized by lower allocative efficiency across productive units that dampen aggregate productivity, the sources of this inefficiency are less well understood. In this paper, we explore one potential source of low agricultural productivity, the misallocation of factors of production associated with land market institutions, and study differences across states in India. By focusing on differences in institutions within a country, we address a challenge in cross-country studies where land institutions may be related with other factors that affect agricultural productivity. We address this issue by considering the substantial variation in land institutions across states in India that have their origins in the nature and timing of the colonial conquest across regions. We emphasize variation in land institutions to study how implicit land market distortions affect households' participation in land rental markets and the efficiency of land allocations across farm operations.

India provides a unique setting to study land markets and agricultural productivity for three reasons. First, agricultural labor productivity in India remains very low despite strong advances in other countries. For instance, in 2010 the real value added per worker in Indian agriculture was only 5 percent of that in the United States, whereas in non-agriculture this ratio was 32 percent. Similarly, the share of employment in agriculture in India remains very high—58 percent in 2010—indicative of a low agricultural productivity level.[1] Second, Indian states exhibit substantial variation in both land institutions and agricultural outcomes. The variation in GDP per worker in agriculture across states in 2011-12 is a factor of 13.5-fold and the share of employment varies between 5 and 75 percent. These are enormous variations across states that resemble the patterns observed across countries but that occur within a common national institutional framework. The market for buying and selling of land is

[1] Data from the Groningen Growth and Development Centre, https://www.rug.nl/ggdc/.

virtually non-existent in all states in India as most agricultural land is inherited (Foster and Rosenzweig, 2017). At the same time, states in India exhibit different degrees of rental market activity that allow us to study the effects of barriers to the extent of rental markets. Third, we use detailed household-level micro data, collected under the same survey design across all states, that distinguishes between cultivated land, owned land, and leased land. This feature of the data allows us to study how state-level distortions affect the decisions of individual farms in the land market.

We emphasize that there are large differences in land institutions across states in India resulting from both historical variation in land revenue systems under the British rule and state-level variation in post-independence land reforms (Besley and Burgess, 2000; Banerjee and Iyer, 2005; NITI Aayog, Govt. of India, 2016). In an attempt to protect tenants from exploitation by landowners, states imposed restrictions on land-leasing, but to different degrees. Some states, such as Kerala, explicitly prohibit the leasing of land. Others, such as West Bengal, only allow sharecropping. These land reforms also impacted landowners' willingness to rent out land either formally or informally for fear of losing their land to tenants. As a result, land rental activity differs markedly across states.

To assess the importance of land markets in Indian states for agricultural productivity, we use micro household-level data from two waves (2004-2005 and 2011-2012) of the Indian Human Development Survey (IHDS). The IHDS contains not only detailed information on farm-specific real agricultural output and inputs, but also information on the amount of land that a household owns and leases to or from other land-market participants. We exploit the panel structure of the data to construct a robust measure of farm-level total factor productivity (TFP) as the household fixed effect of a panel regression that also controls for district and time fixed effects. Using the estimates of farm productivity, we provide evidence on the link between rental-market activity and misallocation across states in India. First, *within states*, rental markets facilitate a more efficient allocation of resources. On average, farmers that rent in land are more productive and own less land, whereas farmers that rent out land are less productive and own more land. Second, *across states*, differences in rental market activity are associated with differences in the extent of misallocation. Third, *across time*, land is reallocated more efficiently in states with more rental-market activity.

To examine how distortions in rental markets affect the allocation of land and agricultural productivity across states, we embed our agricultural production framework into an equilibrium model of heterogeneous farmers and distorted land markets. We model two sources of land-market distortions that create resource misallocation. First, farmers face state-wide barriers to engaging in rental-market transactions, which manifest themselves as a difference between a farmer's cost and return to leasing land. This feature is motivated by the observations that land institutions vary across states and that these institutions imply disparate restrictions on renters and rentees. Second, farmers face individual or idiosyncratic distortions to rental prices, a more traditional component of misallocation, which we parameterize as a function of farm productivity and a random component (Restuccia, 2019). We apply the structural framework by estimating the parameters of state- and farm-specific distortions using the first-order conditions from the farm's profit maximization problem. We identify distortion parameters using three sources of variation in the data: the share of farmers renting, the covariance between the marginal product of land and productivity across farmers, and the overall variance in the marginal product of land across farmers. We show that this parsimonious parameterization of distortions captures remarkably well the distinct patterns of land allocations and rental market activity across farms and across states.

We use the estimated model to perform counterfactuals to assess the effect land markets on agricultural productivity across states. First, we show that an efficient reallocation of land can substantially increase agricultural productivity in all states, even relative to Punjab, the state with the least distorted land market in our sample. On average, an efficient reallocation of land increases agricultural productivity by 33 percent (15 percent relative to Punjab). In Tamil Nadu and Karnataka, the increase in agricultural productivity is 89 and 49 percent (63 and 34 percent relative to Punjab). Second, we decompose the contribution between farm-and state-specific distortions and find that farm distortions contribute to about one-third of the reallocation gains, whereas state-level land wedges contribute the remaining two-thirds. We also show that an efficient reallocation of land would involve substantial increases in both the share of farmers renting (participation in the rental market) as well as the share of land operated by the most productive farms.

Our work relates to the broad literature emphasizing resource misallocation (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Adamopoulos and Restuccia, 2014).[2] It also connects with a literature studying the impact of economic institutions in India (Besley and Burgess, 2004; Aghion et al., 2008; Boehm and Oberfield, 2020) and land institutions (Besley and Burgess, 2000; Banerjee et al., 2002; Banerjee and Iyer, 2005; Besley et al., 2016). We build on the literature using household-level data to study agricultural productivity in India such as Rosenzweig and Wolpin (1993) and Foster and Rosenzweig (1995). A key difference is that we focus on the effect of property rights institutions on agricultural productivity through misallocation. By emphasizing rental markets, we relate to a large literature studying institutions and land markets (Deininger and Feder, 2001; Holden et al., 2011; Chen et al., 2021; Chari et al., 2021; Beg, 2021). Our strategy of analyzing variation across states in India is inspired by the work of Lahiri and Yi (2009) who emphasized the relative economic performance of West Bengal and Maharashtra, two important states in India, using a general-equilibrium sectoral model.

The paper proceeds as follows. In the next section, we describe the basic institutional context of India, with particular reference to the determinants of differences in land-market institutions across states. Section 3 describes the micro panel data and the agricultural production framework used to construct our measure of farm productivity. In section 4, we characterize rental market activity across states and present evidence of the connection between rental market activity and misallocation. Section 5 describes the model, the estimation of

[2] See also Adamopoulos and Restuccia (2020), Restuccia and Santaeulalia-Llopis (2017), De Janvry et al. (2015), Chen (2017), Gottlieb and Grobovšek (2019), Le (2020), among others.

land-market distortions, and the main quantitative results. We conclude in Section 6.

2 Institutional Context

Present day variation in land institutions across India is a combined result of differences in colonial land administrative systems and land reforms undertaken by state governments after independence in 1947. There were three types of land revenue systems in British India: (i) landlord-based, which assigned property rights to the landlord in charge of collecting rents; (ii) individual-based, where individual farmers had property rights and taxes were collected directly from them; and (iii) village-based, where property rights were diffused depending on who was in charge of collection. Banerjee and Iyer (2005) argue that the choice of revenue system by the British across Indian regions were mostly influenced by individual administrators, precedents prior to annexation and political events unrelated to factors determining agricultural productivity. As a result, regions in India experienced different degrees of land inequality and tenant exploitation prior to independence.

After independence, the 1949 Indian Constitution granted states full control over their land administration law and land-tenure issues, as a nationwide policy would not work for all states. The key elements of state land reforms were the abolition of intermediaries, regulation of the size of land holdings (land ceiling legislation), and tenancy reforms to improve tenure security.[3] In this section, we summarize two features of the current land market institutions in India that either directly or indirectly contribute toward the inefficient allocation of land across farmers: (i) tenancy laws and (ii) land records and titles.

Tenancy laws. Indian states enacted tenancy reforms in order to protect tenants from landlord exploitation to varying degrees. These involved banning or imposing heavy restric-

[3] See Appendix A for more details on all types of land reforms enacted by each state.

tions on the leasing of agricultural land.[4] States fall into five categories based on the laws passed (NITI Aayog, Govt. of India, 2016). (1) States that legally prohibited leasing out agricultural land without exceptions, such as Kerala, Jammu & Kashmir, and Manipur. (2) States that allow leasing out only for specific landowners, usually those that cannot cultivate themselves, such as Bihar, Karnataka, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Tripura, Telengana, and Odisha. (3) States that do not prohibit land leasing, but the tenant acquires the right to purchase the land from the owner after a specified period, including Punjab, Haryana, Gujarat, Maharashtra, and Assam. (4) States where leasing is allowed but only under restrictions like sharecropping or minimum lease periods, such as Andhra Pradesh, Tamil Nadu, Rajasthan and West Bengal. (5) States (tribe regions) in which authorities decide on the transfer of tribal land to local farmers.

The implementation of tenancy reforms reduced formal rental market activity in India. The share of households that report leasing land declined from 26% in 1970 to 12% in 2001 (World Bank, 2007). However, informal and short-term tenancies continue to exist everywhere. Informal tenancies are sub-optimal as they lack recognition, leading to a lack of access to credit and other benefits. As a result, informal tenants fail to cultivate their land efficiently (Dept. of Land Resource, Govt. of India, 2009). Restrictive tenancy laws also discourage landowners from leasing out land even in regions where leasing is legal or where informal leasing is widespread but ignored by the government. Some landowners prefer to keep their land fallow for fear of losing their land. This suggests that renters and rentees face different frictions to participating in the land market, which is a feature of the institutional setting that we exploit in our quantitative analysis.

Land records and titles. At independence, the new Indian government adopted land administration institutions from the British colonialists with little modifications since then. The British used land records primarily for tax collection. In landlord-based regions, main-

[4]See Appendix A, Table A.2, for a detailed summary of all tenancy reforms implemented by Indian states between 1950 and 1980.

tenance of cadastral maps was less important since the landlord had secure property rights. However, in regions with individual-based systems, regular maintenance of land records for individual farmers was important, and the British created detailed title documents. Land records in village-based regions varied in quality depending on who was in charge of rent collection. Independent India inherited this variation in land records and titles, leading to vast regional differences in the quality of land property rights.

India also follows a *deeds* registration system to facilitate land transactions, which cannot guarantee the legality of a transaction (World Bank, 2007; Mishra and Suhag, 2017). The low quality of land records and the historical registration systems imply that the registrar has no obligation or ability to check whether a transaction is valid. The right claimed in a registered deed usually has priority over unregistered ones, and subsequently registered deeds. This makes land titles in India presumptive. A further complication is that the burden of verifying the validity of a seller's ownership claims has to be borne by the buyer, who also incurs the cost of an invalid transaction.[5] In contrast, under a *title* registration system the government provides and guarantees the information about past ownership, and the buyer cannot be sued for damages in case of a fraudulent transfer.[6]

The high costs and low benefits of land registration has lead to sub-optimal transaction levels in the rental market, with farmers' investment demand and access to credit being lower without well-defined property rights. The absence of clear property rights has also contributed to land-related conflicts. There is large variation in backlogs of land-related cases across states in India. For example, the share of pending land-related cases that are

[5] In 2004 India ranked 123 out of 140 countries in terms of the cost of registering land transfers measured as a share of property values (e.g. high stamp duties, complex regulations, and money and time spent on duplicate and inefficient procedures) (World Bank, 2007).

[6] While reforms have been implemented to consolidate and digitize land records (Digital India Land Records Modernization Programme), the outcomes are limited since states vary in terms of the scope of historically inadequate land records and the extent of computerized records presently (Mishra and Suhag, 2017). For example, as of 2019, the percentage of digital Record of Rights issued varies from close to 100% in states like Andhra Pradesh, Tamil Nadu, and Tripura to close to 3% in Haryana. Source: Department of Land Resources, Ministry of Rural Development, Govt. of India. `http://dilrmp.gov.in/faces/percent/rptComputerizationOfLandRecord.xhtml`, accessed on June 30, 2020.

more than 10 years old range from 45% in Gujarat (GJ) and Uttar Pradesh (UP) to 0% in Punjab (PB) and Haryana (HR).

Table 1: Average Farm Size and Land Distribution in Indian States

	Land Operational Scale of Farms					
	Ag. Census (2010-11)			IHDS-II (2011-12)		
	Average Farm Size	% of Farms ≤ 2 Ha	% of Farms ≥ 20	Average Farm Size	% of Farms ≤ 2 Ha	% of Farms ≥ 20
India	1.15	85	0.1	2.12	71	1.0
State:						
Andhra Pradesh (AP)	1.08	86	0.03	2.41	60	0.7
Assam (AS)	1.10	86	0.1	1.15	88	0.0
Bihar (BR)	0.39	97	0.003	1.63	81	0.5
Gujarat (GJ)	2.03	66	0.1	3.64	50	1.4
Haryana (HR)	2.25	68	0.5	3.50	47	1.4
Karnataka (KA)	1.55	76	0.1	2.40	64	1.0
Kerala (KL)	0.22	99	0.01	1.61	75	0.0
Madhya Pradesh (MP)	1.78	71	0.1	3.68	50	1.7
Maharashtra (MH)	1.44	79	0.1	2.88	55	0.9
Orissa (OR)	1.04	92	0.03	1.16	85	0.0
Punjab (PB)	3.77	34	1.0	5.67	36	3.4
Rajasthan (RJ)	3.07	58	1.3	1.71	76	0.2
Tamil Nadu (TN)	0.80	92	0.04	2.84	82	1.9
Uttar Pradesh (UP)	0.76	92	0.01	1.57	77	0.2
West Bengal (WB)	0.77	96	0.01	1.03	89	0.0

Notes: All data refers to the land operational scale of farms in hectares. Data from 2010-2011 Agricultural Census and from micro IHDS-II 2011-2012 wave (Desai et al., 2012). We focus on the largest 15 states with population size greater than 20 million.

Differences in land legislation and administration across states are at the heart of contemporaneous differences in the operational scale of farms. Table 1 summarizes the distribution of cultivated land across farms in each state in India using data from the 2010-2011 Agricultural Census. There are substantial differences in average farm sizes across states. For example, Punjab's average farm size is almost 5-fold that in Tamil Nadu and 19-fold that in Kerala. In Punjab, only 9 percent of farms operate less than 2 hectares of land, whereas this percentage is 61 in Tamil Nadu and 77 in Kerala. These enormous differences in the operational size of farms resemble those observed between rich and poor countries (Adamopoulos and Restuccia, 2014).

3 Data

We provide details of the data and the specific variables we use in our analysis. We also describe our empirical measure of farm productivity and provide a characterization of the efficient allocation as a benchmark for comparison and analysis.

3.1 Description

We use panel micro data from the India Human Development Survey (IHDS). This is a panel household-level survey that contains detailed information on agricultural and other commercial activities. The survey is representative at the state- and country-level. We use wave I corresponding to years 2004-2005 (Desai et al., 2005) and wave II corresponding to years 2011-2012 (Desai et al., 2012). For households operating in the agricultural sector, the survey provides detailed information on farm output by crop and all inputs into production. We focus on the household farm as our main unit of analysis (see Aragon et al., 2021a, for a discussion of measurement issues).

Real gross output. Farm households report the quantities of crops produced, farm-specific prices, and total estimated revenue. Although more than 50 percent of farm-crop pairs are not sold in markets, farmers are asked to estimate the price they would receive for their crop if they would sell them. IHDS uses these prices to estimate farm-specific revenue. We construct a measure of real gross output at the farm level by deflating farm-specific revenue. Because we lack data on price deflators for agriculture by state, we use food CPI for agricultural workers in each state from the Indian Ministry of Labour and Employment. We express constant prices over time relative to wave I and across states relative to Punjab. We note that a more natural measure of real output would be to use common prices per crop. Currently, only IHDS wave I contains information on crop-specific prices, and the second wave reports only farm-specific revenue. We corroborate that our revenue measure of output correlates strongly with the real measure of output from wave I using common prices across farms.

Other inputs. For labor inputs, farms report family and hired labor, both in terms of days and hours worked in the last 12 months. Information on capital input in production is available in terms of quantities for machinery (e.g. bullcarts, pumps), draft animals, and capital services rented in and out. We aggregate these into a real household-level capital stock using 1997-1998 prices for machinery, the mean reported price for draft animals, and the reported mean annual interest rate on agricultural bank loans for converting capital services into a stock.[7] For intermediate inputs, farmers report expenditures on seeds, fertilizer, pesticides, and miscellaneous products. We lack data on the quantity of intermediate inputs and therefore deflate farm-level nominal intermediate input expenditures using village-level kerosene prices. While the level kerosene prices may differ from that of other intermediate inputs (e.g. fertilizer), our empirical approach requires only that we identify relative farm TFP within each state. We believe kerosene prices are a good proxy since they reflect the same relative trade costs that drive relative intermediate input prices.

Information on land inputs per household is available with respect to area cultivated, owned, rented in, and rented out. We use cultivated land as our measure of operated land by the farm household, but our analysis also exploits the information on the amount of cultivated land that is owned by the household, and the amount of cultivated land rented in and rented out.

[7] Machinery prices are from Singh (2006), while other prices and interest rates are mean values of those reported in IHDS wave I.

Final sample. The first wave of IHDS contains information on 41,554 households and we focus on the 13,971 farm households that cultivate a positive amount of land. From these, 11,066 households are also in IHDS wave II, 2,365 (17%) leave farming, 509 (4%) split up from the household, and 1,020 (7%) are lost to re-contact. From the panel sample, 2.5% have zero or missing values for output, labor, or intermediate inputs. We use a linear machine learning algorithm (Zou and Hastie, 2005) to impute the missing observations based on information from the household's state and district, cultivated land, real capital stock, as well as age, gender, and education of the household head. We emphasize, however, that our results are not affected by these imputations as output and factor input distributions are nearly identical when simply dropping the households with missing information from the sample. We also trim outliers, but rather than excluding households across the board at the top and bottom of a given distribution, we exclude households that experience large changes in land to output ratios between the two waves. In total, we drop 200 households (2%) that belong to the top 2% of households in terms of absolute changes in land-output ratios. After restricting our analysis to states with an estimated population of more than 20 million, we are left with a final sample of 8,642 households in 15 states for the analysis. The states in our final sample are: Andhra Pradesh (AP), Assam (AS), Bihar (BR), Gujarat (GJ), Haryana (HR), Karnataka (KA), Kerala (KL), Madhya Pradesh (MP), Maharashtra (MH), Orissa (OR), Punjab (PB), Rajasthan (RJ), Tamil Nadu (TN), Uttar Pradesh (UP), and West Bengal (WB). These states account for 97% of India's population and 92% of value added in agriculture in 2011. Our final sample also represents well the full sample in terms of the distribution of cultivated land. Moreover, the distribution of cultivated land in the final sample of the micro data captures fairly well the distribution of land from the agricultural census (see Table 1).

3.2 Farm Productivity and Efficient Allocations

We use our detailed micro data to estimate a permanent measure of farm productivity. We assume that households produce a homogeneous good and have a common production function that only differs in terms of their total factor productivity. The amount of gross output produced by a farm household i in state s and wave t, is given by:

$$y_{ist} = z_{ist}[(k_{ist}^{\alpha} l_{ist}^{\beta} n_{ist}^{1-\alpha-\beta})^{1-\theta} m_{ist}^{\theta}]^{\gamma}; \quad \alpha, \beta, \theta, \gamma \in (0, 1), \tag{1}$$

where y_{ist} is real farm gross output, k_{ist} is real capital stock, l_{ist} is operated land size, n_{ist} is total labor in hours, and m_{ist} is real intermediate inputs. Note that the farm technology features decreasing returns to scale in variable inputs, which is a key element in determining the size of the farm given farm productivity, prices, and distortions. While specifying a common production function at the outset may seem restrictive, the evidence suggests that it generates reasonable distributions of farm productivity compared to an alternative approach of estimating the production function using panel data methods (Aragon et al., 2021b). Our panel data comprises only two waves so we are restricted to specifying the production function at the outset.

We set the parameter values for α, β, θ, and γ to expenditure shares of value gross output using a variety of data. We set $\alpha = 0.09$, $\beta = 0.36$, $\theta = 0.35$, and $\gamma = 0.54$, which imply a capital share of 4.9 percent, a land share of 19.4 percent, an intermediate inputs share of 18.9 percent, and a residual labor share of 56.8 percent which includes the farmer proprietor's income. These values are consistent with moments in developing countries (Adamopoulos et al., 2021; Chen et al., 2021). We emphasize that our estimates of farm-level productivity described below control for district and time fixed effects, hence, potential variation in these parameters across states are subsumed in the fixed-effect controls. Similarly, in our analysis in Section 5, we focus on land as a composite input and, as a result, we abstract from variation in input ratios across farmers, which may be due to technology differences.

We measure farm total factor productivity z_{ist} as a residual from the production function in equation (1) for each wave and state in the data and use it to estimate a permanent measure of farm productivity that controls for variation in productivity across time and space. In particular, we follow Adamopoulos et al. (2021) to decompose the logarithm of farm TFP ($\ln z_{ist}$) as follows:

$$\ln z_{ist} = \ln z_t + \ln z_i + \nu_{ist}, \tag{2}$$

where $\ln z_t$ is a year fixed effect component that captures time-varying shocks to productivity (e.g., weather) that are common across farmers, $\ln z_i$ is a household farm fixed effect component that captures persistent productivity differences across farmers including state level differences, and ν_{ist} is an error term that reflects farmer- and time-specific productivity shocks. We estimate equation (2) using panel data methods to extract the household farm fixed effect $\ln z_i$ which is inclusive of location-level differences (e.g. land quality). We then remove location-level differences by regressing $\ln z_i$ on location dummies and extracting the residual. Using the district location information of each farmer, denoted by d, we estimate,

$$\ln z_i = \ln z_d + \ln \text{TFP}_i,$$

where the predicted error term $\ln \text{TFP}_i$ is our estimate of permanent farm-specific TFP which controls for time and local fixed effects. In our final sample, there are on average 17 districts per state and an average district accounts for 0.6% of all farmers.

Despite the limited time dimension of the data, the standard deviation of permanent farm TFP $\ln \text{TFP}_i$ is 0.71 nationwide. The cross-sectional dispersion in measured productivity $\ln z_{ist}$ for the second wave is 1.04, hence, controlling for variation across time and space reduces the cross-sectional dispersion of farm TFP by about 30 percent. Table 2 summarizes the distribution of farm TFP for India as a whole and for each state in our sample. There is substantial dispersion in farm productivity in all states, with a standard deviation of log farm productivity of 0.51 in West Bengal and 0.8 in Kerala. We note that there are substantial

Table 2: Total Factor Productivity (TFP) in Agriculture across Indian States

	Agriculture TFP relative to Punjab		Distribution of log Farm TFP		
	Actual	Permanent	SD	90 − 10	75 − 25
India	0.37	0.86	0.71	1.78	0.89
State:					
Andhra Pradesh (AP)	0.30	0.80	0.71	1.77	0.98
Assam (AS)	0.27	0.80	0.63	1.42	0.72
Bihar (BR)	0.31	0.92	0.61	1.49	0.73
Gujarat (GJ)	0.52	0.81	0.85	2.12	1.18
Haryana (HR)	0.51	0.91	0.65	1.60	0.81
Karnataka (KA)	0.33	0.82	0.84	2.16	1.09
Kerala (KL)	0.71	0.74	0.80	1.90	1.01
Madhya Pradesh (MP)	0.40	0.88	0.70	1.79	0.88
Maharashtra (MH)	0.36	0.83	0.71	1.78	0.91
Orissa (OR)	0.21	0.96	0.54	1.35	0.67
Punjab (PB)	1.00	1.00	0.67	1.79	0.85
Rajasthan (RJ)	0.28	0.86	0.80	2.03	0.98
Tamil Nadu (TN)	0.31	0.72	0.67	1.78	0.89
Uttar Pradesh (UP)	0.30	0.94	0.64	1.67	0.89
West Bengal (WB)	0.32	0.96	0.51	1.33	0.65

Notes: Agriculture TFP in each state is measured TFP computed as the ratio of aggregate agricultural gross output relative to aggregate composite inputs using the second wave of the micro data. Actual refers to measured TFP using actual gross output for each farm. Permanent uses the resulting gross output from actual inputs and the estimated permanent (farm fixed effect) measure of farm TFP that controls for district and time fixed effects. Statistics of the distribution of log farm TFP refer to the estimated permanent component of farm TFP.

differences in measured TFP across states in India. For instance, measured agricultural TFP in Punjab is 4.8-fold larger than in Orissa, 2.8-fold larger than in Maharashtra, and 3.1-fold larger than in West Bengal, see the first column in Table 2. We emphasize that about a quarter of these differences across states is accounted for by differences in measured aggregate TFP using our estimated permanent measure of farm TFP that controls for time and district fixed effects. The district fixed effects account for the bulk of the remaining differences in measured aggregate TFP across states. To the extent that misallocation of land can distort selection in occupational choices, investment, and technology choices (Adamopoulos et al., 2021; Ayerst, 2020), land institutions can lead to substantial state-level differences in agricultural TFP.

A useful benchmark for comparing allocations and aggregate outcomes across states in India is the efficient allocation, i.e. the allocation that maximizes aggregate output in a state given aggregate inputs. We solve for each state's efficient allocation by solving the farm-level allocations of capital, land, labor, and intermediates that maximizes aggregate output subject to the state's endowments of capital, land, labor and intermediates K_s, L_s, N_s, M_s. We drop time subscripts for convenience and solve:

$$\max_{\{k_{is},l_{is},n_{is},m_{is}\geq 0\}_{i=1}^{F_s}} \sum_{i=1}^{F_s} z_{is}[(k_{is}^{\alpha} l_{is}^{\beta} n_{is}^{1-\alpha-\beta})^{1-\theta} m_{is}^{\theta}]^{\gamma},$$

subject to

$$\sum_{i=1}^{F_s} k_{is} = K_s \qquad \sum_{i=1}^{F_s} l_{is} = L_s \qquad \sum_{i=1}^{F_s} n_{is} = N_s \qquad \sum_{i=1}^{F_s} m_{is} = M_s.$$

The efficient allocation involves allocating factors across the given set of F_s farmers in state s according to their relative productivity. Defining farm productivity as $s_{is} \equiv z_{is}^{1/(1-\gamma)}$, the efficient allocations with superscript e are given by:

$$k_{is}^{e} = \frac{s_{is}}{\sum_{i=1}^{F_s} s_{is}} K_s \qquad l_{is}^{e} = \frac{s_{is}}{\sum_{i=1}^{F_s} s_{is}} L_s \qquad n_{is}^{e} = \frac{s_{is}}{\sum_{i=1}^{F_s} s_{is}} N_s \qquad m_{is}^{e} = \frac{s_{is}}{\sum_{i=1}^{F_s} s_{is}} M_s.$$

It is straightforward to show that in the efficient allocation, farm output is a linear function of farm productivity, i.e.:

$$y_{is}^{e} = \frac{s_{is}}{\left[\sum_{i=1}^{F_s} s_{is}\right]^{\gamma}} [(K_s^{\alpha} L_s^{\beta} N_s^{1-\alpha-\beta})^{1-\theta} M_s^{\theta}]^{\gamma}.$$

Aggregate output in the efficient allocation, Y_s^e, is a Cobb-Douglas aggregate of total inputs, and agricultural TFP A_s^e:

$$Y_s^e = A_s^e (F_s)^{1-\gamma} [(K_s^\alpha L_s^\beta N_s^{1-\alpha-\beta})^{1-\theta} M_s^\theta]^\gamma, \quad \text{where} \quad A_s^e = \left[\frac{1}{F_s} \sum_{i=1}^{F_s} s_{is} \right]^{1-\gamma}.$$

Following Adamopoulos et al. (2021), we define farm revenue total factor productivity (TFPR) as output per composite input, which given the production function in equation (1) is:

$$TFPR_{is} = y_{is} / [(k_{is}^\alpha l_{is}^\beta n_{is}^{1-\alpha-\beta})^{1-\theta} m_{is}^\theta].$$

An important property of the efficient allocation that we exploit below is that both the marginal product of land and farm TFPR are constant across farms:

$$\text{MPL}_{is}^e = \gamma(1-\theta)\beta \frac{y_{is}^e}{l_{is}^e} = \gamma(1-\theta)\beta \frac{Y_s^e}{L_s}, \quad \text{and} \quad \text{TFPR}_{is}^e = \left[\frac{\sum_{i=1}^{F_s} s_{is}}{Y_s^e} \right]^{(1-\gamma)/\gamma}.$$

Hence, in this context, variation in marginal products of land and revenue total factor productivity are informative about implicit distortions.

4 Rental Markets and Productivity

We examine rental market activity across states and provide some facts about the link between rental market activity and misallocation. We focus on rental market activity because sales/purchases of land remain rare in India. Most households either inherited their land, or the state assigned their land to them. By reallocating land from low- to high-productive farms, well-functioning rental markets can help mitigating the inefficiencies in land use in the absence of a market for selling and buying land. Land market institutions in India are rife with frictions that potentially result in the inefficient use of land across farmers. Differences in legal restrictions on renting across states show up as variation in rental market activity, which leads to differences in agricultural efficiency across states.

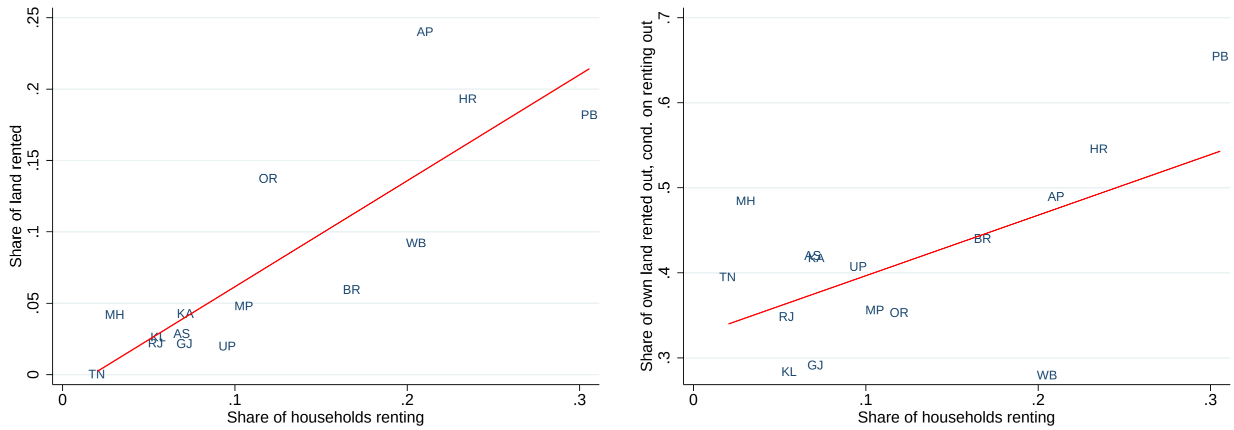
4.1 Rental Market Activity

We use the final sample of farm households to characterize the extent of rental market activity across states and over time. We define farmers as *renting in* if they report having paid in cash for an amount of leased in land. Similarly, we define farmers as *renting out* if they report having received cash for an amount of leased out land. We focus on cash rentals as our main measure of rental market activity, in particular, we exclude sharecropping as a form of rentals because tenancy regulations often do not apply to these arrangements (Besley and Burgess, 2000). However, in Appendix B, we show that our empirical results are quantitatively similar when including sharecropping. A state's rental market then comprises all farmers that are either renting in or out, and a state's rental market activity is the fraction of farmers that participate in the rental market.

In our final sample, 10.3% of households participate in the rental market: 3.7% of households rent out, whereas 6.7% rents in. A very small percentage of households (0.16%) report both renting in and out. We count a household as renting in (out) if the amount of land rented in (out) is larger than the amount of land rented out (in). In total, 6.8% of all cultivated land in our sample is rented in.

Rental market activity differs markedly across states, as summarized in Figure 1, panel A. In most states, such as Tamil Nadu, Kerala, Maharashtra, less than 10% of households participate in the rental market, and less than 5% of land is rented. However, there are some states with relatively active land markets. In Punjab, 31.5% of households participate in the land rental market and 18.2% of all cultivated land is rented. Differences in rental market activity also arise along the intensive margin. Panel B of Figure 1 shows that farmers renting out land tend to transact a larger share of their owned land in states that have more active rental markets. In Punjab, for example, where rental market activity is high, farmers renting out transact 65% of their land. In Tamil Nadu, where rental market activity is low, farmers renting out transact only 28% of their land.

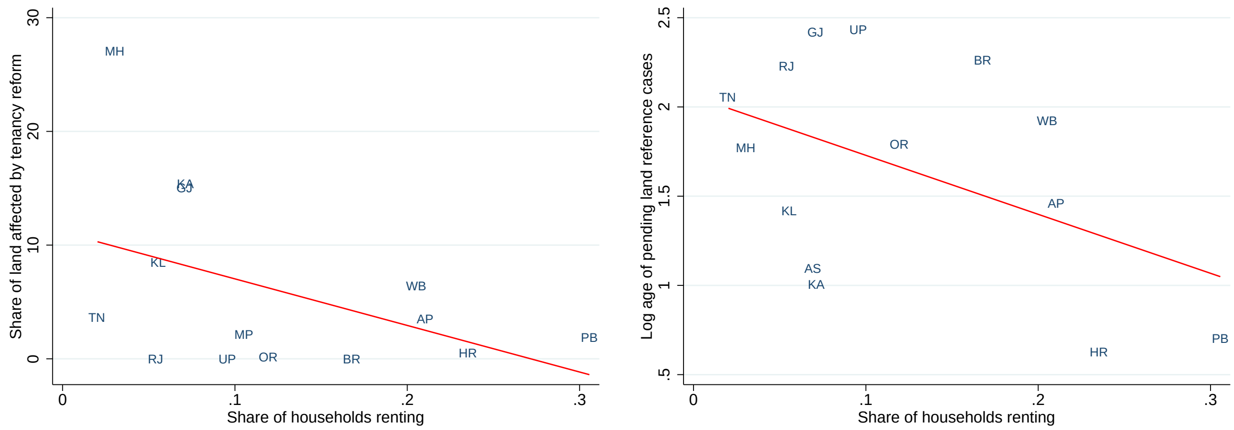
Figure 1: Land Rental Markets in India



Notes: (a) Share of cultivated land rented against the share of households that participate in the rental market across states. (b) Share of own land that households rent out, conditional on renting out, against the share of households that participate in the rental market. Data are from IHDS-II.

Why are there such sizeable differences in land rental market activity across states? We emphasize two factors. First, participating in the rental market is more costly in states with more stringent tenancy regulation. We collect state-level estimates of the share of arable land transferred as a result of tenancy legislation from Kaushik and Haque (2005). Figure 2, panel A, shows that states with higher shares of land affected by tenancy reforms tend to have less active rental markets. For instance, in the state of Maharashtra, where 27% of land was transferred as a result of tenancy legislation, only 3% of households participate in the rental market. Second, ill-defined property rights combined with weak contract enforcement raise the effective transaction costs beyond the level implied by *de jure* regulation. Following Boehm and Oberfield (2020), we collect state-level estimates of the age of pending cases that pertain to land disputes from the National Judicial Data Grid (Verma, 2018). Panel B of Figure 2 documents that states with higher rates of court congestion tend have less active rental markets.

Figure 2: Land Reforms and Court Quality



Notes: Land rental market activity across states and (a) the share of agricultural land affected by land reforms, (b) the log age of pending land reference cases. Reform implementation data are from Kaushik and Haque (2005), obtained in Deininger et al. (2009), estimates based on official data of Indian Ministry of Agriculture. Data on age of pending cases are from the National Judicial Data Grid (Verma, 2018).

4.2 Some Facts

We provide suggestive evidence on the link between rental market activity and productivity, which motivates our quantitative model in the next section.

Fact 1 *Within states, farmers renting in are more productive and own less land, whereas farmers renting out are less productive and own more land.*

Panel A of Table 3 reports the results from Probit regressions of whether a farm rents in land on log permanent TFP and log endowed land. For all specifications, the result is that more productive farms are significantly more likely to expand cultivated land by renting in. The magnitude of the coefficient on permanent TFP in column (1) indicates that a farm with a one standard deviation higher permanent TFP is 19 percentage points more likely to rent in land. This finding is robust to accounting for between-state differences by introducing state fixed effects in column (2). In column (3) we consider the farm log land endowment (own land). Conditional on permanent TFP, a farm with a one standard deviation higher land endowment is 17 percentage points less likely to rent in. The magnitude of the coefficients on TFP and the land endowment barely change when accounting for individual demographic and land quality controls in columns (4) and (5).

Panel B of Table 3 reports the results of Probit regressions on whether a farm rents out land on farm TFP and land endowment. Conditional on the land endowment, farmers that rent out are significantly *less* productive. A one standard deviation higher permanent TFP is associated with a 15 percentage points lower probability of renting out. Farmers that own one standard deviation more land are 42 percentage points more likely to rent out. These coefficients increase to 19% and 43% after accounting for demographic and land quality controls, respectively.[8]

Fact 2 *States with more active rental markets have less dispersed marginal products of land across farms.*

There is a strong negative relationship between the extent of rental markets and measures of misallocation across states in India (see Appendix B, Figure B.3). We show this negative relationship remains when allowing for a variety of controls. Table 4, Panel A, reports the results from regressions of farm absolute deviations of (log) marginal product of land from the state mean on the share of farms participating in the rental market in the state. The results indicate that states with more active rental markets, marginal products of land are significantly less dispersed. The relationship remains strong and significant after accounting for farm TFP, demographic characteristics, land quality, and state-level controls in columns (2) to (5).

Table 4, Panel B, reports the results from regressions of a farm's absolute deviation of log TFPR from the state mean on the share of households participating in a state's rental market. States with more active rental markets have significantly lower dispersion of log

[8]Note that since we do not observe productivity of farmers who rent out all their land, they are excluded from the empirical analysis. Our findings are an underestimate if these are low productivity households.

Table 3: Determinants of Rental Market Activity

Panel A: Dependent variable is whether a farm rents in land or not					
	(1)	(2)	(3)	(4)	(5)
	Probit	Probit	Probit	Probit	Probit
TFP (log)	0.188***	0.199***	0.294***	0.305***	0.295***
	(0.0355)	(0.0394)	(0.0512)	(0.0528)	(0.0556)
Own land (log)			-0.181***	-0.170***	-0.168***
			(0.0396)	(0.0405)	(0.0394)
State FE	N	Y	Y	Y	Y
Demographic controls	N	N	N	Y	Y
Land quality controls	N	N	N	N	Y
Observations	8359	8359	8359	8359	8359
R^2	0.0192	0.1019	0.1148	0.1213	0.1220

Panel B: Dependent variable is whether a farm rents out land or not					
	(1)	(2)	(3)	(4)	(5)
	Probit	Probit	Probit	Probit	Probit
TFP (log)	0.0590**	0.0633**	-0.150***	-0.159***	-0.189***
	(0.0272)	(0.0261)	(0.0416)	(0.0374)	(0.0361)
Own land (log)			0.415***	0.411***	0.428***
			(0.0570)	(0.0584)	(0.0614)
State FE	N	Y	Y	Y	Y
Demographic controls	N	N	N	Y	Y
Land quality controls	N	N	N	N	Y
Observations	8359	8359	8359	8359	8359
R^2	0.0019	0.0457	0.1065	0.1196	0.1262

Notes: Standard errors in parentheses, clustered by state. We standardize log TFP and log owned land within states. Demographic controls include a farm operator's age, gender, years of education, and whether the farm operator is literate or not. Land quality controls include the share of cultivated land that is irrigated, and the share of cultivated land that is used for orchard production. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 4: Rental Market Activity and Misallocation

Panel A: Dependent variable is absolute deviation of (log) marginal product of land from state mean					
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
Share hh renting	-1.439***	-1.439***	-1.441***	-1.216***	-1.092***
	(0.362)	(0.362)	(0.360)	(0.351)	(0.324)
TFP (log)		-0.0155*	-0.0165*	-0.0103	-0.0134
		(0.00800)	(0.00900)	(0.00819)	(0.00822)
Demographic controls	N	N	Y	Y	Y
Land quality controls	N	N	N	Y	Y
State-level controls	N	N	N	N	Y
Observations	8617	8617	8617	8617	8617
R^2	0.028	0.029	0.029	0.038	0.051

Panel B: Dependent variable is absolute deviation of (log) TFPR from state mean					
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
Share hh renting	-0.914***	-0.914***	-0.915***	-0.731**	-0.627*
	(0.297)	(0.297)	(0.291)	(0.295)	(0.301)
TFP (log)		-0.00275	-0.00588	-0.00175	-0.00168
		(0.00654)	(0.00836)	(0.00886)	(0.00832)
Demographic controls	N	N	Y	Y	Y
Land quality controls	N	N	N	Y	Y
State-level controls	N	N	N	N	Y
Observations	8617	8617	8617	8617	8617
R^2	0.013	0.013	0.016	0.024	0.034

Notes: Standard errors in parentheses, clustered by state. We standardize log TFP and log owned land within states. Demographic controls include a farm operator's age, gender, years of education, and whether the farm operator is literate or not. Land quality controls include the share of cultivated land that is irrigated, and the share of cultivated land that is used for orchard production. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5: Land Reallocation and Rental Markets

Dependent variable is change in (log) cultivated land between waves I and II	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
Reallocation potential wave I	0.272***	0.231***	0.175***	0.177***	0.161***
	(0.0272)	(0.0498)	(0.0323)	(0.0327)	(0.0344)
Reallocation potential wave I x Share hh renting		0.473	1.042***	1.039***	1.079***
		(0.389)	(0.255)	(0.249)	(0.246)
State FE	N	N	Y	Y	Y
Demographic controls	N	N	N	Y	Y
Land quality controls	N	N	N	N	Y
Observations	8617	8617	8617	8617	8617
R^2	0.151	0.152	0.217	0.220	0.228

Notes: Standard errors in parentheses, clustered by state. We standardize log TFP and log owned land within states. Demographic controls include a farm operator's age, gender, years of education, and whether the farm operator is literate or not. Land quality controls include the share of cultivated land that is irrigated, and the share of cultivated land that is used for orchard production. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

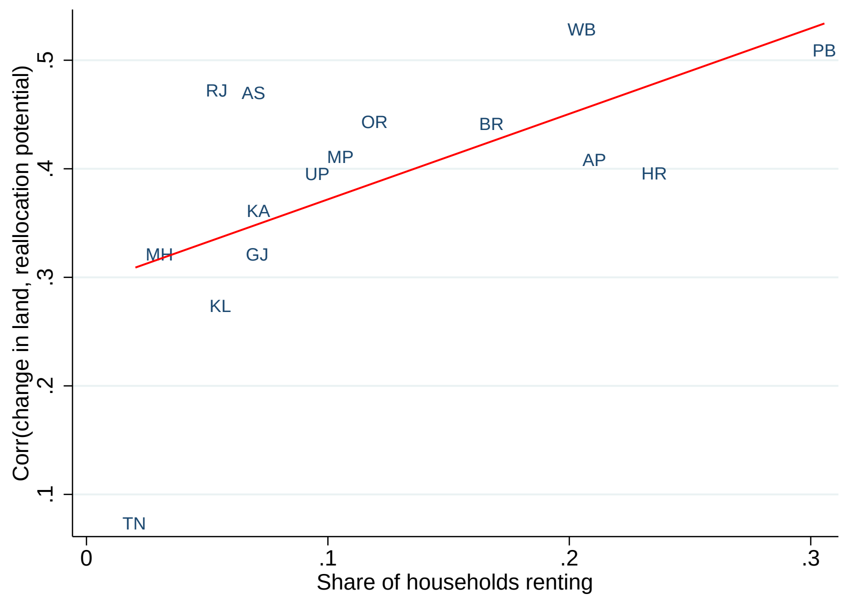
TFPR. Again, these findings are robust to a host of farmer- and state-level controls in columns (2)-(5).

Fact 3 *States with more active rental markets reallocate land more efficiently over time, i.e. land reallocates from less to more productive farms.*

We construct a measure of reallocation potential of farm i in state s and wave t, as the ratio between the efficient to actual amount of operated land (l^e_{ist}/l_{ist}) where l^e_{ist} is the efficient land allocation derived previously.

Table 5 shows regressions of a farmer's change in cultivated land between the two waves on its log reallocation potential in wave I. Throughout, the reallocation potential is a strong and robust predictor of the change in the amount of cultivated land, which suggests that nationwide efficiency is increasing over time. In columns (2)-(5) we introduce an interac-

Figure 3: Land Reallocation and Rental Market Activity



Notes: The correlation between farm-level change in cultivated land and reallocation potential in wave I and the share of households participating in the rental market across states. Data from IHDS I and IHDS II.

tion term between a farmer's reallocation potential and the rental market activity in its state. After accounting for between-state differences using fixed effects in column (3), the interaction term is positive and significant, which indicates states with more active rental markets reallocate land more efficiently. This coefficient changes little when accounting for demographic and land quality characteristics at the farm-level in columns (4) and (5).

Figure 3 provides another summary of how land is reallocated more efficiently in states with more active rental markets We report the within-state correlation between a farmer's change in cultivated land and its reallocation potential. In line with the results in Table 5, land is reallocated more towards farmers farther from their efficient allocation in states with higher levels of rental market activity. Overall, the evidence suggests a strong link between rental market activity and land misallocation, potentially contributing to the agricultural productivity differences we observe across states.

5 Model

We develop a model of agricultural production with heterogeneous farms and distorted rental markets, building on Deininger and Nagarajan (2010) and Adamopoulos and Restuccia (2014), to assess the quantitative relevance of rental market activity on agricultural productivity across Indian states.

5.1 Description

We consider an agricultural economy that comprises S regions called states indexed by s. Each state s is endowed with an aggregate amount of land L_{st} and a finite number of farm households F_{st} indexed by i that differ in their farming productivity z_{ist} and land endowment $\bar{l}_{ist}$. There is no trade or factor mobility between states. In what follows, we drop time subscripts for ease of exposition.

Individual farms produce a homogeneous output good and we normalize the price of the output good to one. We assume farmers cannot sell their endowed land, so that land reallocation occurs only through rentals. While this assumption may seem restrictive, in practice there are very few land sale transactions in India. In our final sample, only 3% of farming households purchased the land they own, while 95% acquired the land through family. In contrast, about 10% of households participate in the rental market in either wave. Farmers can rent land to (l_{is}^{out}) or from (l_{is}^{in}) other farmers, but face farm-specific transaction costs q_{is}^{in} and q_{is}^{out} per unit of land. For simplicity, we model farm-specific costs as taxes on the rental market price of land q_s, which we denote as τ_{is}^{in} and τ_{is}^{out}. In practice, these taxes stand in for a myriad of explicit and implicit regulations that affect land transactions.

We focus on the institutions that affect land rental markets across states and model the effect of these institutions through land wedges. We argue that a suitable approach to capture the effect of these institutions on farm decisions is for land wedges to impact all other inputs so that input ratios are unaffected. It is straightforward to show that this approach is equivalent to modeling land as a composite input in production since all the input ratios are constant. The evidence from many different contexts is supportive of this approach (Hsieh and Klenow, 2009; Restuccia and Santaeulalia-Llopis, 2017; Adamopoulos et al., 2021; Chen et al., 2021). We note that in our data, the variation in input ratios across farms only accounts for 30 percent of the productivity gains of reallocation. To the extent that this variation may be due to technology differences across farmers, we abstract from this source of variation in our analysis. Furthermore, as discussed in Section 2, legal access to land is an essential requirement for farmers in India to access institutional credit and other farm benefits. Frictions to accessing land would then show up as frictions on other factors of production as well. We follow this approach in specifying the model below.

5.2 Decentralized Allocation

Given farm productivity z_{is}, land endowment $\bar{l}_{is}$, prices and wedges, a farm chooses the amount of cultivated land l_{is}, which is the sum of land rented in l_{is}^{in} and the amount of owned land that is not rented out $\bar{l}_{is} - l_{is}^{out}$, to maximize profits:

$$\max_{\{l_{is}, l_{is}^{out}, l_{is}^{in} \geq 0\}} \pi_{is} \equiv z_{is} l_{is}^{\gamma} - q_s[(1+\tau_{is}^{in}) l_{is}^{in} + (1+\tau_{is}^{out})(\bar{l}_{is} - l_{is}^{out})], \tag{3}$$

subject to

$$l_{is} = \bar{l}_{is} + l_{is}^{in} - l_{is}^{out}.$$

We can contrast this problem with the standard heterogeneous farm model (e.g., Adamopoulos et al., 2021) in which farms do not choose *how* they participate in the market for land, but only the total amount of cultivated land l_{is}, for which they pay a farm-specific price $q_{is} = q_s(1 + \tau_{is})$. Using the definition of cultivated land and the two problems, we can express this price as:

$$q_{is} = q_{is}^{out}\frac{\bar{l}_{is} - l_{is}^{out}}{l_{is}} + q_{is}^{in}\frac{l_{is}^{in}}{l_{is}}.$$

The rental price of land is thus the weighted average of the price of renting in land and renting out, with weights equal to the shares of cultivated land owned and rented in. As a result, the land wedge is the weighted average of wedges for renting in land and renting out:

$$(1 + \tau_{is}) = (1 + \tau_{is}^{out})\frac{\bar{l}_{is} - l_{is}^{out}}{l_{is}} + (1 + \tau_{is}^{in})\frac{l_{is}^{in}}{l_{is}}.$$

The typical approach in the misallocation literature is to infer the producer wedge as that required to rationalize the observed producer allocation as an equilibrium outcome given the producer's productivity. In this context, only producer productivity and operational land are required. Our approach exploits the additional information that is provided on the amount of land owned and operated, with rented land as the vehicle for the separation between owned and operated land. This allows us to characterize in more detail the distortions to rental markets and to assess the contribution of rental market activity in accounting for productivity differences across Indian states.

Within a state, farm-specific rental prices $\{q_{is}^{in}, q_{is}^{out}\}_{i=1}^{F_s}$ rationalize the observed farm land choices $\{l_{is}, l_{is}^{in}, l_{is}^{out}\}_{i=1}^{F_s}$. This allocation can be summarized as:

$$q_s(1 + \tau_{is}^{in}) \geq MPL_{is} = q_s(1 + \tau_{is}^{out}) \quad \text{if } l_{is}^{in} = 0 \text{ and } l_{is}^{out} > 0, \tag{4}$$

$$q_s(1 + \tau_{is}^{in}) = MPL_{is} \geq q_s(1 + \tau_{is}^{out}) \quad \text{if } l_{is}^{in} > 0 \text{ and } l_{is}^{out} = 0, \tag{5}$$

$$q_s(1 + \tau_{is}^{in}) \geq MPL_{is} \geq q_s(1 + \tau_{is}^{out}) \quad \text{if } l_{is}^{in} = 0 \text{ and } l_{is}^{out} = 0, \tag{6}$$

where $MPL_{is} = \gamma \frac{y_{is}}{l_{is}}$ is the marginal product of land of farm i in state s.

A *competitive equilibrium* is a set of prices $\{q_s, \tau_{is}^{in}, \tau_{is}^{out}\}$ and allocations $\{l_{is}, l_{is}^{in}, l_{is}^{out}\}$ such that: (i) Given prices, farmers' allocations maximize profits, i.e., solve the problem in equation (3), and (ii) the land market clears, i.e., $\sum_i l_{is} = \sum_i \bar{l}_{is}$. Appendix C describes our procedure to solve for the competitive equilibrium in each state.

5.3 Estimating Land-Market Distortions

In order to estimate state-specific land-market distortions from available data, we impose the following restrictions:

$$(1 + \tau_{is}^{in}) = (1 + \tau_{is}),$$

$$(1 + \tau_{is}^{out}) = (1 + \tau_{is})(1 + \tau_s)^{-1},$$

where $(1 + \tau_{is})$ is a farm-specific wedge and $(1 + \tau_s)$ is a state-specific distortion, common across farms within a state, that drives a wedge between the cost of renting in and the returns to renting out. The state-specific wedge $(1 + \tau_s)$ can be interpreted as a state-wide land transaction tax that is borne by the lessor. Our results are isomorphic to the case in which the tax burden is shared with the lessee.

Furthermore, we impose the following parametric assumptions about idiosyncratic farm-level distortions:

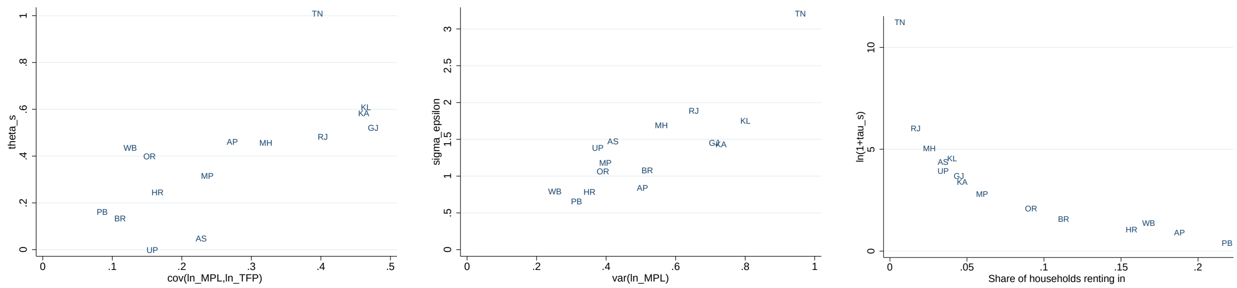
$$\ln(1 + \tau_{is}) = \kappa_s + \theta_s \ln z_{is} + \epsilon_{is},$$

$$\epsilon_{is} \sim N(0, \sigma_{\epsilon s}^2), \text{i.i.d. across farms.}$$

This parameterization is known to generate a good fit with mirco data (Restuccia and Rogerson, 2017; Restuccia, 2019). The parameter κ_s is a constant that we normalize to zero in our empirical estimation of wedges since it cannot be distinguished from τ_s. However, we use this parameter when decomposing the contributions of idiosyncratic versus state-wide features of distortions in the counterfactuals.

Under these assumptions, we solve the choice problem in equations (4) to (6), constructing three moments that depend on the three unknowns (τ_s, θ_s, $\sigma_{\epsilon s}^2$). We use the data counterpart of these moments to estimate the distortion parameters. The moments we construct are: (i)

Figure 4: Identification of Rental-Market Distortions



Notes: Panel A reports the estimated θ_s against state variation in the covariance between log marginal product of land and farm productivity. Panel B reports the estimated σ_s against state differences in the variance of log marginal product of land. Panel (c) reports the estimated state-level rental wedge $\ln(1 + \tau_s)$ against variation in the share of households renting in.

the covariance between the marginal product of land and permanent TFP across farmers, (ii) the variance of the marginal product of land across farmers, and (iii) the share of farmers renting. We provide more details on this procedure and the motivation for our choice of specific moments in Appendix D.

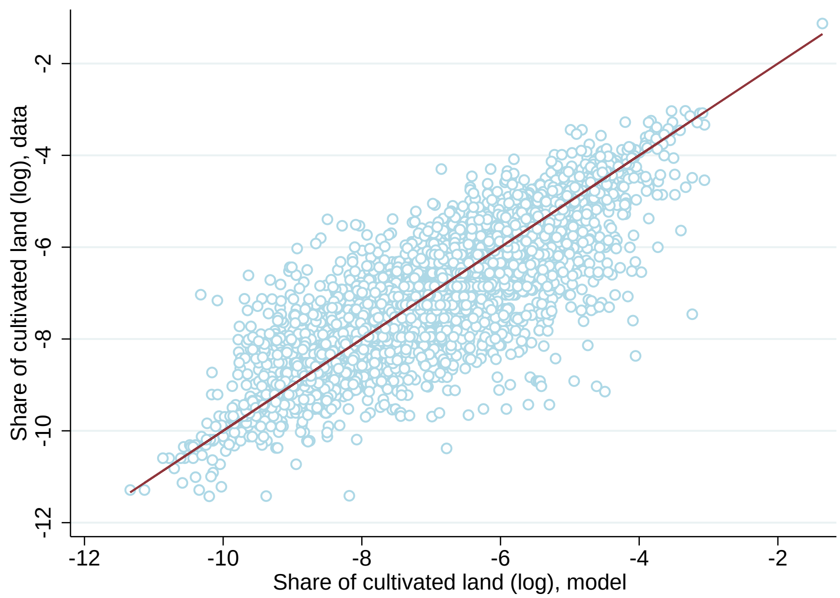
Figure 4 reports the estimated parameter values for θ_s, $\sigma^2_{\epsilon s}$, and $\ln(1 + \tau_s)$ against the respective moments that provide their identification in the data across states (see Appendix E, Table E.6 for the specific moments we use for each state in estimating land market distortions and the resulting estimated parameter values).

There is a systematic pattern of land distortions and rental markets across states (see Appendix E, Figure E.4). Land distortions are less severe in states with more active rental markets. The estimates of θ_s, for example, range from 1.01 in Tamil Nadu to 0 in Uttar Pradesh. This wide range is consistent with evidence of the high correlation in other developing countries such as China, Malawi, Ethiopia, and Uganda where land markets are severely restricted, and of low correlation in developed countries such as the United States (Restuccia and Santaeulalia-Llopis, 2017; Adamopoulos et al., 2021; Chen et al., 2021; Aragon et al., 2021b). These patterns suggest that frictions tend to systematically constrain the more productive farmers that would like to expand. We also observe a systematic relationship between state-level rental market frictions and rental market activity.

5.4 Model Fit

We have taken a parsimonious parametric approach to capturing land market distortions in the data, summarized by three parameters: the slope and variance of farm-specific distortions, and a state-level barrier to leasing land. This approach successfully captures the disaggregated patterns of actual land allocations across states.

Figure 5: Land Allocations in the Model and Data, All Indian States



Notes: Cultivated land in farms relative to total cultivated land in each state in the model (unweighted average of 100 simulations) and data. The red line represents the 45 degree line.

Figure 5 reports the share of cultivated land in each farm as a proportion of total cultivated land in the state, for all farmers in India, both in the estimated model as well as in the micro data. It characterizes the overall fit of the model for the allocation of land across farms. The red line represents the 45-degree line which would be a perfect fit of the model to the data. The light blue circles represent farms in the model and the data. Note that despite the limited parameters imposed in the model, the estimates provide a fairly good fit of the land allocations in the data, with the circles closely around the 45-degree line.

Table 6, first column, provides a summary statistic of the fit of land allocations for each state. It reports the correlation between farm-level land shares in the model and the data. This correlation hovers around 80 percent for most states. Table 6, second and third columns, report the share of land operated by the 10 percent most productive farms in each state in the model and data. The model captures well the overall pattern of the allocation of land across productive uses.

Table 6: Land Allocations and Rented Land, Model and Data

	Correlation of Land Allocations Model and Data	Share of Land 10% Most Productive	
		Data	Model
India:	0.88	0.27	0.30
State:			
Andhra Pradesh (AP)	0.64	0.30	0.32
Assam (AS)	0.84	0.19	0.22
Bihar (BR)	0.71	0.26	0.41
Gujarat (GJ)	0.88	0.24	0.26
Haryana (HR)	0.79	0.27	0.39
Karnataka (KA)	0.85	0.26	0.27
Kerala (KL)	0.84	0.21	0.20
Maharashtra (MH)	0.88	0.27	0.27
Madhya Pradesh (MP)	0.88	0.37	0.37
Orissa (OR)	0.76	0.23	0.29
Punjab (PB)	0.75	0.33	0.39
Rajasthan (RJ)	0.87	0.27	0.29
Tamil Nadu (TN)	0.89	0.11	0.11
Uttar Pradesh (UP)	0.86	0.24	0.32
West Bengal (WB)	0.83	0.25	0.26

Notes: Column (1) reports the correlation between the share of land cultivated by a farmer in the data and the model for each state. Columns (2) and (3) report the share of land operated by the 10% most productive farms in each state in the data and the model. The model refers to the unweighed average of 100 simulations. The land shares for India are sample means, weighed by farmers per state.

5.5 Counterfactuals

Given our estimates of land market distortions for each state, we now explore counterfactuals aimed at assessing the aggregate consequences of land market frictions. Starting from the baseline calibrated model, we construct an "Efficient" counterfactual where all land market distortions are eliminated, that is we set $\tau_s = \theta_s = \sigma_{\epsilon s} = 0$. We also decompose the role of idiosyncratic versus state-level distortions by computing a "No idiosyncratic" counterfactual, were we set $\theta_s = \sigma^2_{\epsilon s} = 0$. For this counterfactual, we pivot the slope of distortions around the same mean, that is we set θ_s to zero and increase κ_s to keep the same average wedges in each state. Recall that the constant κ_s was normalized to zero in the baseline calibration. The gap between the efficient and the no idiosyncratic distortions counterfactuals (the ratio of efficient to no idiosyncratic) reflects the residual role of the state-level distortions τ_s.

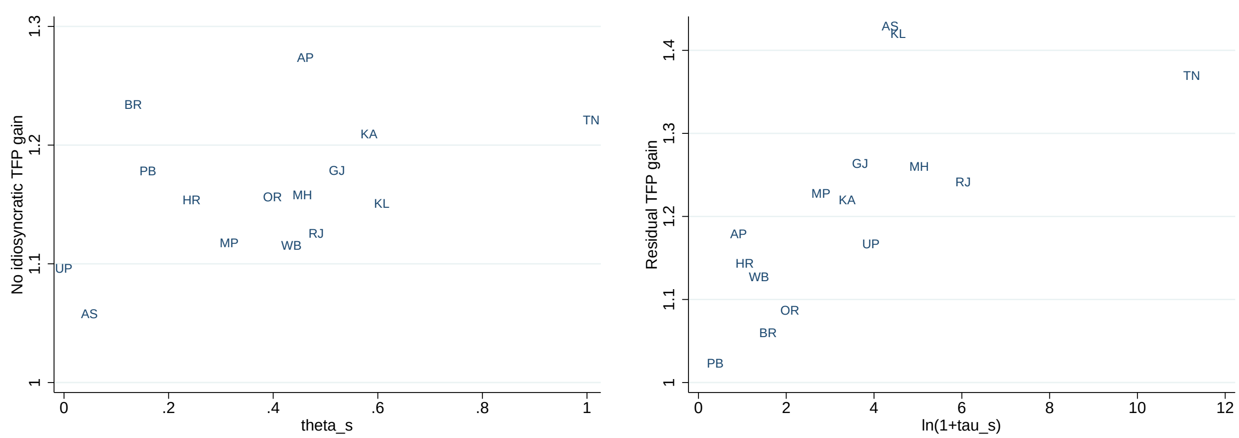
Table 7: Counterfactual Agricultural TFP relative to Baseline Model

	Efficient	No idiosyncratic	Residual
India:	1.38	1.15	1.20
State:			
Andhra Pradesh (AP)	1.50	1.27	1.18
Assam (AS)	1.51	1.06	1.43
Bihar (BR)	1.31	1.23	1.06
Gujarat (GJ)	1.49	1.18	1.26
Haryana (HR)	1.32	1.15	1.14
Karnataka (KA)	1.48	1.21	1.22
Kerala (KL)	1.63	1.15	1.42
Maharashtra (MH)	1.46	1.16	1.26
Madhya Pradesh (MP)	1.37	1.12	1.23
Orissa (OR)	1.26	1.16	1.09
Punjab (PB)	1.21	1.18	1.02
Rajasthan (RJ)	1.40	1.13	1.24
Tamil Nadu (TN)	1.67	1.22	1.43
Uttar Pradesh (UP)	1.28	1.10	1.24
West Bengal (WB)	1.26	1.12	1.37

Notes: Agricultural TFP relative to baseline model. "Efficient" is when $\sigma^2_{\epsilon s} = \theta_s = \tau_s = 0$. "No idiosyncratic" is when $\sigma^2_{\epsilon s} = \theta_s = 0$. Residual is the ratio of Efficient to No idiosyncratic counterfactuals and reflects the contribution of state-level land wedges τ_s. Values for India are sample means, weighed by farmers per state. Permanent TFP constructed using the estimated permanent (farm fixed effect) measure of farm TFP.

Table 7 reports the results of each counterfactual for agricultural TFP in each state and for the average of India. We emphasize the following results. First, eliminating land distortions to achieve an efficient allocation of resources would produce a substantial increase in agricultural productivity, especially among the least productive states. An efficient reallocation of land would increase agricultural productivity by 38 percent on average (15 percent relative to Punjab). But for some states the increase is much larger: 67, 63, and 51 percent in Tamil Nadu, Kerala, and Assam (39, 35, and 25 percent relative to Punjab). Such an increase in agricultural TFP would have a much larger effect on agricultural labor productivity because of the reallocation of labor away from agriculture (Restuccia et al., 2008) and other productivity enhancing effects such as better selection into agriculture (Adamopoulos et al., 2021), investment in productivity (Bento and Restuccia, 2017, 2021), the adoption of modern technologies (Ayerst, 2020), among others. We also find that the productivity gains from an efficient reallocation of land across states are systematically related to rental market activity, consistent with our previous empirical findings. The largest TFP gains are in states with the least active rental markets (see Appendix E, Figure E.5).

Figure 6: Decomposition of Agricultural TFP Gains



Notes: Agricultural TFP in each counterfactual relative to the baseline model. "No idiosyncratic" sets $\sigma^2_{\epsilon s} = \theta_s = 0$. Residual is the ratio of Efficient to No idiosyncratic counterfactuals and reflects the effect of state-level land wedges τ_s.

Second, both idiosyncratic farm-specific distortions and state-specific land wedges contribute substantially to depress agricultural productivity. For instance, eliminating idiosyncratic distortions increases agricultural TFP by 15 percent on average compared to 38 percent in the efficient allocation. As a result, idiosyncratic distortions contribute to about one-third of the reallocation productivity gains from eliminating distortions $(\ln(1.15)/\ln(1.38))$, with state-specific land distortions contributing to the remaining two-thirds of the average reallocation gains $(\ln(1.20)/\ln(1.38))$. Figure 6, Panel A, documents the positive relationship between the TFP gain in the no idiosyncratic distortions counterfactual and the elasticity of distortions θ_s, whereas Panel B in Figure 6 shows a positive relationship between the residual TFP gains and the state-level wedges $\ln(1 + \tau_s)$.

In order to illustrate the channels through which the efficient reallocation productivity gains are attained in each state, Table 8 reports two statistics related to the state of rental markets in the efficient counterfactual relative to the benchmark model: the share of farms renting in land (first column) and the share of land operated by the 10% most productive farms (second column). The efficient allocation implies a tripling of the share of Indian farms renting in. In the efficient allocation, the share of land operated by the 10 percent most productive farms more than doubles from 30 percent in the baseline model to 64 percent. Hence, both more rental activity and more land allocated to the most productive farms are key drivers of the productivity gains from an efficient reallocation of land across states.

6 Conclusions

We study distortions in land rental markets and their impact on agricultural productivity across states in India. We develop a model of land rentals across heterogeneous farms and use it to estimate land market distortions for each state. We find that rental market activity has substantial positive effects on agricultural productivity. For instance, an efficient reallocation of land would increase agricultural TFP by 38 percent on average and by more

Table 8: Other Statistics relative to Baseline Model, Efficient Counterfactual

	Change in share of:	
	farms renting	land operated by 10% most productive farms
India:	0.22	0.34
State:		
Andhra Pradesh (AP)	0.07	0.37
Assam (AS)	0.28	0.37
Bihar (BR)	0.34	0.18
Gujarat (GJ)	0.18	0.27
Haryana (HR)	0.15	0.21
Karnataka (KA)	0.13	0.48
Kerala (KL)	0.25	0.47
Maharashtra (MH)	0.20	0.44
Madhya Pradesh (MP)	0.21	0.28
Orissa (OR)	0.25	0.31
Punjab (PB)	0.14	0.10
Rajasthan (RJ)	0.21	0.44
Tamil Nadu (TN)	0.43	0.54
Uttar Pradesh (UP)	0.32	0.23
West Bengal (WB)	0.18	0.23

Notes: "Efficient" is a counterfactual with no land distortions, i.e., $\sigma^2_{\epsilon s} = \theta_s = \tau_s = 0$.

than 50 percent in some states. Our findings suggest that land market distortions contribute substantially to agricultural productivity differences across states.

We emphasize that despite the importance of resource misallocation embedded in our results, there are substantial differences in agricultural TFP across states that remain unexplained. In our analysis, these differences are absorbed by the district-level fixed effects when measuring farm TFP. It would be interesting to investigate the role of other differences in the characteristics of agricultural production and differences in land market distortions across states. For instance, the adoption and diffusion of productive technologies (such as modern seed varieties, intermediate inputs, and mechanization) depend on such distortions. At the same time, it seems relevant to further study the role of states' land quality endowments in accounting for productivity differences. We leave these important areas of research for future work.

References

Adamopoulos, T., Brandt, L., Leight, J., and Restuccia, D. (2021). Misallocation, selection and productivity: A quantitative analysis with panel data from china. *Econometrica*, forthcoming.

Adamopoulos, T. and Restuccia, D. (2014). The size distribution of farms and international productivity differences. *American Economic Review*, 104(6):1667–97.

Adamopoulos, T. and Restuccia, D. (2020). Land reform and productivity: A quantitative analysis with micro data. *American Economic Journal: Macroeconomics*, 12(3):1–39.

Aghion, P., Burgess, R., Redding, S. J., and Zilibotti, F. (2008). The unequal effects of liberalization: Evidence from dismantling the license raj in india. *American Economic Review*, 98(4):1397–1412.

Appu, P. S. et al. (1997). *Land reforms in India: a survey of policy, legislation and implementation.* Vikas.

Aragon, F., Restuccia, D., Rud, J., et al. (2021a). Heterogeneity, measurement error, and misallocation in african agriculture: A comment. Technical report.

Aragon, F. M., Restuccia, D., and Rud, J. P. (2021b). Are small farms really more productive than large farms? *Food Policy*, forthcoming.

Ayerst, S. (2020). Distorted technology adoption. Technical report, International Monetary Fund.

Banerjee, A. and Iyer, L. (2005). History, institutions, and economic performance: The legacy of colonial land tenure systems in india. *American economic review*, 95(4):1190–1213.

Banerjee, A. V., Gertler, P. J., and Ghatak, M. (2002). Empowerment and efficiency: Tenancy reform in west bengal. *Journal of political economy*, 110(2):239–280.

Beg, S. (2021). Digitization and Development: Property Rights Security, and Land and Labor Markets. *Journal of the European Economic Association*. jvab034.

Bento, P. and Restuccia, D. (2017). Misallocation, establishment size, and productivity. *American Economic Journal: Macroeconomics*, 9(3):267–303.

Bento, P. and Restuccia, D. (2021). On average establishment size across sectors and countries. *Journal of Monetary Economics*, 117:220–242.

Besley, T. and Burgess, R. (2000). Land reform, poverty reduction, and growth: Evidence from india. *The Quarterly Journal of Economics*, 115(2):389–430.

Besley, T. and Burgess, R. (2004). Can labor regulation hinder economic performance? evidence from india. *The Quarterly journal of economics*, 119(1):91–134.

Besley, T., Leight, J., Pande, R., and Rao, V. (2016). Long-run impacts of land regulation: Evidence from tenancy reform in india. *Journal of Development Economics*, 118:72–87.

Boehm, J. and Oberfield, E. (2020). Misallocation in the market for inputs: Enforcement and the organization of production. *The Quarterly Journal of Economics*, 135(4):2007–2058.

Chari, A., Liu, E. M., Wang, S.-Y., and Wang, Y. (2021). Property rights, land misallocation, and agricultural efficiency in china. *The Review of Economic Studies*, 88(4):1831–1862.

Chen, C. (2017). Untitled land, occupational choice, and agricultural productivity. *American Economic Journal: Macroeconomics*, 9(4):91–121.

Chen, C., Restuccia, D., and Santaeulàlia-Llopis, R. (2021). The effects of land markets on resource allocation and agricultural productivity. *Review of Economic Dynamics*, forthcoming.

De Janvry, A., Emerick, K., Gonzalez-Navarro, M., and Sadoulet, E. (2015). Delinking land rights from land use: Certification and migration in mexico. *American Economic Review*, 105(10):3125–49.

Deininger, K. and Feder, G. (2001). Land institutions and land markets. *Handbook of agricultural economics*, 1:287–331.

Deininger, K., Jin, S., and Nagarajan, H. K. (2009). Land reforms, poverty reduction, and economic growth: evidence from india. *The Journal of Development Studies*, 45(4):496–521.

Deininger, K. and Nagarajan, H. K. (2010). Land reforms, poverty reduction, and economic growth: Evidence from india. pages 225–279.

Dept. of Land Resource, Govt. of India (2009). Report of the committee on state agrarian relations and the unfinished task in land reforms. Accesses: 2020-06-24 https://dolr.gov.in/documents/report-of-committee-on-state-agrarian-relations.

Desai, S., Vanneman, R., and of Applied Economic Research, N. C. (2005). India human development survey (ihds), 2004-2005. *Inter-university Consortium for Political and Social Research [distributor], 2018-08-08*. https://doi.org/10.3886/ICPSR22626.v12 (accessed September 3, 2018).

Desai, S., Vanneman, R., and of Applied Economic Research, N. C. (2012). India human development survey-ii (ihds-ii), 2011-12. *Inter-university Consortium for Political and Social Research [distributor], 2018-08-08*. https://doi.org/10.3886/ICPSR36151.v6 (accessed September 3, 2018).

Foster, A. D. and Rosenzweig, M. R. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. *Journal of political Economy*, 103(6):1176–1209.

Foster, A. D. and Rosenzweig, M. R. (2017). Are there too many farms in the world? labor-market transaction costs, machine capacities and optimal farm size. Technical report, National Bureau of Economic Research.

Gollin, D., Parente, S., and Rogerson, R. (2002). The role of agriculture in development. *American Economic Review*, 92(2):160–164.

Gottlieb, C. and Grobovšek, J. (2019). Communal land and agricultural productivity. *Journal of Development Economics*, 138:135–152.

Gough, K. (1974). Peasant uprisings in india. *Economic and Political Weekly*, 9(13):1391–412.

Holden, S. T., Deininger, K., and Ghebru, H. (2011). Tenure insecurity, gender, low-cost land certification and land rental market participation in ethiopia. *The Journal of Development Studies*, 47(1):31–47.

Hsieh, C.-T. and Klenow, P. J. (2009). Misallocation and Manufacturing TFP in China and India. *The Quarterly Journal of Economics*, 124(4):1403–1448.

Jin, S., Deininger, K. W., and Nagarajan, H. K. (2006). Equity and efficiency impacts of rural land rental restrictions: Evidence from india. Technical report.

Kaushik, A. and Haque, T. (2005). Nature of land market interventions in india. *Institute for Sustainable Development Noida*.

Lahiri, A. and Yi, K.-M. (2009). A tale of two states: Maharashtra and west bengal. *Review of Economic Dynamics*, 12(3):523–542.

Le, K. (2020). Land use restrictions, misallocation in agriculture, and aggregate productivity in vietnam. *Journal of Development Economics*, page 102465.

Mearns, R. (1999). *Access to land in rural India*. The World Bank.

Mishra, P. and Suhag, R. (2017). Land records and titles in india. Accessed: 2020-06-24 https://www.prsindia.org/policy/discussion-papers/land-records-and-titles-india.

NITI Aayog, Govt. of India (2016). Report of the expert committee and model law on agricultural land leasing. Accessed: 2020-06-24 from https://niti.gov.in/sites/default/files/2020-05/Report-of-the-Expert-Committee-and-Model-Law-on-Agricultural-Land-Leasing.pdf.

Restuccia, D. (2019). Misallocation and aggregate productivity across time and space. *Canadian Journal of Economics/Revue canadienne d'économique*, 52(1):5–32.

Restuccia, D. and Rogerson, R. (2008). Policy Distortions and Aggregate Productivity with Heterogeneous Plants. *Review of Economic Dynamics*, 11(4):707–720.

Restuccia, D. and Rogerson, R. (2017). The causes and costs of misallocation. *Journal of Economic Perspectives*, 31(3).

Restuccia, D. and Santaeulalia-Llopis, R. (2017). Land misallocation and productivity. Technical report, National Bureau of Economic Research.

Restuccia, D., Yang, D. T., and Zhu, X. (2008). Agriculture and aggregate productivity: A quantitative cross-country analysis. *Journal of Monetary Economics*, 55(2):234–250.

Rosenzweig, M. R. and Wolpin, K. I. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in india. *Journal of political economy*, 101(2):223–244.

Singh, G. (2006). Agricultural machinery industry in india (manufacturing, marketing and mechanization promotion).

Verma, K. (2018). e-courts project: A giant leap by indian judiciary. *Journal of Open Access to Law*, 6(1).

World Bank (2007). Land policies for growth and poverty reduction. Accesses: 2020-06-24 http://documents.worldbank.org/curated/en/531431468035337578/India-Land-policies-for-growth-and-poverty-reduction.

Zou, H. and Hastie, T. (2005). Regularization and variable selection via the elastic net. *Journal of the royal statistical society: series B (statistical methodology)*, 67(2):301–320.

Appendix (For On-Line Publication)

A Land Reforms in India

The key elements of land reforms were: (i) abolition of intermediaries, (ii) regulation of the size of land holdings (land ceiling legislation), and (iii) tenancy reforms to improve tenure security. Governments implemented the abolition of intermediaries quickly and successfully. Land ceiling legislation was often ineffective at transferring holdings to landless households. Authorities often set ceilings too high, as they exempted land that was "productively used". Overall implementation was limited as state governments set additional costs and regulations. For example, Jin et al. (2006) describe how several states stipulated that beneficiaries of transferred land could only gain ownership rights once they had reimbursed the government for administrative expenses and the compensation it had paid to the original landowner. In Uttar Pradesh, beneficiaries did not receive ownership rights but became government tenants. In other states, new owners did not have the right to sell their new land for more than 10 years. [9]

Tenancy reform encountered considerable landlord resistance. Deininger and Nagarajan (2010) note that the implementation of land and tenancy reforms did not start in earnest until the 1970s. This allowed landlords to prepare by often evicting tenants and resuming self-cultivation, or by transforming tenants into wage workers. According to estimates by Appu et al. (1997) based on census data, about 30 million tenants—one third of the total active population in agriculture—were evicted in order to avoid having to give rights to tenants.

Table A.1 provides a summary of all land reforms passed between 1950 and 1980, as summarized by Besley and Burgess (2000). Table A.2 summarizes each state's restrictions on leasing land as from NITI Aayog, Govt. of India (2016). The reforms show a variety of interventions across states, from providing tenure security and ownership rights to systems that limit lease rights. The main takeaway is that tenancy reform took many different forms across states.

Why did the legislation and implementation of land reforms differ so much across Indian states? In British India, land revenue systems differed markedly by state and district. For instance, in a landlord-based system, the landlord had effective property rights whereas in

[9] See also Appu et al. (1997) and Mearns (1999) for other anecdotal evidence suggesting that authorities implemented land ceiling reforms ineffectively.

Table A.1: Description of Land Reforms in Indian States

State	Year	Description
Andhra Pradesh (AP)	1954	Protected tenancy status, minimum lease term, right of purchase non-resumable land.
	1974	Tenancy $\leq 2/3$ ceiling, confers continuous right of resumption on landowners, tenant gets right of purchase.
Assam (AS)	1971	'Occupancy' tenants have tenure security and may acquire landholding, subletting disallowed.
Bihar (BR)	1957	Rights of permanent tenancy in homestead lands on persons with < 1 acre of land.
	1973	Prohibits subletting, prevents sub-lessees from acquiring occupancy rights.
	1986	Provides underraiyats possibility to acquire occupancy rights.
Gujarat (GJ)	1960	Tenants entitled to acquire ownership right after one year land expiry, dwelling sites.
	1973	Regulated, limited opportunity to acquire ownership rights for tenants.
Karnataka (KA)	1961	Grants tenants right to purchase, fixes tenure for 1/2 leased area.
	1974	Removal of some exemptions earlier tenancy legislation.
Kerala (KL)	1963	Grants tenants right to purchase.
	1974	Call for employment security, fixed hours, minimum wages, etc..
	1979	Confers ownership rights on tenants with concealed tenancy.
Madhya Pradesh (MP)	1959	Past leasing prohibited, entitles tenants right to acquire.
Maharashtra (MH)	1950	Transfer of ownership to tenants of non-resumable lands (Marathwada region only).
	1958	Idem for all other regions
Orissa (OR)	1976	Tenure fixed for non-resumable area, subletting prohibited.
Punjab (PB)	1953	Tenure security for small-scale, continuous tenants.
	1955	Grants tenants right to acquire ownership of non-resumable land.
	1972	Limits on tenancy regulated land.
Rajasthan	1955	Confers tenure security to tenants and subtenants, ownership rights potentially transferable.
Tamil Nadu (TN)	1952	Greater tenure security.
	1956	Abolishment of usury and rack-renting.
	1965	Prohibition of tenant eviction.
	1969	Administration of tenancy records.
	1971	Prohibition of tenant eviction.
	1976	Acquisition rights for occupants.
Uttar Pradesh (UP)	1977	Tenants given complete tenure security, leases banned.
West Bengal (WB)	1950	Liberalization of sharecroppers harvest proportion.
	1953	Abolition of all intermediary tenures.
	1972	Full rights to tenants of homestead land.
	1975	Idem.
	1977	Raises presumption in favour of sharecroppers, minimum tenancy land size.

Notes: Land reforms from Besley and Burgess (2000). Year refers to most recent amendment. Besley and Burgess (2000) also include amendments when measuring the number of reforms.

individual- or village-based system, property rights were diffused. Banerjee and Iyer (2005) argue that variation in these types of systems is mainly explained by date of British conquest. Most states that were conquered early had landlord-based system before conquest. As the landlord-based systems were easy to set up, but costly to change, these systems persisted into independence. After British elites experienced a shift in views on governance in the 1820s, it became easier to establish non-landlord systems in states that came under British control at a later stage. Independence fueled class-based resentment in states with landlord-based systems, which led to demands for land reforms (e.g., Gough, 1974).

Table A.2: Description of Tenancy Reforms in India

State	Law Governing Leasing	Nature of Legal Restrictions on Land Leasing
Andhra Pradesh	Andhra Pradesh (Andhra Area) Tenancy Act, 1956, as amended in 1974.	There is no explicit ban on leasing. But the terms and conditions of leasing are restrictive. Any lease after 1974 has to be in writing and registered, for a minimum period of six years. Also on resumption of land by the landowner, the tenant has to be left with not less than one half of the land held by him under lease prior to such resumption.
Telangana	The Andhra Pradesh (Telengana Area) Tenancy & Agriculture Act, 1950, as amended in 1951, 1954, 1956, 1961, 1969 and 1979.	Leasing is prohibited except for certain categories of land owners, such as (a) landowners who own land equal to or less than three times the family holding* (section-7) and (b) disabled persons (a minor, a female, persons with physical and mental infirmity, persons in defence services with permission of district collector). A copy of every lease shall be filed before the tehsildar.
Assam	Assam (Temporarily settled Areas) Tenancy Act, 1971, applicable to the entire state.	No explicit ban on land leasing. Sub-letting is prohibited. Occupancy tenants who have held land as tenant for at least three years continuously enjoy security of tenure and can acquire ownership right on payment of compensation at the rate of 50 times the rate of annual revenue, payable for such lands. Non-occupancy tenant can acquire the right of occupancy if he has held land continuously for three years.
Bihar	Bihar Land Reforms Act, 1961.	Leasing is prohibited except by disabled ryots, i.e. a minor, a widow, or an unmarried, divorced or separated woman, or a person with physical or mental disability, or a person in the armed forces, or a public servant in receipt of salary not exceeding Rs. 250 per month (Section-19).
Jharkhand	Chhotanagpur Tenancy Act, 1908 and Santhal Pargana Tenancy Act, 1945.	Leasing is prohibited, except with permission from a competent authority (the Deputy Commissioner). This is required not only for Adivasis, but also for Scheduled Caste or backward caste raiyats to lease out land. Besides, the land cannot be transferred even to an Adivasi who does not reside within the jurisdiction of the same police station to which the landowner belongs (Section – 46(1) of CNTA).

Continued on next page...

Table A.2 — *Continued from previous page*

State	Law Governing Leasing	Nature of Legal Restrictions on Land Leasing
Gujarat	Bombay Tenancy And Agril, Land Act 1948, as amended by Act No. 5 of 1973 (erstwhile Bombay areas).	No explicit ban on land leasing, but the landowner risks losing the land when the tenancy is created. A tenant acquires the right to purchase the land leased within one year of lease period. Legal leases are possible only when the tenant is not in the position to exercise his or her right to purchase, due to financial difficulties or otherwise.
Gujarat	Saurashtra Land Reforms Act, 1951 and Prohibition of Leases Act, 1953.	Renewal of lease or a fresh lease after 1.9.1954 is prohibited except by persons under disability such as a widow, a minor, a member of the armed forces or persons suffering from physical or mental disability, or government, local authority, industrial and commercial undertakings.
Gujarat	Bombay Tenancy and Agricultural land (Vidharbha and Kutch Area) Act, 1958, as amended by Govt. of Gujarat in 1961, 1964, 1965, 1968 and 1973.	No explicit ban on land leasing. But the Act provides for voluntary purchase of ownership right.
Himachal Pradesh	The H.P. Tenancy and Land Reforms Act, 1972, as amended in 1976 and 1987.	Leasing out is banned except when done by disabled persons such as members of armed forces, unmarried, divorced or separated women, a widow, a minor, persons under physical or mental disability, or a student of a recognized institution.
Jammu & Kashmir	The Jammu & Kashmir Agrarian Reforms Act, 1976.	Creation of tenancy is banned without any exception.
Karnataka	The Mysore Land Reforms Act, 1961 as amended w.e.f. 1 March, 1974.	Leasing out is banned except when done by a soldier or a seaman.
Kerala	Kerala Land Reforms Act, 1963, as amended in 1969, 1971, 1972 and 1973.	Leasing out is banned without any exception.
Madhya Pradesh & Chhattisgarh	MP Land Revenue code, 1959, as amended up to date.	Leasing out is prohibited except when done by a disabled person (a widow, unmarried woman, married but separated woman, a minor, a person in imprisonment, a person serving in armed forces, a public charitable or religious institution, or a local authority, or a co-operative society).
Maharashtra	Bombay Tenancy and Agricultural land Act,1948, as amended in 1956 (for the old Bombay area) and The Hyderabad Tenancy and Agricultural Lands Act, 1950, as amended in 1954 for Marathwada (Hyderabad area).	No explicit legal ban on leasing. But the tenant has the right to purchase the land leased by him within one year of the creation of the tenancy. Any tenancy created after the tillers (i.e. 1st April, 1957) day, (except by the serving member of armed forces) is void, as the tenants shall acquire the right to purchase. Tenants cultivating personally on 1st April, 1957, i.e. the tillers day, shall be deemed to have purchased the ownership right from the landlord up to the ceiling area.

Continued on next page...

Table A.2 — *Continued from previous page*

State	Law Governing Leasing	Nature of Legal Restrictions on Land Leasing
Odisha	Orissa Land Reforms Act, 1965, as amended in 1973 and 1976.	Leasing out agricultural land is banned except by a person under disability or under a privileged raiyat w.e.f. 1.10.1965. A person under disability includes: (i) a widow or unmarried or separated women (ii) a minor, (iii) a person incapable of cultivating land due to physical or mental disability, (iv) a serving member of armed forces, (v) a raiyat whose land holding does not exceed 3 standard acres. A privileged raiyat means Lord Jagannath, any trust or institution declared as a privileged raiyat, or any other religious or charitable trust of a public nature.
Manipur	The Manipur Land Revenue and Land Reforms Act, 1960 as amended in 1975 (applicable to plain areas only).	Leasing is banned except by a person with a disability.
Punjab	Punjab Tenancy Act, 1887, The PEPSU Tenancy and Agricultural Lands Act, 1955, as amended in 1957, 1959, 1962, 1968 and 1969; Punjab Security of Land Tenancy Act, 1953 as amended in 1955, 1957, 1959, 1962, 1968 and 1969 and Punjab Land Reforms Act, 1972.	No explicit ban on leasing. But section 16 of the LR Act, 1972 provides that the tenant of a big landowner is entitled to purchase his land if he has been in continuous possession of the land for a minimum period of six years, if the land is not included within the reserved or ceiling area of the landowner, or when the landowner is a disabled person (widow or unmarried woman, or a person suffering from physical or mental disability). The land of the tenant must be below the ceiling. the tenant must have land below ceiling. A landowner with land below the ceiling can evict a tenant, subject to the tenant being left with not less than five standard acres.
Haryana	Punjab Security of Land Tenures Act, 1953 for the erstwhile Punjab area and PEPSU Tenancy and Agricultural Land Act, 1955 for PEPSU area, as amended up to date.	No explicit ban on land leasing. But there are other restrictive clauses, as in Punjab. However, the Haryana law does not provide the right to purchase rented land land falling within the ceiling surplus areas of land owner, as in Punjab. Such land vests in the government, although tenants are given preference in the allotment of such lands. A tenant can lease in land for a minimum period of three years, and a maximum of six years.
Rajasthan	Rajasthan Tenancy Act, 1955.	There is no explicit ban on land leasing. But the terms and conditions of lease are restrictive. A tenant is entitled to a written lease, which may be attested if not registered.
Tamil Nadu	Madras cultivating tenants protection Act, 1955 as amended in 1965 and Madras cultivating Tenants (payment of Fair rent) Act, 1956.	There is no explicit ban on leasing. But the landlord can use the land for personal cultivation, not exceeding one half of the land leased out to the tenant except when he is a member of armed forces. If the landlord owns above 13.5 acres of wet land, or pays sales, professional, or income tax, he cannot even resume land from the tenant. A tenant or agricultural laborer occupying any Kudiyirupees (a dwelling house or hut) cannot be evicted.

Continued on next page...

Table A.2 — *Continued from previous page*

State	Law Governing Leasing	Nature of Legal Restrictions on Land Leasing
Tripura	The Tripura Land Revenue and Land Reforms Act, 1960.	A raiyat or jotedar can lease out, but the tenant can hold the land in perpetuity. The lease cannot be terminated except by a person with a disability, i.e. a widow, a minor, an unmarried woman, or a divorced or judicially separated woman, or a member of the armed forces, or a person under physical or mental disability. A tenant under raiyat cannot be evicted from his land except by an order of a competent authority on specific grounds.
Uttar Pradesh & Uttarakhand	The Uttar Pradesh Zamindari Abolition Land Reforms Act, 1950.	Leasing is banned except when done by a disabled person and to agriculture-related educational institutions. A disabled person is defined as an unmarried, divorced, or separated woman, a widow, or a woman whose husband is incapable of cultivating due to physical or mental infirmity, or a minor whose father suffers from infirmity, or a person who is a lunatic or an idiot or blind, or a student of a recognized educational institution whose age does not exceed 25 years and whose father suffers from infirmity, or a serving member of the armed forces, or a person under detention or imprisonment.
West Bengal	The West Bengal Land Reforms Act, 1955 as amended in 1970, 1971 and 1981.	Only sharecropping is allowed. No fixed rent or fixed produce tenancy is allowed, not even by a person with a disability of any kind.

Source: NITI Aayog, Govt. of India (2016).

B Additional Tables/Figures Empirical

Table B.3: Determinants of Rental Market Activity—Including Sharecropping

	Dependent variable is whether a farm rents in land or not				
	(1)	(2)	(3)	(4)	(5)
	Probit	Probit	Probit	Probit	Probit
TFP (log)	0.143***	0.154***	0.344***	0.369***	0.369***
	(0.0329)	(0.0349)	(0.0341)	(0.0366)	(0.0393)
Own land (log)			-0.367***	-0.354***	-0.354***
			(0.0536)	(0.0508)	(0.0501)
State FE	N	Y	Y	Y	Y
Demographic controls	N	N	N	Y	Y
Land quality controls	N	N	N	N	Y
Observations	8359	8359	8359	8359	8359
R^2	0.01	0.08	0.125	0.14	0.14

Notes: In contrast to the main text, we classify sharecropping farmers as renters. Standard errors in parentheses, clustered by state. We standardize log TFP and log owned land within states. Demographic controls include a farm operator's age, gender, years of education, and whether the farm operator is literate or not. Land quality controls include the share of cultivated land that is irrigated, and the share of cultivated land that is used for orchard production. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Figure B.3 reports the relationship between rental market activity and the dispersion in the marginal product of land or TFPR across states. Panel A documents a strong negative relationship between the state-level standard deviation of the log marginal product of land and the share of households participating in the rental market. Panel B documents a negative relationship between the state-level dispersion in log TFPR and rental market activity.

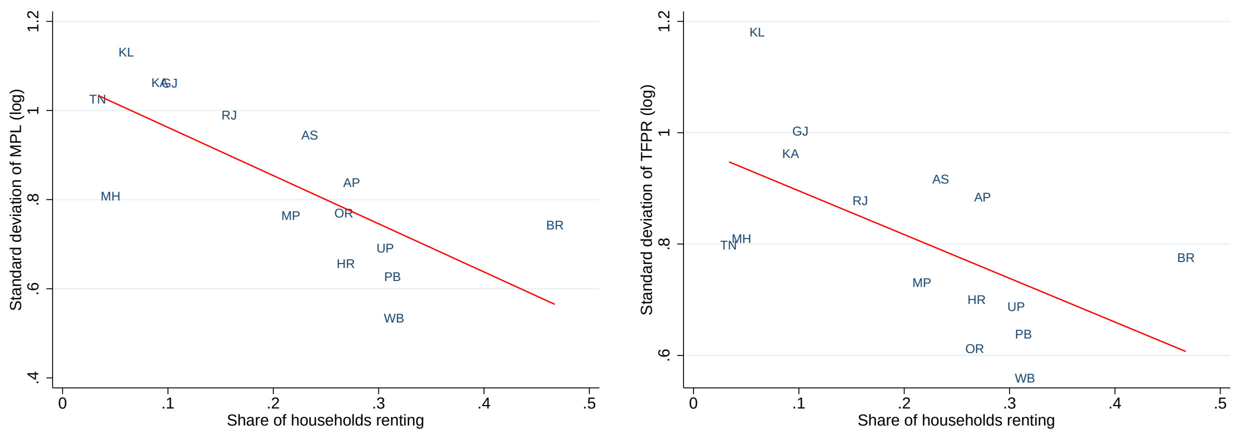
Table B.4: Land Rental Markets and Misallocation—Including Sharecropping

Panel A: Dependent variable is absolute deviation of (log) marginal product of land from state mean					
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
Share hh renting	-0.934**	-0.934**	-0.938**	-0.790**	-1.018***
	(0.329)	(0.329)	(0.325)	(0.304)	(0.192)
TFP (log)		-0.0155*	-0.0148	-0.0107	-0.0134
		(0.00799)	(0.00850)	(0.00749)	(0.00821)
Demographic controls	N	N	Y	Y	Y
Land quality controls	N	N	N	Y	Y
State-level controls	N	N	N	N	Y
Observations	8617	8617	8617	8617	8617
R^2	0.028	0.029	0.029	0.038	0.051

Panel B: Dependent variable is absolute deviation of (log) TFPR from state mean					
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
Share hh renting	-0.687**	-0.687**	-0.689**	-0.570**	-0.728***
	(0.249)	(0.249)	(0.245)	(0.245)	(0.228)
TFP (log)		-0.00276	-0.00460	-0.00233	-0.00168
		(0.00654)	(0.00789)	(0.00859)	(0.00832)
Demographic controls	N	N	Y	Y	Y
Land quality controls	N	N	N	Y	Y
State-level controls	N	N	N	N	Y
Observations	8638	8638	8638	8638	8638
R^2	0.022	0.022	0.024	0.029	0.041

Notes: In contrast to the main text, we classify sharecropping farmers as renters. Standard errors in parentheses, clustered by state. We standardize log TFP and log owned land within states. Demographic controls include a farm operator's age, gender, years of education, and whether the farm operator is literate or not. Land quality controls include the share of cultivated land that is irrigated, and the share of cultivated land that is used for orchard production. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Figure B.1: Rental Market Activity and Misallocation - Incl. Sharecropping



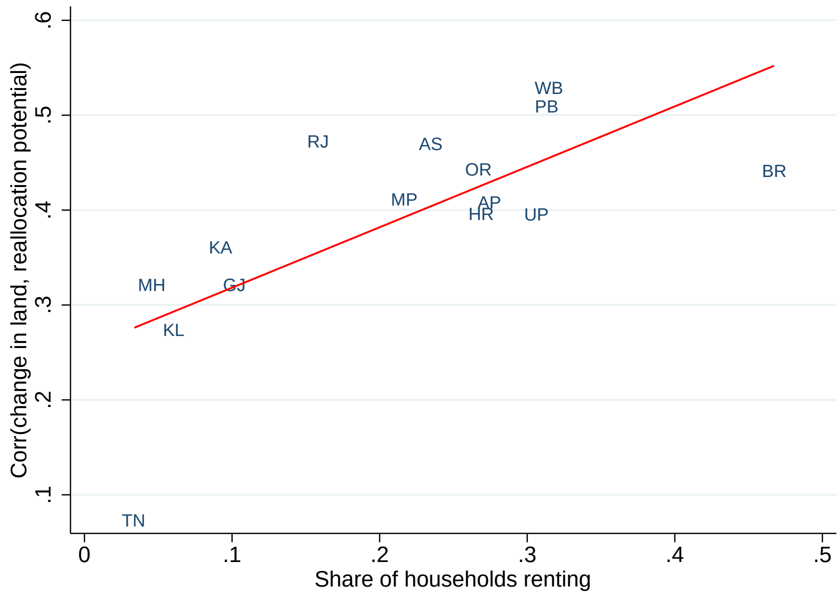
Notes: In contrast to the main text, we classify sharecropping farmers as renters. Panel A reports the standard deviation of (log) farm-level MPL and panel B the standard deviation of (log) TFPR both with respect to the share of households renting in each state.

Table B.5: Land Reallocation and Rental Markets—Including Sharecropping

Dependent variable is change in (log) cultivated land between waves I and II	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
Reallocation potential wave I	0.273***	0.177***	0.142***	0.145***	0.126***
	(0.0274)	(0.0329)	(0.0185)	(0.0189)	(0.0201)
Reallocation potential wave I		0.599***	0.750***	0.743***	0.776***
		(0.160)	(0.108)	(0.107)	(0.107)
State FE	N	N	Y	Y	Y
Demographic controls	N	N	N	Y	Y
Land quality controls	N	N	N	N	Y
Observations	8638	8638	8638	8638	8638
R^2	0.150	0.160	0.222	0.225	0.233

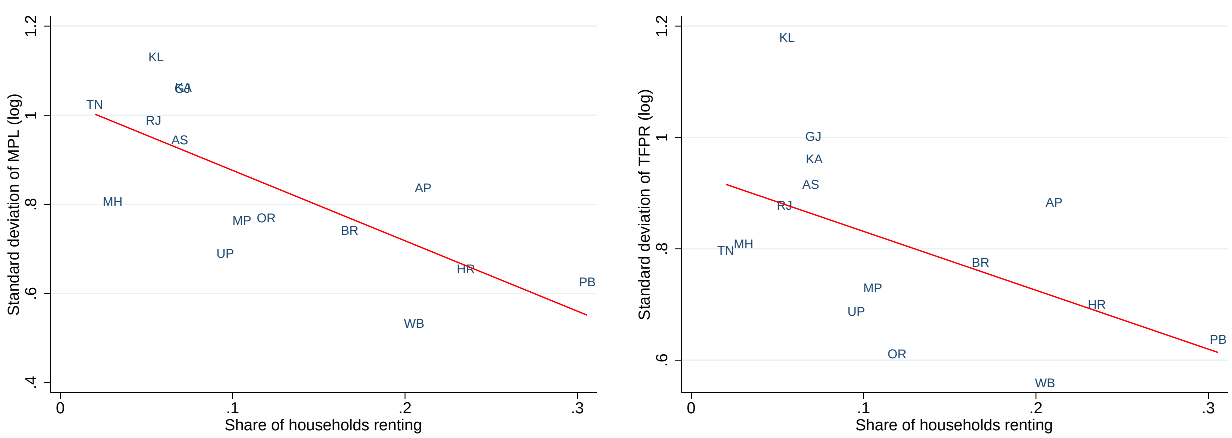
Notes: In contrast to the main text, we classify sharecropping farmers as renters. Standard errors in parentheses, clustered by state. We standardize log TFP and log owned land within states. Demographic controls include a farm operator's age, gender, years of education, and whether the farm operator is literate or not. Land quality controls include the share of cultivated land that is irrigated, and the share of cultivated land that is used for orchard production. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Figure B.2: Land Reallocation and Rental Market Activity—Including Sharecropping



Notes: In contrast to the main text, we classify sharecropping farmers as renters. The correlation between farm-level change in cultivated land and reallocation potential in wave I and the share of households participating in the rental market across states. Data from IHDS-I and IHDS-II.

Figure B.3: Rental Market Activity and Misallocation



Notes: Panel A reports the standard deviation of (log) farm-level MPL and panel B the standard deviation of (log) TFPR both with respect to the share of households renting in each state.

C Solving for the Decentralized Equilibrium

First, we define the labor endowment of a state as $\bar{L}_s \equiv \sum_{is}^{F_s} l_{is}$, where l_{is} is the observed amount of land cultivated by farmer i in state s in IHDS-II. To correct for fallow land, we measure the land endowment $\bar{l}_{is}$ as the share of owned land that is cultivated. We then use the following algorithm to solve for the decentralized equilibrium in an economy with F_s:

Given each state distortions θ_s, τ_s, and $\sigma_{\epsilon,s}$, perform the following steps:

1. For each farmer, draw $\epsilon_{is} \sim N(0, \sigma_{\epsilon,s}^2)$.
2. Compute $MPL_{l_{it}=\bar{l}_{is}} = \gamma z_{is}(\bar{l}_{is})^{\gamma-1}$.
3. Guess land price q_s (the initial guess could be the land price associated with the efficient allocation of resources) and compute:
   - $q_{is}^{in} = \ln q_s + \theta \ln z_{is} + \epsilon_{is}$,
   - $q_{is}^{out} = \ln q_s + \theta \ln z_{is} - \ln(1 + \tau_s) + \epsilon_{is}$.
4. Partition farmers into three sets and compute demand for land l_{is}^D for each farmer:
   - $l_{is}^D = (\frac{\gamma z_{is}}{q_{is}^{in}})^{\frac{1}{1-\gamma}}$ if $\ln MPL_{l_{it}=\bar{l}_{is}} > q_{is}^{in}$,
   - $l_{is}^D = (\frac{\gamma z_{is}}{q_{is}^{out}})^{\frac{1}{1-\gamma}}$ if $\ln MPL_{l_{it}=\bar{l}_{is}} < q_{is}^{out}$,
   - $l_{is}^D = \bar{l}_{is}$ if $q_{is}^{in} \geq \ln MPL_{l_{it}=\bar{l}_{is}} \geq q_{is}^{out}$.
5. Compute total demand L_s^D for land
   - $L_s^D = \sum_{i=1}^{F_s} l_{is}^D$,
6. Check $f = L_s^D - \bar{L}_s$. If not converged, i.e., f not close to 0, update guess of q_s and iterate on (3)-(6) until convergence.

D Estimation of Land Distortions

We describe in detail the procedure for estimating the parameter of land market distortions: τ_s, θ_s, and $\sigma_{\epsilon,s}$.

Variation in the data. We use three sources of variation in the data to identify the three parameters determining land distortions:

- If $\tau_s = 0$, most farmers participate in the rental market. The share of farmers renting in thus gives us variation to identify τ_s.
- If $\tau_s = 0$ and $\theta_s = 0$, the covariance between $\ln MPL_{is}$ and $\ln z_{is}$ equals zero. This covariance thus gives us variation to identify θ_s, conditional on τ_s.
- If $\tau_s = 0$, $\theta_s = 0$ and $\sigma^2_{\epsilon s} = 0$, the variance of $\ln MPL_{is}$ equals zero. This variance thus gives us variation to identify $\sigma^2_{\epsilon s}$, conditional on τ_s and θ_s.

Formally, we use three population moments (indexed by M^x):

(M^1) $cov(\ln MPL_{is}, \ln z_{is}) = cov(\mathbb{1}\{l^{out}_{is} > 0\}(\ln q_s + \theta_s \ln z_{is} - \ln(1+\tau_s) + \epsilon_{is}) + \mathbb{1}\{l^{in}_{is} > 0\}(\ln q_s + \theta_s \ln z_{is} + \epsilon_{is}) + \mathbb{1}\{l^{out}_{is} = l^{in}_{is} = 0\}(\ln z_{is}(\bar{l}_{is})^{\gamma}), \ln z_{is})$,

(M^2) $var(\ln MPL_{is}) = var(\mathbb{1}\{l^{out}_{is} > 0\}(\ln q_s + \theta_s \ln z_{is} - \ln(1+\tau_s) + \epsilon_{is}) + \mathbb{1}\{l^{in}_{is} > 0\}(\ln q_s + \theta_s \ln z_{is} + \epsilon_{is}) + \mathbb{1}\{l^{out}_{is} = l^{in}_{is} = 0\}(\ln z_{is}(\bar{l}_{is})^{\gamma}))$,

(M^3) $1 - \mathbb{E}(l^{in}_{is} > 0) = \Phi(\frac{1}{\sigma_{\epsilon,s}}(\ln MPL_{is} - \theta_s \ln z_{is} + (\ln(1+\tau_s) - \ln q_s))$.

Note that if $\tau_s = 0$, the first two moments simplify to the closed form solutions

$$cov(\ln MPL_{is}, \ln z_{is}) = \theta_s var(\ln z_{is}), \qquad var(\ln MPL_{is}) = \theta_s^2 var(\ln z_{is}) + \sigma^2_{\epsilon,s}.$$

Note that conditional on other parameters, θ_s governs M^1, $\sigma^2_{\epsilon s}$ governs M^2, and τ_s governs M^3.

Algorithm. We follow these steps to find parameter values for distortions:

1. Guess initial parameters $(\tilde{\theta}_s)_1$, $(\tilde{\sigma}^2_{\epsilon s})_1$, $(\tilde{\tau}_s)_1$. We use $\tilde{\theta}_s = 0.5$, $\tilde{\sigma}^2_{\epsilon s} = 1$, and $\tilde{\tau}_s = 0$.
2. For each of 100 different sets of draws $\{\epsilon^x_{is}\}_{i=1}^{F_s}$, solve the decentralized equilibrium using the algorithm in Appendix C.
3. Compute implied moments by averaging over 100 equilibria:

($\tilde{M}^1$) $\tilde{cov}(\ln MPL_{is}, \ln z_{is})$,

($\tilde{M}^2$) $\tilde{var}(\ln MPL_{is})$,

($\tilde{M}_1^3$) $1 - \sum_{i=1}^{F_s} \mathbb{1}(l_{is}^{in} > 0)$.

4. Compute distance D between actual moments (M^x) and implied moments ($\tilde{M}^x$):

$$D = \sqrt{\frac{1}{3}\sum_{x=1}^{3}(\frac{\tilde{M}^x - M^x}{M^x})^2}$$

5. If not converged (i.e. distance larger than tolerance), construct new implied moments using adjusted parameter guesses.

6. Iterate (2)-(4) until distance is less than tolerance.

E Additional Tables/Figures Model

Table E.6 summarizes the moments we use for each state in estimating land market distortions and the resulting estimated parameter values. As discussed earlier, states differ substantially in the observed dispersion of the marginal product of land across farms, which is indicative of distortions and land misallocation. For instance, many states have more than double the dispersion in the marginal product of land across farms relative to Punjab. The higher dispersion is systematically related with farm productivity, unlike in Punjab where the covariance of farm productivity and permanent TFP is fairly low. There are substantial differences in idiosyncratic distortions and state-level wedges, as shown in the last three columns of Table E.6.

Figure E.4 reports the estimated parameters of distortions ($\theta_s, \sigma_{\epsilon,s}, \tau_s$) for each state against the share of farmers renting.

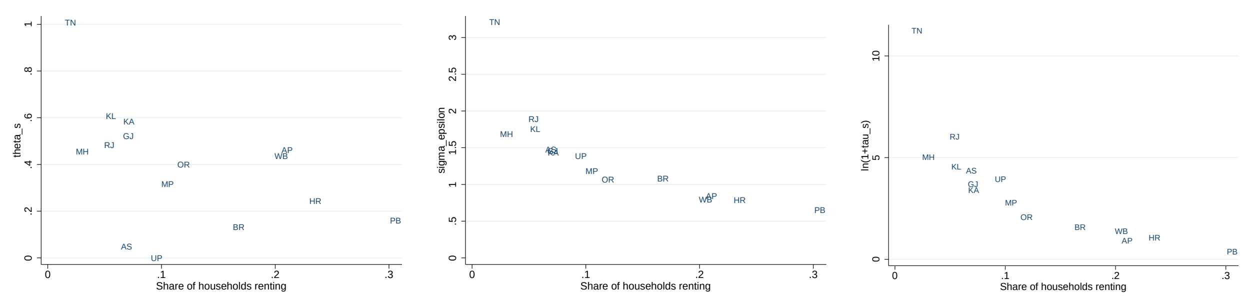
The gains across states from an efficient reallocation of land are systematically related to rental market activity. The largest TFP gains are in states with the least active rental markets, as documented in Figure E.5.

Table E.6: Targeted Moments and Estimated Parameters across Indian States

	Targeted moments			Estimated parameters		
	Covariance (lnMPL, lnTFP)	Variance (lnMPL)	Share renting in	θ_s	σ_s^2	$\ln(1+\tau_s)$
India	0.28	0.56	0.17	0.36	2.04	3.51
State:						
Andhra Pradesh (AP)	0.27	0.50	0.19	0.46	0.71	0.92
Assam (AS)	0.23	0.42	0.04	0.05	2.17	4.36
Bihar (BR)	0.11	0.52	0.12	0.13	1.16	1.58
Gujarat (GJ)	0.48	0.71	0.04	0.52	2.10	3.68
Haryana (HR)	0.17	0.35	0.16	0.24	0.62	1.06
Karnataka (KA)	0.46	0.73	0.05	0.58	2.05	3.38
Kerala (KL)	0.46	0.80	0.04	0.61	3.06	4.54
Maharashtra (MH)	0.32	0.56	0.03	0.46	2.84	5.02
Madhya Pradesh (MP)	0.24	0.40	0.06	0.32	1.39	2.79
Orissa (OR)	0.15	0.39	0.09	0.40	1.14	2.08
Punjab (PB)	0.09	0.32	0.23	0.16	0.43	0.38
Rajasthan (RJ)	0.40	0.65	0.02	0.48	3.56	6.02
Tamil Nadu (TN)	0.39	0.96	0.01	1.01	10.3	11.2
Uttar Pradesh (UP)	0.16	0.38	0.04	0.00	1.92	3.92
West Bengal (WB)	0.13	0.25	0.17	0.43	0.63	1.38

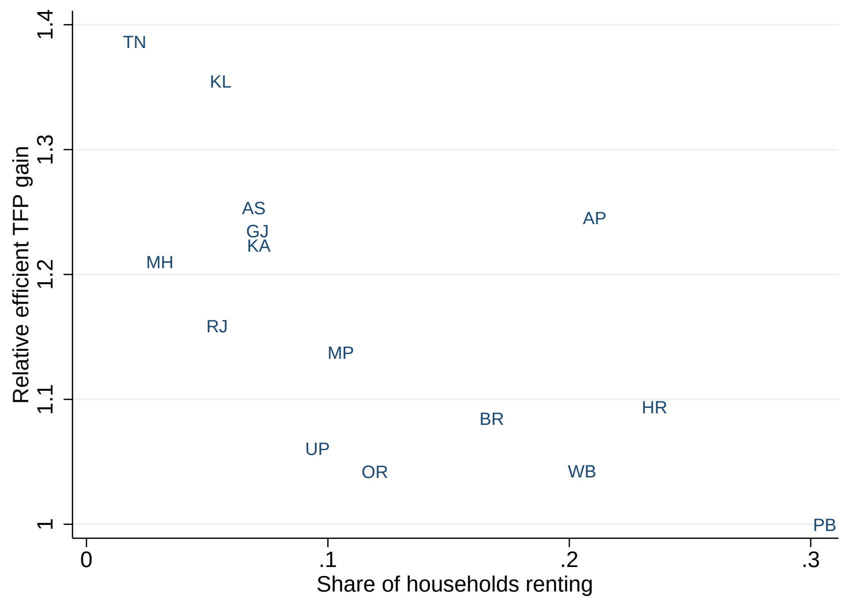
Notes: Moments used as targets in model estimation and estimated parameter values by state. The moments are: (1) the covariance of (log) marginal product of land and (log) permanent TFP across farmers, (2) the variance of (log) marginal product of land across farmers, and (3) the share of farmers renting in (some of) their operated land. Values for India are sample means, weighed by farmers per state.

Figure E.4: Land Distortions across Indian States



Notes: Estimated parameters of distortions against the share of farmers renting in each state. Panel A plots the estimated elasticity of land distortions with respect to productivity across farmers θ_s, panel B plots the estimated standard deviation of unsystematic idiosyncratic distortions, $\sigma_{\epsilon,s}$, and panel C plots state-level land wedges $\ln(1+\tau_s)$.

Figure E.5: Rental Markets and Relative Agricultural TFP Gains across States



Notes: Agricultural TFP gains are the aggregate productivity gains from an efficient allocation of resources in each state relative to Punjab.