Computerization and Development: Formalizing Property Rights and its Impact on Land and Labor Allocation

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Abstract

I test the land and labor market effects of a property rights reform that computerized rural land records, and provided access to digitized records and automated transactions to agricultural landowners and cultivators in Pakistan. Using the staggered roll-out of the program, I find that while the reforms do not shift land ownership, landowning households are more likely to rent out land and lower their agricultural participation. At the same time, cultivating households have access to more land, as rented in land and overall farm size per cultivating household increases. Improved tenure security also shifts the type of rental contracts, and the input choices of cultivators. Aggregate district level data suggests an improvement in overall crop yield. These results have implications for both the allocation of land across farmers and the selection of labor into farming.

Keywords: Property Rights, Rural Mobility, Agricultural Land Markets, ICT in Development, Institutions

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1 Introduction

Weak property rights and tenure insecurity leads to high transaction costs and market constraints that hinder the optimal allocation of productive inputs. Land market frictions in developing countries not only impede efficient trading of land, but also affects the occupational choices of individuals, in particular the selection of workers into agriculture (Adamopoulos et al., 2017; Chen, 2017). Agricultural landowners facing restrictions in renting out or selling their land select into farming when it might be optimal to practice a non-agricultural activity. Relatedly, barriers to purchasing or tenancy prevent productive famers from expanding the scale of operation and realizing returns to scale and mechanization. Foster and Rosenzweig (2011) state that efficient and productive agriculture exists in places where farms are large and mechanized, while in developing countries farming is predominantly small scale and traditional.[2] Understanding impediments to secure property rights and market activity, and the resulting constraints for occupational choices and farm expansion and modernization is crucial as agricultural productivity growth is imperative for development (Gollin et al., 2002).

In this paper, I examine the effect of a land records computerization program in Punjab, Pakistan, on land market transactions and labor market allocation. Leveraging this reform, which formalized land record maintenance and transactions, and improved access to property rights information, allows me to build on the comprehensive research documenting improved tenure security and investment as a result of large scale titling as well as of less intensive property rights regularization programs. This paper contributes to a gap in the existing literature by examining the market effects of land rights formalization, and establishing impacts on both land and labor market outcomes. I find evidence

[2] Adamopoulos and Restuccia (2014) note a 34-fold difference in average farm size (land per farm) between rich and poor economies.

that light-touch property rights reforms have the potential to relieve markets constraints through their effect on both the allocation of land across farmers, and selection of workers into farming. Resolving these frictions also impacts agricultural contractual choices, and the scale and input usage in farming.

Theoretical literature on property rights suggests that they affect production and efficient resource allocation through two broad channels — limiting expropriation and promoting market transactions, which can facilitate optimal investment and factor allocation, and relieve credit constraints (Besley and Ghatak, 2009). Additional theoretical support is offered by Chen (2017) demonstrates that untitled land cannot be traded across farmers, creating land misallocation and distorting individuals' occupational choice between farming and working outside agriculture. Empirical work constitutes identification of these channels by examining either large scale titling programs or programs that formalize property rights, without offering explicit land titles.

The literature establishes the positive effects of land titling and certification programs, as well as land rights formalization reforms, by inducing higher investment through the 'limiting expropriation' channel (Field, 2007; Do and Iyer, 2008; Galiani and Schargrodsky, 2010; Deininger et al., 2011; Ali et al., 2014).[3] Hornbeck (2010) proposes and finds evidence that farmers' ability to effectively protect their farmland using wire fences corresponded to improved property rights and is associated with greater investment and productivity. Relatedly, poiltical connections render higher security of tenure in Ghana, incentivizing investment and improving productivity (Goldstein and Udry, 2008).

Less consistent evidence has been documented for the theoretical argument that tenure security facilitates market activity. The evidence on large titling programs' effect on market transactions is generally inconclusive. Field and Torero (2006), Do and Iyer (2008) and Galiani and Schargrodsky (2010) do

[3] Also see Feder (1988); Besley (1995).

not find that titling significantly improves credit access, while Wang (2012), Carter and Olinto (1996) and López and Romano (2000) argue that that they do. Market effects of lighter touch formalization reforms are even less well-known—Deininger and Goyal (2012) find that land registry computerization in India increases credit access, though the effects are modest and only in urban areas. The existing literature is similarly lacking in comprehensive evidence of how tenure insecurity affects land rental and sales in particular, as well as the contract choices of landowners and tenants. Deininger et al. (2010) and Lunduka et al. (2010) provide evidence suggesting tenurial insecurity prevents the efficient functioning of the land rental market in Ethiopia and Malawi. Macours et al. (2010) find that tenurial insecurity constrains the matching of landlords and tenants in Nicaragua. Even fewer papers systematically identify the effect of property rights and security on labor choices, particularly in rural areas. This paper fills this gap in the literature by documenting the benefits of a property rights computerization program in progressing tenure security, and facilitating land and labor market activity without extensive land titling.

Property rights and land market transactions are non-existent or excessively informal in the vast majority of developing countries. In Punjab, land records have been maintained under the same structure since the colonial period—records of 20 million landowners were held by 8000 local officers or *patwaris*, who manually updated and managed these records.[4] The inefficient and dispersed land records system has led to tenure insecurity, with owners relying on the discretion of the *patwaris* for any transaction or proof of ownership and tenancy rights. These barriers to land transactions and security of property result in high transaction costs and low mobility of land, potentially affecting the scale of farming and the labor market choices of rural landowners.

In 2009, the Punjab government launched the Land Record Management

[4] *Patwari* was a historically appointed officer during the British colonial government, and has persisted as an office in the present land management system.

Information System to formalize and centralize land records in the province. Through this program, which was phased out in stages across all districts of the province, land records were obtained from the *patwaris*, computerized and made available to the public at a central location in each sub-district. While no titles are given out as part of the program, an owner or tenant can go to a designated center and obtain a government attested copy of his ownership or tenancy status. All land transactions and changes to ownership or tenancy are conducted digitally at this designated center. The program thus represents an overhaul of an informal system that is replaced with a more centralized and computerized system. Automation of land transactions reduces the influence of *patwaris* and other local officers who initially acted as 'middle-men' in land transactions. I use the staggered roll-out of the program between 2010 and 2015 to document effects on rental market participation and labor choices of landowning households. I also text the program's effects on farming operation, particularly, tenancy, farm scale, inputs and productivity among cultivating households.

I find evidence that the program increased rental market transactions as shown by a higher likelihood of renting out by landowners in districts as they receive the program. Consistent with higher likelihood of rental activity, I find that the rate of agricultural participation by landowners goes down, supporting the idea that market frictions affect selection of workers across sectors. Land owning households shift into non-agricultural occupations, particularly business ownership. This increase in renting out is driven by lower income, and potentially less connected households, who may have faced tenure insecurity and market constraints more acutely. I do not find any significant effects on land ownership or land sales and purchases, suggesting these market frictions cannot be resolved with the simple computerization reform as this one.

While landowners are more likely to rent out land and exit agriculture,

households that stay in cultivation increase their scale of farming as shown by higher average farm size in program districts. There is a shift in the type of tenancy contracts towards fixed cash rental and away from sharecropping, supporting previous evidence that sharecropping is more likely to prevail when tenure insecurity is high (Bellemare, 2012). Heterogeneity analysis shows that land availability and farming scale increases predominantly for landless cultivators through greater access to leased land. There is suggestive evidence that input usage changes as a result of improved tenure security and increased farm scale. Cultivating households switch crop choice, and are more likely to utilize pesticides. Suggestive evidence points to increased adoption of farm machinery, which is consistent with both improved tenure security and increase farm scale. Household level data does not provide evidence of improvement in farm output or yield, but district level data on aggregate output by crop show greater improvements in yield in districts that receive the program sooner. Thus, the paper is cautious in claiming large affects of the program on agricultural productivity; however, the changes to land allocation, farming scale and inputs, and aggregate output provide suggestive evidence for allocative efficiency and productivity improvement due to the program.

I make a few contributions to the extensive body of empirical literature on property rights by looking at the computerization of land records in Punjab province of Pakistan. First, I provide direct evidence of the role of property rights insecurity in hindering agricultural land rental. Land contracting laws in China studied by Chari et al. (2017), facilitate land rental and result in a reallocation of land across farmers, improving allocative and productive efficiency. The findings of this paper indicate the that even with privately owned property, transaction costs in the land market may restrict land rental activity. Formalizing land records and transactions can enhance tenure security and facilitate rental transactions without explicit legislation as in Chari et al. (2017).

The second contribution of my paper is the additional effects that I document on labor allocation of landowning households as a rental transaction costs go down. Several studies have noticed the obstacles to occupational and geographic mobility in developing contexts, and its impact on agricultural and overall productivity (Chen et al., 2017; Bryan et al., 2014). In establishing the land and labor market effects of the property rights reform, I also contribute to the recent, but rapidly growing, literature on broad misallocation in factor markets in developing countries Hsieh and Klenow (2009); Restuccia and Santaeulalia-Llopis (2017); Adamopoulos et al. (2017).

Third, I focus on a light touch program in a context with private ownership, without explicit titling or direct targeting of market transactions. The existing complexity of land rights in Pakistan, lack of information on part of the citizens as well as authorities, and discrepancies in distribution of power in a rural context where land rights and power are connected Beg (2019), make it infeasible and costly to implement a universal land titling program. The program in Punjab converts the manual paper-based land records into a computerized database and marks a significant improvement to the land record management system that is a key precedent for well-defined property rights. As Roth and McCarthy (2013) note formalization does not mean formal land titling and registration; rather, there is a continuum of land rights formalization that extends from strengthening tenurial rights in law to better communicating those rights to land holders to resolving conflicts associated with rights clarity to strengthening informal land leasing arrangements and contracts to formal titling and registration within both individual and group contexts. The Punjab land record computerization program is a 'soft-touch' intervention, in contrast to the titling programs, and resulted in a formalization of property rights through better clarity of rights and automation of market transactions bypassing bureaucratic hurdles and corrupt officers.

Fourth, there is less focus in property rights in the context of South Asia,

where land rights, particularly in rural areas, are haphazardly maintained and persistently informal. Agricultural participation is still pretty high in South Asian countries - 50% of total labor force in India, 45% and 48% in Pakistan and Bangladesh, respectively (compared to 24% for middle income countries) (World Bank, 2013). On the other hand agriculture accounts for just 18% of the GDP on average for South Asia.[5] Consistent with the high participation in agriculture, the average proportion of rural population in South Asia is 67% of the total, lower by 16 percentage points in the 50 years since 1960.[6] The rural-urban transition is relatively slower compared to Latin America for example, where the share of rural population fell by more than half from 51 to 20% between 1960 and 2013. Indeed, many have noted that despite accelerating economic growth, the structural transformation in India and South Asia has generally been slow (Binswanger-Mkhize, 2013). Improving tenancy security and rights of land use, as I explore in this paper, can potentially stimulate labor market allocation, productivity and structural transformation.

Lastly, I highlight that the role of ICT in governance and public service delivery holds substantial promise for lower income nations (Banerjee and Jain, 2003; Ghosh and Banerjee, 2006). Banerjee et al. (2014) find that disbursing program funds through an electronic method reduces the number of administrative tiers involved and consequently lowers leakages of public funds. The land record computerization program similarly improves access to property rights records, and automates the land transaction process eliminating the role of officers and administrative departments whose involvement made the process prone to corruption and delays. Thus the paper also illustrates the use of ICT to promote market development and repress instances corruption and bureaucratic inefficiencies under limited state capacity.

The next section describes the background of land markets in Punjab and

[5] 17%, 25% and 16% for India, Pakistan and Bangladesh, respectively.
[6] 61% of the population is rural in Pakistan, down from 78% in 1960.

the reform. Section 3 describes the general empirical specification and data and section 4 describes the effect of the program for landowning and cultivating households. Section 5 discusses the validity of findings and offers additional robustness checks and section 6 concludes.

2 Background[7]

Punjab, the context of the study, has a total area of 205,345 square kilometers and is the most populated province of Pakistan with 80.5 million inhabitants (55.6% of Pakistan's total population), 70% of who live in rural areas. Agriculture plays an important role in the province's economy. The Board of Revenue bears responsibility of the administration of agricultural land. Most land is privately owned, although there is some communal and state owned land. The history of the land revenue system in Pakistan dates pre-colonial Sultan Alauddin Khilji (1255—1316), who was the first ruler to introduce a system of land administration in the Sub-continent. Mughal emperors laid foundations for a system of land administration in South Asia that the British colonists improved and formalized. The British appointed formal revenue officials charged with maintenance of land records and collection of land taxes. This land record system inherited by Pakistan at independence underwent minimal changes in over a 60 year period.

Several levels of administration are involved in the land record maintenance: the District, Subdistrict, Kanungo circle, and Patwar circle. At the lowest administrative level of the records system – the Patwar Circle – are *patwaris*. They are the custodian of land rights records as well as responsible for many social, political, and administrative tasks including maintenance of weather records, crop harvest information, village crimes reports, and voter registers. The *patwari* keeps the particulars of landowners and tenants up to date, supplies copies of

[7]Background about land record documents is based on United Nations Human Settlements Programme (2012)

revenue records to the public and handles the sale and purchase or creation of lien or charge or loan on any property. In Punjab, about 8,000 *Patwaris* maintain land records pertaining to 20 million land owners, holding them so informally as in a cloth bag called a 'Basta'. Above the *patwari* are other land revenue officers with monitoring and bureaucratic roles. The *patwari* is thus the first point of contact for any land owner or tenant seeking land record services. Any land transaction is initiated at the level of the *patwari*, and affected at upper administrative levels.

Land records are maintained through various statements, of which I describe the most commonly used and relevant to this study below. First, the document that most citizens are primarily concerned with is the *Register Haqdaran Zamin* or Land Right Holders Register, which lists the owners of the lands, including identifying details of the cultivator or tenant, soil and rent (figure 1). Individual ownership documents or *Fard Malkiyat/Fard* can be prepared using the *Register Haqdaran Zamin*. The register of right holders corresponds to a *Mussavi* or a cadastral map of a village (see figure 2). These maps were initially prepared by the British and specified each land parcel in a village with a unique parcel or (*Khasra*) number and dimensions (Hunter et al. 1908). Any changes to land rights are recorded in a separate register of mutations, *Register Inteqalaat)*, which is used to update the register of right holders every four years. All of the above documents are held and maintained by the *patwari*. Additionally the *patwari* maintains a *Khasra Girdawari* which records the cultivator and crop information by *khasra* or land parcel.

Tenants' and landowners' rights, and updates that arise due to rental or sale, are thus recorded and updated using a combination of the above documents at the discretion of the *patwari*. Recording updates, or acquisition of the *Fard* or *Khasra Girdawari* are the most common services offered to citizens through the land revenue records system. For instance if a land owner rents out land to

a tenant, the *Khasra Girdawari* is updated for the relevant land parcel and the *Register Haqdaran Zamin* is updated to reflect cultivating rights of the tenant. A survey conducted by Gallup Pakistan for the Board of Revenue found that 42% of a sample of land owners and cultivators from Punjab report higher dissatisfaction with the system of land records than with other government departments. 64% describe the system as lacking transparency and 82% report having to pay a bribe at some point to obtain land record services. The vague and outdated system was thus prone to corruption and potentially led to tenure insecurity. 76% of respondents in the poll reported illegal occupation of land as the main form of land dispute and 56% identified that the major source of all land disputes was incorrect land records. These reports indicate that the old system suffered from problems with tenure security for owners and cultivators, resulting in frictions in market activity. Owners may be deterred from renting out and cultivators from renting in due to the risk of illegal occupation and inability to verify and uphold their rights under the existing system.

Under the existing land legislation, there is no formal state certificate or title to land; transfers, sales and attestation of land rights (through the *Fard*) are conducted based on the local officers' records and arbitration. The local officers' act as middle-men in land market transactions and their responsibility over record keeping yields considerable influence to them. In 2010, the Government of Punjab in India with a similar land administration system made attempts to abolish colonial posts like *patwaris* and *kanungos*. They noted that officers at the lower rung in state's revenue department were often accused of corruption and making 'fraudulent changes' in the revenue records of the area in which they have jurisdiction (Sural, 2013).

With urbanization the land rights continue to be maintained by *patwaris* until an agency or urban development authority acquires the land. The urban land record system is similarly opaque. Overall there is no single agency maintaining

updated urban land records for all of Punjab, and there is limited coordination in record keeping functions being carried out by the various agencies. The ambiguity of law regarding records of land rights is particularly harmful to the poor, who cannot afford protracted land disputes. Numerous legal disputes result from limited enforcement of land rental contracts, e.g. illegal possession of land, eviction of tenants, and recovery of rent.[8]

The overall dispersed and duplicative nature of land records makes land rights uncertain, negatively impacts economic development, and threatens the vulnerable and the poor whose rights remain virtually unprotected. Beginning in years 2005-2009, the Government of the Punjab received financial support from the World Bank to begin the computerization of land records with the objectives of improving service delivery and enhancing the perceived level of tenure security. The main objective of this endeavor was to facilitate increased access to land records at low costs, specifically for the poorest and less connected households. The provincial government department noted that:

> Inequalities of land distribution, tenure insecurity and difficulties associated with the land administration and registration system are closely interrelated and continue to impose significant constraints on both rural and urban populations, particularly the poor. Land transactions are relatively high cost, and disputes about accuracy of land rights are caused, among others, by the inefficient and dispersed land records system. As a result land markets are thin and land prices are in excess of the discounted value of potential agricultural earnings from land. The low mobility of land contributes to perpetuating the highly unequal distribution of land and, thus, livelihood opportunities. (World Bank – Project Information Document 2005)

The first objective of the program was to computerize all land records, including the *Haqdaran Zameen* and Khasra Girdawari, as currently maintained by the local level *patwar* officers—these include all rural land records, as well as urban records that still fall under the agrarian land record maintenance system.

[8]Cases of land disputes are either handled by the Revenue Courts or Civil Courts, but cannot be resolved efficiently due to lack of decisive land rights records.

The second objective was to establish a service center in each subdistrict of the province to host these records and replaced the lower level land record officers for maintaining and updating these records and providing citizens with land mutation, *fard* issuance and other land record related services. The computerized records establish both the identity of the owner and tenant, and can be looked up on the world wide web or obtained from the designated service centers. The cadastral maps were not digitized initially but their digitization is part of the agenda under the new record maintenance system.

The right holders (owners or tenants) can visit a service center where the staff can search and verify their record using their national ID number, providing the client with a copy of their record within minutes. This service center can provide owners with a government attested copy of the record, allowing him/her to use that record in a court of law similar to using a title. Any mutation, due to to sale, transfer or inheritance, is to be registered at the same service center. These services were initially provided by the *Patwari*; following the new system, a signature from the *patwari* would not be required for the registration of any transaction, as it was previously. One hundred and fifty centers across the province now provide automated land records services, reducing the average time required to complete transactions from 2 months to 45 minutes (Gonzalez, 2016). Specifically, because all statements of ownership and cultivation rights are computerized and centrally maintained, the program enhances security of tenure for owners as well as tenants.

While the service centers increased access to digitized records and centrally maintained records of ownership and cultivation rights, they may have a simultaneous limiting affect through reduced proximity to land records. Initially, a *patwari* was available for each *patwar* circle, which comprises a few proximate villages, and was well-know to all village members in his jurisdiction—once all

service centers are fully operational, only one center is available per subdistrict.[9] Thus, individuals are expected to pay higher travel costs to access the centralized records. In the case of *Fard* transfer, due to inheritance or sale, these travel costs still needed to paid prior to the program as transacting parties were required to visit district revenue offices at several stages to complete their transaction. Time and distance cost could effectively be lower after the program even with many fewer service centers than *patwaris*. Changes to cultivation, for instance in the case of land rental, are still initially reported to the *patwari*, who then send updated records to services centers at the beginning of each agricultural season. Rental transaction are thus un-affected in terms of their process, but record is transitioned from being manual and disaggregated to digital and central.

The project thus resulted in two main changes to the pre-existing system: (1) Centralized record keeping for ownership and tenancy rights, and (2) low cost and centralized land transactions. By making the computerized land record centrally available at sub-district level the new system decreased the influence of the local officers and *patwaris* in both land record keeping and land transactions. It offers considerably better access and verifiability for ownership and cultivation rights, Thus the program has potential effects on both tenure security and, consequently, the land market.

3 Empirical Strategy and Data

I exploit the staggered rollout of the program by using a difference in difference strategy to compare trends in districts that received the program earlier relative to those that received it later. The program roll out began in 2009 when one service center was set up to facilitate the field work required for obtaining, verifying and computerizing land records. Figure 3 shows the rollout of the service center

[9] Eve though the *patwar's* role is not abolished, 150 service centers took on the tasks provided previously by approximately 8000 *patwaris*

after this initial stage. A database was created for each subdistrict with the computerized village records and the service centers provided rights verification and land transaction services. The program proposed one service center for each subdistrict that would be located in the 'tehsil' or subdistrict capital. By 2015 all subdistricts have a functioning service center. Since the household survey data provides the districts each household belongs to, I use the fraction of subdistricts in a district d that have a functioning service center by year t to obtain program intensity at district level. I run the following specification at the household level:

$$y_{idt} = \beta_0 + \beta_1 ProgramIntensity_{dt} + \Psi_{idt} + \Pi_d + T_t + \Pi_d \times T + \epsilon_{dt},$$

where y_{idt} is an outcome for household i in district d and year t. Ψ_{idt} are household level controls, Π_d and T_t are district and year fixed effects, respectively. To control for district specific trends, I include an interaction of district fixed effects with a linear yearly trend. Standard errors are clustered at the district-year level. The district fixed effects account for time-unvarying differences across districts, allowing me to estimate the change in outcomes as the program intensity increases in any specific district. The major concern in this kind of an identification strategy would be that districts, particularly those where the program was implemented with higher intensity, experience differential trends even in the absence of the program. I thus control for district specific trends to account for differential trends in outcomes across the districts. Even if outcomes have a different trend across districts, unless this trend is collinear with the progress of the program in a specific district, we should be able to estimate the effect of $ProgramIntensity_{dt}$. Later I conduct additional tests to validate the identification strategy.

I focus on the co-efficient on $ProgramIntensity_{dt}$ measured by the number of service centers in any district as a percentage of the maximum the district can have. The maximum service centers in a district is the number of subdistricts. There are 36 districts and 150 subdistricts in total. Table 1 shows the average val-

ues of $ProgramIntensity_{dt}$ over the sample period. Thus, $ProgramIntensity_{dt} = 1$ indicates that all subdistricts in district d have the program; the coefficient β_1 then represents the difference in the trend in district where the program is completed relative to districts where the program has not begun.

The program progress data is obtained from the Board of Revenue of Punjab, outlining the operational date for each service center in the province. The household data is obtained from Household Income and Expenditure surveys (HIES) surveys conducted bi-yearly across the country. The HIES surveys are conducted at the provincial level — I use 5 HIES survey rounds from 2005 to 2015. These surveys, conducted in 2005-6, 2007-8, 2011-12, 2013-14 and 2015-16, collect demographics, employment, expenditure and saving information from a sample of approximately 18,000 households across the country.[10] Aggregate crop output data is obtained from the Agricultural Statistics of Pakistan, which records the overall production and area cultivated for each crop at the district level for each year. Summary statistics from the household data are shown in Table 2.

4 Results

Lack of ownership security restricts landowners from trading their land, i.e. renting out or selling their land. Only 22 percent of landowning households report renting out their land, while only about 1 percent report having sold or purchased a portion of their agricultural land holding in the prior year. Among cultivating households, 15 percent are landless and less than a third of report renting in any land for cultivation.

[10] In addition to the HIES, there are living standard measurement surveys that are representative at district level surveying 80,000 households and collect information on demographics, employment, access to public services and key social indicators. The provincial level survey has a larger questionnaire and smaller sample, while the district level survey has a larger sample but does not contain key farm related data. For this reason I use the HIES in the main regressions, but show additional analysis int he appendix using data from the PSLM for outcomes measured in both surveys.

To examine the land market effects of the program, I first test if land ownership shifts as the program is rolled out. The first outcome in Table 3 in an indicator for land ownership among all rural households. There is no change in ownership, which could be consistent with no market activity or market transactions that caused land ownership to shift across households without changing the overall rate of ownership. To investigate this, I consider the change in the trend of owned holding size and recent land transactions by landowning households as the program is rolled out. I find that the rate of land purchase or sale, or average land holding among landowners, does not respond to the program, suggesting that the program does not relieve the constraints on land ownership transactions.

Improving tenure security is expected to increase the likelihood of tenancy transactions, even if land ownership does not change. Column (5) in Table 3 shows that among landowning households the likelihood of renting out increases by 5% when the program is completed in their district. This is a large effect, given the 22% rate of renting out on average across the districts prior to the program. Landowners renting out could be those who previously owned land or households who are able to purchase more land due to the program and then rent it out. Since there are no significant effects on agricultural land ownership rate, ownership transactions, or the average size of land owned, we can deduce that the change in tenancy is driven by previous landowners. Thus, the program can resolve some land market frictions that constrain existing landowners from renting out, but not all market constraints.

Appendix table A3 replicates the same outcomes, restricting the sample to only farming households, or households that operate a farm. The rationale is that even though overall land ownership does not shift, specifically farm households might have gained greater access to land. The table demonstrates that even among households engaged in farm cultivation, there are no changes to land

ownership, or land purchases. The last column in A3 additionally demonstrates that cultivating households with owned land holdings do not rent out their land, and the land rental effect in table 3 is driven by landowning households who do not use their land for cultivation. This motivates additional tests on agricultural participation and occupations choices among land owning households, that I run below.

Relieving constraints on renting out for existing landowners can have spillover effects on the labor market. Specifically, agricultural participation is allegedly high due to insecure property rights on agricultural land that prevents households from participating in off-farm activities for better income, as vacating land bears the risk of losing it (Field 2007). Increased rental activity is by landowning households implies some landowning household members no longer need to practice cultivation if they have opportunities for participating in non-farm activities. The next set of results in Table 4 examine the effect of the program on participation in non agricultural activities by landowning households. Consistent with high likelihood of renting out, I find that on average these households are less likely to participate in agriculture. Three different outcome variables indicate this. In column (1), the outcome is an indicator for landowning household where at least one member cultivates a farm. In column (2), participation in agricultural is defined more specifically as households with at least one member performing "self-cultivation", or cultivating owned land. Column (3) shows the program effect on the likelihood of any household member working broadly in agriculture (including wage work). All three measures for capturing agricultural participation by landowning households show a significant negative change as the program is completed in a district; specifically, the program lowers the likelihood that a landowning household participates in any agricultural activity by 9.5 percentage points. Thus landowners are on average 24% more likely to rent out their agricultural land and 11% more likely to quit

agriculture due to the program.

Column (4) of Table 4 shows the intensive margin measured by the share of household income from agricultural activities. Consistent with the changes in the occupational choices of landowning households, the proportion of income from agricultural activities falls by 7 percentage points more in districts where the program is completed relative to district where the program hasn't started yet. This corresponds to an 11% drop in income share of landowning households from agriculture. I also test the changes in the alternate occupational choices of landowning households as they are able to rent out their agricultural land and exit agriculture. Table 5 shows a significant increase in the share of household members that participate in non-agricultural activities. These are statistically significant for participation in small and large business ownership, and large (but statistically insignificant) for participation in self-employment or as paid employees.[11]

In summary the results above demonstrate that weak property rights constrain landowners into agriculture, forcing them to cultivate their owned land as renting out or selling is costly. Improved ownership security through the computerization of ownership and tenancy rights reduced market frictions, allowing landowners to rent out their land and increase participation in non agricultural activities by quitting cultivation. I test the heterogenous affects of the program by income quartile in the appendix Tables A1-A2. Heterogeneous affects demonstrate that land market frictions are particularly extreme for poorer and consequently less connected households. The program improves land rental probability and reduces agricultural participation for households in the lowest income quartile; the richest household experience significantly lower impact on both land rental and labor participation, relative to the poorest households. These effects are consistent with them motivation nehind the design of this

[11] A natural outcome to test would be the rate of migration. The data does not allow us to test this explicitly, but the demonstrated effects suggest migration may have increased for landowning households.

computerization program (see Section 2).

The next set of regressions estimate the program effects for cultivating households. First, I test for differential changes in the rate of renting in agricultural land in districts with a high program intensity. Table 6 shows that the likelihood of renting in among cultivating households does not change due to the program. There is suggestive evidence that farmers shift toward fixed land rental and away from sharecropping; this is demonstrated in column (2) and (3) of Table 6 as the likelihood of leasing land on fixed rent increase due to the program (insignificant) while sharecropping goes down (statistically significant). A test of the equality of the program effect from columns (2) and (3) has a Chi-squared statistic of 6.01 (p-value 0.01), rejecting the equality of the program's impact on the likelihood of fixed rent leasing versus sharecropping. This result is consistent with the view that land owners with less secure property rights may choose sharecropping, as it allows landlords to exert stricter property control by bearing a higher amount of production risk than in fixed rent contracts. Sharecropping is also typically arranged between landlords and tenants in the same village due to the sharing nature of this tenancy arrangement and for ease of monitoring; thus the threat of weak property rights might be less binding for sharecropping.

The results presented thus far demonstrate that renting out by landowners increases, but renting in by cultivators does not. The lack of effect on the intensive margin for renting in suggests there might be effects on the intensive margin, i.e. existing tenant households rent in larger areas of land. The next set of results test program effects on average farm area (total and rented in) to further explore these hypotheses.

Table 7 shows the effect of the program on the intensive margin of renting in, measured by average quantity of rented in land among cultivating households. There is a strong positive effect on land rented in on fixed cash rent, and no significant effect on land sharecropped. The program proves to relieve the

constraints in the fixed rent lease market for agricultural land. Column (3) shows that owned cultivated area is marginally higher, but in the absence of any effects on land acquisition by cultivating households, this effect is suspected to simply reflect improved security of already owned property. Finally, column (4)-(5) suggest that as more land is rented in average farm size increases, indicating meaningful impacts of the program on scale of agriculture in Punjab. Change in average operational farm size is 15% higher just after the program's completion in districts that receive the program earlier relative to districts that receive it later. In the appendix, I explore heterogeneity across households in these outcomes; Table A4 presents these effects and shows that among cultivating households, landless households benefit from greater access to land due to improved rental markets. This heterogeneity in market access confirms the programs' pre-intentioned goals of facilitating land transactions the least connected households.

The effect of the program on farming scale has important implications for agricultural input choices, mechanization and productivity improvement, as farm size is assumed to be a constraint to adoption of capital intensive technologies (Foster and Rosenzweig 2011). If optimal farm area induces higher input, especially capital, usage on farms, output should increase. Even if the capital margin is unaffected, increased tenancy activity alone may result in a better allocation of land and higher aggregate productivity. I examine the effects of the program on crop choice, farm inputs and output in Tables 8-9. First, these results demonstrate farmers shift into rice and away from planting maize on their land, as shows in Table 8. The coefficients are nearly identical with opposite signs, lending more confidence to the inference that farmers make this switch in crop choices. Such a shift may or may not be expected, and there are not many consistent explanations that explain this shift.

Input choices show an increase in the usage of fertilizer, pesticides and hired labor, but insignificant in most cases except for pesticide where the effect

is significant at the 10% level (Tables 9). The usage of rented equipment goes down, which could be simultaneous with increased likelihood that farmers' use owned machinery and equipment. Since data on farmer ownership of agricultural machinery is not available, I cannot explicitly test this hypothesis. The farmers do report if they acquired (purchased or received) any agricultural machinery, including tube wells, tractors, ploughs, thresher, harvester or truck, in the previous year. I test the affect of the program on acquisition of agricultural machinery and find that while there is no overall effect, landless households are particularly more likely to have acquired agricultural equipment when the program is completed in their districts (Appendix Table A5). Altogether, greater farm size, higher usage of pesticide, increased owned equipment and reduced equipment rental are consistent with increased incentives to invest in productive mechanized inputs.

To infer if enhanced land access for cultivators and changes in crop and input choices, and the reallocation in the labor market results in output gains, I test the program's effects on output using farmer reported survey data on farm yield, as well as administrative district level data on annual crop production. Column (5)-(6) in table 9 show no significant effects on the total output or output per acre. Despite an improvement in farming scale and crop choices, yield does not show a significant improvement. The program may be ineffective in improving productivity, or more time needs to pass for farmers to considerably adjust investments choices before better yields are realized.

Table 10 employs alternate, aggregate district level crop production data from the administrative sources. The regressions are at district-crop-year level, where the outcome of interest is log of crop yield (ton/ha) for each district by year and for the four major crops (rice, cotton, wheat and maize). In addition district fixed effects and district specific linear trends, the regression includes crop fixed effects and spans all years from 2004 to 2015. I find that while the

program doesn't affect total cultivated area, aggregate yield increases by 4.6% more in districts with the program relative to districts that receive the program later. This effect is significant at the 5% level. This alternate data does provide evidence of improved productivity, but suffers from caveats that are typical for government collected administrative data.

5 Robustness and Identification Concerns

As a robustness check, I combine the HIES with the Pakistan Social and Living Standards Measurement (PSLM) surveys, to allow for more time periods. THE PSLM is conducted in alternate years (when the HIES is not conducted) and is a similar survey to the HIES but administered at a larger scale. Thus the PSLM contains more households, but is shorter and in particular does not contain any information about cultivation. The outcomes that are measured in both surveys include land ownership and rental, and household occupation. Thus I can show the program effect on these outcomes using both surveys as a robustness exercise. Since the number of households vary across the two surveys, I calculate the average for each outcome for each district in each year, and run the analysis at the district year level to ensure that each district-year gets the same weight in the regression. The output from these regressions is shown in Table A6 and confirms the outcomes from the regressions using only HIES data. I find that the likelihood of renting out and leaving agriculture goes down for households in the districts that receive the program sooner than those that receive it later. There is no change in land ownership, size of agricultural land holding among land owners and the likelihood of renting in among cultivating households.

Identification would be threatened if the program rollout was driven by trends land market activity across districts. Figures 4 shows the event study graphs for some of the outcomes with data available in all years. These figures show the coefficients indicators for γ_l from the following regression.

$$y_{dt} = \gamma_0 + \sum \gamma_l YearsSinceProgram_{dt,l} + \Pi_d + T_t + \Pi_d \times T + \varepsilon_{dt}$$

$YearsSinceProgram_{dt,l}$ is an indicator that equals one if it has been l years since the start of the program in district d and year t; the omitted category is $l = -1$, or the year just before the program starts in any district. These graphs show that that program start is not driven by changes in land market activity, as the trend is flat in the pre-program period.

I also explicitly test if changes in the land market drive the rollout of service centers across the subdistrict. Particularly, are prior trends in rental activity, operational farm size or sales activity correlated with the main independent variable in the above regressions, $ProgramIntensity$. I construct district level change in these land market outcomes between each survey year. Since the HIES survey is conducted every alternate year, these changes capture the shift over the previous 2 year period. I then run the following regression:

$$ProgramIntensity_{dt} = \phi_0 + \phi_1 \triangle Z_{d,t} + \Pi_d + T_t + \eta_{dt}$$

$ProgramIntensity_{dt}$ is as defined above; Z includes average district level share of households renting out, renting in, owning agricultural land, or engaged in buying or selling agricultural land, and average farm size. $\triangle Z_{d,t} = Z_{d,t} - Z_{d,t-1}$ measures the change in Z since the last survey round (over the preceding 2). The regression output is shown in Table A8. Prior changes in neither of these variables are correlated with the progress of the program. Table A8 mitigates the concern the program effects identified in the above analysis capture preexisting changes in land market outcomes. A regression of Program Progress on all these changes simultaneously has an *F-stat* of 1.06 with a *p-value* of 0.388 indicating that the changes in these land market variables do not significantly explain the roll out of the program. Table A9 further confirms that the pre-existing trend in yield is unrelated to program rollout.

Lastly, in Table A10 I also conduct additional falsification tests to test that

the program is not correlated with changes in urbanization, literacy, education or family size. The trends in these outcomes do not respond differentially to the program, ruling out other demographic changes in program districts that may have led to land and labor market effects that are observed due to the program.

6 Concluding Remarks

Tenure insecurity and thin land markets are a feature of rural Punjab (Pakistan) where agrarian law has been informally defined for centuries and local officers have discretionary powers in land market transactions. This limits mobility in the land and labor markets suppressing agricultural as well as overall productivity. Through the Punjab government's efforts land records have been digitized and are available on the world wide web as well as physically at designated service centers. Innovative use of ICT allowed land transactions to be automated and free from involvement of corrupt officers and administrative hurdles. The paper offers evidence that despite being very recent, the program has managed to significantly affect land markets. Rental markets are more active affecting *allocation* of land within agriculture and *selection* of cultivators into agriculture.

Improved allocation of land due to land market activity after the program suggests that informal land rights and restrictions on market activity may be responsible for factor misallocation and lower productivity. Landowners who faced these market constraints rent out land and exit agriculture. On the flip side households that stay in cultivation, rent in more land, effectively increasing average farm size, which has implications for modernization and aggregate agricultural productivity. Consistent with the increased rental activity and improved land allocation, aggregate yield improves in districts with the program, although the yield effects are not observed in farm level data. I hypothesize that these changes in market activity are driven by improved security of tenure and effective facilitation of land transactions, but I cannot directly test these

mechanisms.

The formalization of property rights can thus have potentially large positive effects while obviating the financial and feasibility hurdles of titling programs. The results also illustrate that land and labor market constraints limit rural mobility in the South Asian context, shedding light on the rural-urban divide and the prospect of structural transformation. Lastly, the paper further reinforces our understanding of development economics by exhibiting how ICT use is manifested in public service processes and can ease market frictions in lower income countries.

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7 Figures and Tables

Figure 1: *A Land Record Register as maintained by Patwari (Adeel 2010)*

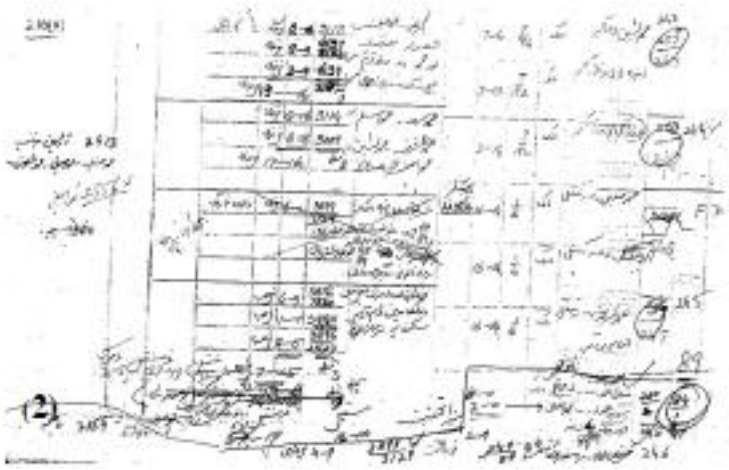

Figure 2: *A Cadastral Map for a village in Punjab (Adeel 2010)*

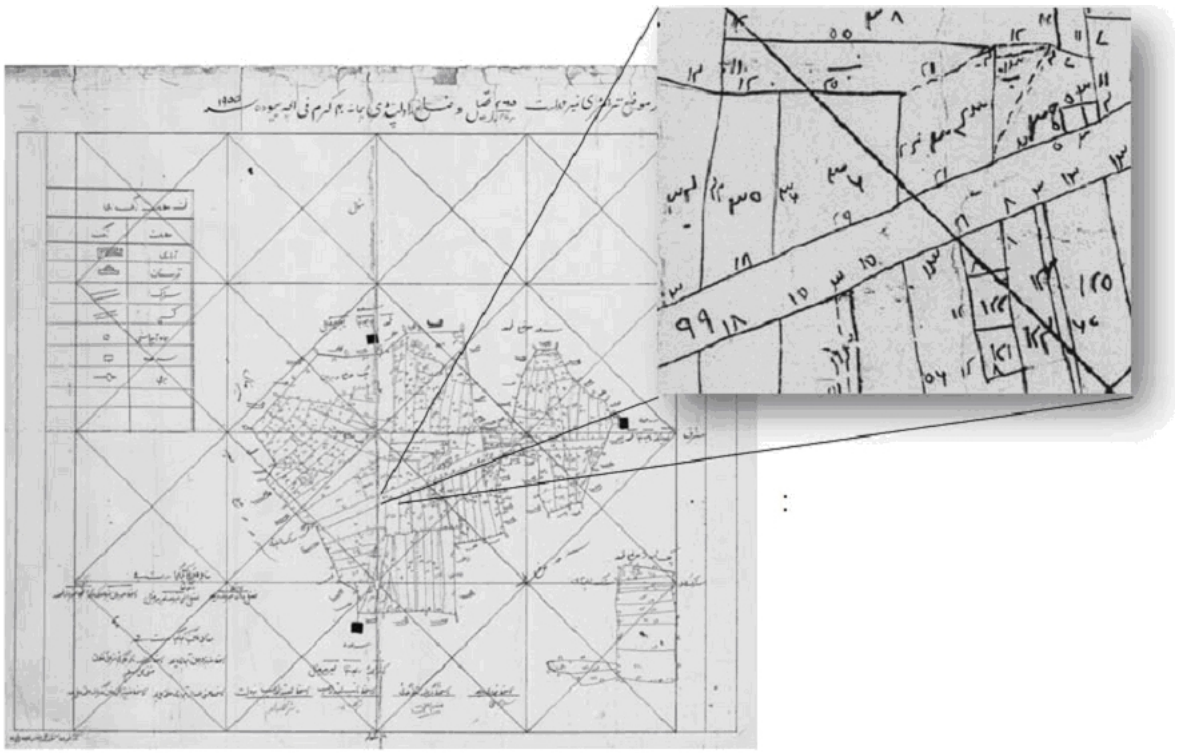

Figure 3: *Program Rollout*

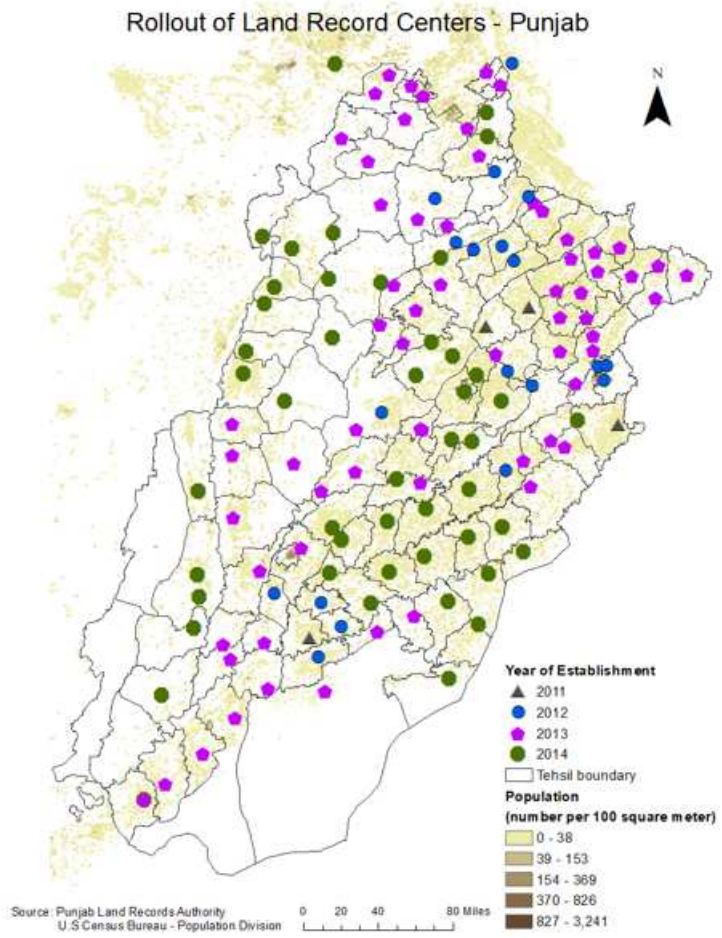

Figure 4: *Trend in Renting out (top-left); Renting in (top-right); Land ownership (bottom-left); Household Members in Agriculture (bottom-right)*

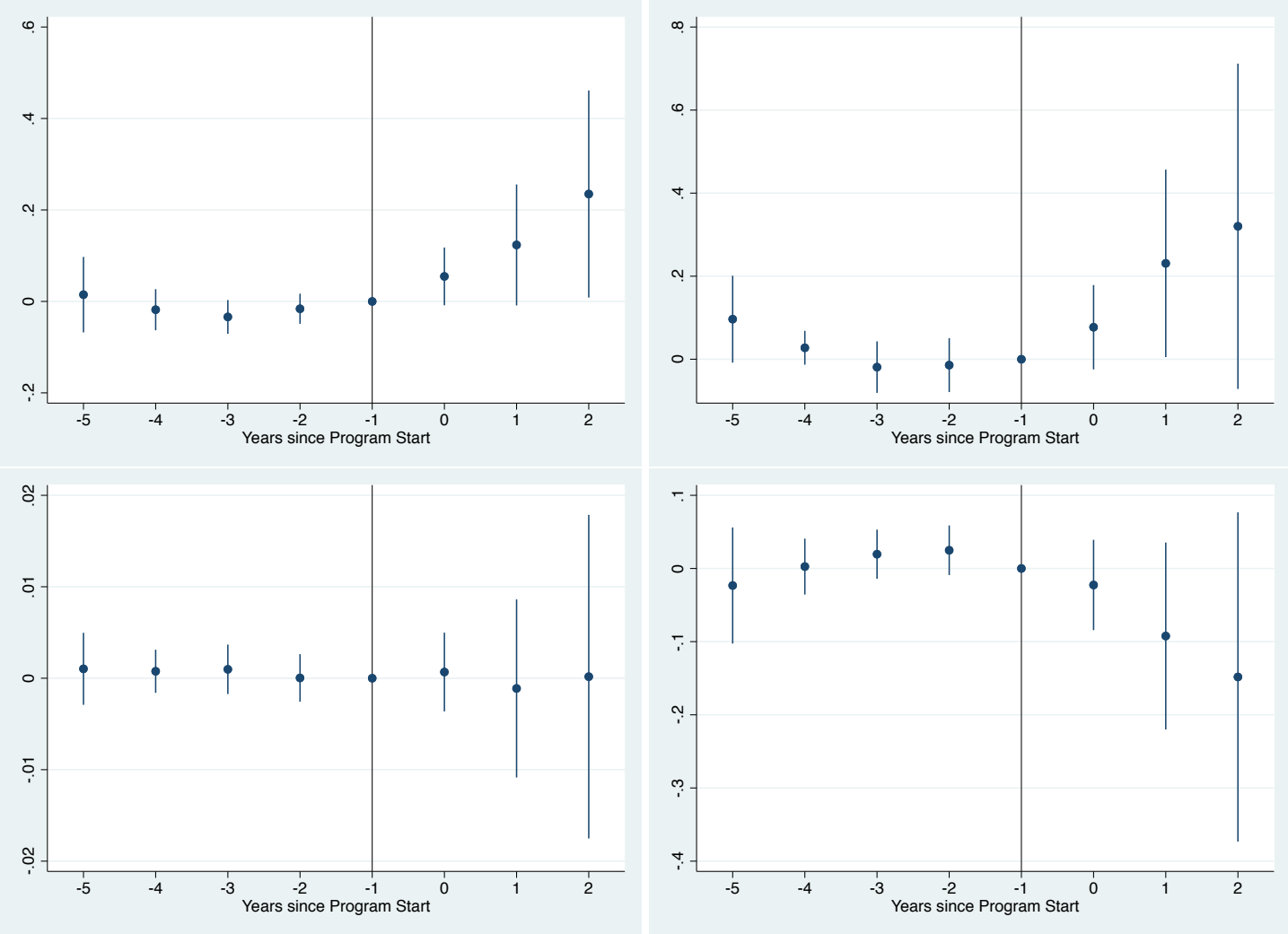

Table 1: *Summary of Program Progress*

	mean	sd
2010		
% of Subdistricts with a Center	0.00694	0.0417
% of Villages with Fully Functional Database	0	0
2011		
% of Subdistricts with a Center	0.0551	0.187
% of Villages with Fully Functional Database	0	0
2012		
% of Subdistricts with a Center	0.164	0.351
% of Villages with Fully Functional Database	0.0622	0.158
2013		
% of Subdistricts with a Center	0.59	0.447
% of Villages with Fully Functional Database	0.243	0.235
2014		
% of Subdistricts with a Center	0.967	0.126
% of Villages with Fully Functional Database	0.657	0.313

Table 2: *Summary Statistics*

District level aggregates:	(1)
Share of agricultural households renting in	0.207
	(0.0940)
Operational Farm Area (acres)	6.777
	(2.547)
Farm area rented in on fixed rent (acres)	1.641
	(2.547)
Farm area rented in on sharecropping (acres)	0.587
	(1.088)
Share of households owning agricultural land	0.352
	(0.150)
Owned agricultural land (acres)	6.269
	(2.640)
Share of landowning households renting out	0.254
	(0.125)
Agricultural share of household income	0.605
	(0.146)
Percentage of household members in agriculture	0.257
	(0.0855)
Share of households who cultivate a farm	0.780
	(0.138)

Notes: Standard errors are provided in parentheses.

Table 3: *Program Effect on Market Activity for Land Owners*

	(1) Own Agland (Y/N)	(2) Agland Purch. (Y/N)	(3) Agland Sold (Y/N)	(4) Own Agland (acres)	(5) Agland Rentout (Y/N)
Program Intensity	-0.016	0.002	0.001	0.495	0.053**
	(0.022)	(0.003)	(0.005)	(0.509)	(0.025)
Observations	19,059	7,584	7,584	7,579	7,584
Mean Dep., Pre-program	0.433	0.006	0.009	6.844	0.219
Sample Households	All Rural	All Landowning	All Landowning	All Landowning	All Landowning

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 4: *Program Effect on Agricultural Participation*

	(1) HH Operates Any Farm	(2) HH Operates Owned Land	(3) HH Member Ag Worker	(4) Share Income from Ag
Program Intensity	-0.086***	-0.073**	-0.092***	-0.073**
	(0.026)	(0.036)	(0.031)	(0.030)
Observations	7,597	7,597	7,597	7,597
Mean Dep., Pre-program	0.818	0.624	0.808	0.655

Notes: Cultivator indicates households that operate a farm, Ag HH indicates households where at least one member participates in an agricultural activity. Ag Inc and Ag workers are agricultural share of household income and households working members, respectively. All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 5: *Program Effect on Non-Agricultural Participation*

	(1) Small Business Owners	(2) Large Business Owners	(3) Self-Employed	Paid Employees
Program Intensity	0.164*	0.133***	0.286	0.863
	(0.087)	(0.051)	(0.345)	(0.708)
Observations	7,597	7,597	7,597	7,597
Mean Dep., Pre-program	0.082	0.024	2.180	5.521

Notes: Outcomes indicate if any member of the household participates in the specific activity. All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 6: *Program Effect on Land Rental for Cultivators*

	(1) Rent in	(2) Fixed Rent	(3) Sharecrop
Program Intensity	0.011	0.036	-0.019
	(0.034)	(0.028)	(0.018)
Observations	7,418	7,418	7,418
Mean Dep., Pre-program	0.332	0.249	0.085

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 7: *Program Effect on Farm Size and Rented in Land*

	(1) Rented	(2) Sharecropped	(3) Owned	(4) Total Cultivated	(5) Ln(Total Cultivated)
Program Intensity	0.951***	0.177	0.729*	1.194***	0.152**
	(0.340)	(0.266)	(0.437)	(0.380)	(0.062)
Observations	7,418	7,418	7,418	7,418	7,418
Mean Dep., Pre-program	1.647	0.711	5.779	7.289	

Notes: Rent area corresponds to area under fixed cash rent contracts and S/C refers to area under sharecropping contracts. Farm size is total operational farm area including owned land. All regressions include district and year fixed effects with with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 8: *Program Effect on Crop Choice*

	(1) Wheat	(2) Cotton	(3) Sugarcane	(4) Rice	(5) Maize
Program Intensity	-0.020	0.028	-0.016	0.066**	-0.060**
	(0.019)	(0.032)	(0.023)	(0.033)	(0.024)
Observations	7,390	7,390	7,390	7,390	7,390
Mean Dep., Pre-program	0.893	0.310	0.169	0.316	0.055

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 9: *Program Effect on Agricultural Inputs and Production*

	(1) Use Fertilizer	(2) Use Pesticide	(3) Use Hired Labor	(4) Use Rented Equipment	(5) Ln (Output)	(6) Ln (Yield)
Program Intensity	0.001	0.043*	0.037	-0.028*	0.112	0.025
	(0.015)	(0.025)	(0.041)	(0.017)	(0.091)	(0.062)
Observations	7,280	7,280	7,277	7,283	7,308	7,219
Mean Dep., Pre-program	0.943	0.752	0.479	0.921		

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 10: *Program Effect on Agricultural Production using District level data*

	(1) Log Area	(2) Log Yield
Program Progress	-0.044	0.046**
	(0.033)	(0.023)
Observations	1,119	1,118

Notes: Regressions are at district-crop-year level, and the outcomes are logged total area and yield for each crop in each district and year. All regressions include district, crop and year fixed effects with robust standard errors clustered at the district-year level.
*** p<0.01, ** p<0.05, * p<0.1.

8 Appendix Tables and Figues

Table A1: *Program Effect on Market Activity by Income Quartile*

	(1) Own Agland (Y/N)	(2) Agland Purch. (Y/N)	(3) Agland Sold (Y/N)	(4) Own Agland (acres)	(5) Agland Rentout (Y/N)
Program Intensity	-0.001	0.002	-0.002	1.130	0.105**
	(0.002)	(0.004)	(0.009)	(0.720)	(0.042)
Program Intensity x Inc Quartile 2	0.001	0.001	0.014	-0.359	-0.012
	(0.002)	(0.002)	(0.011)	(0.619)	(0.041)
Program Intensity x Inc Quartile 3	0.005*	-0.000	0.005	-0.332	-0.036
	(0.003)	(0.003)	(0.009)	(0.641)	(0.042)
Program Intensity x Inc Quartile 4	0.001	0.001	-0.002	-1.179	-0.076*
	(0.002)	(0.004)	(0.010)	(0.738)	(0.042)
Observations	7,597	7,584	7,584	7,579	7,584
Mean Dep., Pre-program	0.997	0.007	0.009	6.699	0.219
Sample Households	All Rural	All Landowning	All Landowning	All Landowning	All Landowning

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A2: *Program Effect on Agricultural Participation by Income Quartile*

	(1) HH Operates Any Farm	(2) HH Operates Owned Land	(3) HH Member Ag Worker	(4) Share Income from Ag
Program Intensity	-0.144***	-0.083*	-0.182***	-0.121***
	(0.040)	(0.046)	(0.041)	(0.040)
Program Intensity x Inc Quartile 2	0.016	-0.051	0.052	0.024
	(0.038)	(0.044)	(0.038)	(0.040)
Program Intensity x Inc Quartile 3	0.042	-0.002	0.126***	0.075*
	(0.036)	(0.044)	(0.037)	(0.039)
Program Intensity x Inc Quartile 4	0.082**	0.036	0.101***	0.045
	(0.040)	(0.038)	(0.035)	(0.037)
Observations	7,597	7,597	7,597	7,597
Mean Dep., Pre-program	0.818	0.624	0.808	0.655

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A3: *Program Effect on Market Activity for Cultivators*

	(1) Own Agland (Y/N)	(2) Agland Purch. (Y/N)	(3) Agland Sold (Y/N)	(4) Own Agland (acres)	(5) Agland Rentout (Y/N)
Program Intensity	-0.013	0.002	0.000	0.546	-0.012
	(0.027)	(0.004)	(0.006)	(0.558)	(0.017)
Observations	7,418	6,226	6,226	6,224	6,226
Mean Dep., Pre-program	0.844	0.007	0.007	7.203	0.084
Sample Households	All Cult.	Landowning Cult.	Landowning Cult.	Landowning Cult.	Landowning Cult.

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A4: *Program Effect on Land Rental for Cultivators*

	(1) Rent in (Y/N)	(2) Cultivated Area (Rented in)	(3) Cultivated Area (SC in)	(4) Cultivated Area (Total)
Program Intensity	-0.003	0.731**	0.213	0.658*
	(0.029)	(0.330)	(0.259)	(0.387)
Program Intensity x Landless	0.045*	0.883	-0.535	0.830
	(0.024)	(0.614)	(0.413)	(0.573)
Observations	7,418	7,418	7,418	7,418
Mean Dep., Pre-program	0.332	1.647	0.711	7.289
p_value of sum	0.168	0.024	0.383	0.042

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A5: *Program Effect on Agricultural Equipment*

	(1)	(2)
Program Intensity	-0.015	-0.019
	(0.028)	(0.028)
Program Progress × Landless		0.035**
		(0.015)
Observations	6,906	6,906

Notes: All regressions include district and year fixed effects with robust standard errors clustered at the district-year level in parentheses.
Outcome variable is an indicator if a cultivator has acquired agricultural equipment in the last year (Tube well, Tractor, Plough, Thresher, Harvester or Truck)
*** p<0.01, ** p<0.05, * p<0.1.

Table A6: *Program Effect on Using Data from Additional Years*

	(1) All HHs who Own Agland	(2) Owned Ag Land Size (acres)	(3) Landowning HHs who Rent out	(4) Landowning HHs with members in Ag. Work	(5) Landowning HHs' share of of Ag Income	(6) Cultivating HHs who Rent in
Program Intensity	0.019	0.563	0.042*	-0.053**	-0.030	0.003
	(0.017)	(0.502)	(0.024)	(0.026)	(0.025)	(0.025)
Observations	340	340	340	340	340	340
Mean Dep., Pre-program	0.370	7.247	0.224	0.711	0.589	0.216

Notes: Regressions are at district level showing average district average for each of the outcome variables using HIES and PSLM data. All regressions include district and year fixed effects, and linear district level trends. Robust standard errors reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table A7: *Prior Level of Outcomes*

Rentin	0.867				
	(1.137)				
Renout		0.299			
		(1.592)			
Average Farmszie			-0.000		
			(0.070)		
Own Agland				1.036	
				(1.056)	
Bought/Sold Agland					-18.739***
					(6.053)
Observations	32	32	32	32	32

Notes: Each independent variable is the district level average for the year 2007, the survey year before the program rollout begins.
*** p<0.01, ** p<0.05, * p<0.1.

Table A8: *Prior Changes in Outcomes*

Dependent Variable: Program Progress	(1)	(2)	(3)	(4)	(5)
Rentout	0.262				
	(0.186)				
Rentin		-0.180			
		(0.292)			
Farmsize			0.011		
			(0.008)		
Own Agland				0.059	
				(0.198)	
Bought/Sold Agland					-0.059
					(0.789)
Observations	136	136	136	136	136
R-squared	0.829	0.826	0.829	0.825	0.825

Notes: The dependent variable is the lag in program completion, i.e. program completion year - year the program rollout began in the province. Each independent variable is the change in district level average since the prior survey round. Regressions include district and year fixed effects with robust standard errors.
*** p<0.01, ** p<0.05, * p<0.1.

Table A9: *Prior Changes in Crop Yield*

	(1)	(2)	(3)	(4)
Cotton	-0.031			
	(0.077)			
Maize		0.033		
		(0.041)		
Rice			0.033	
			(0.035)	
Wheat				0.035
				(0.129)
Observations	199	272	247	272

Notes: Each independent variable is the change in district level yield for each crop over the prior year. Regressions include district and year fixed effects with robust standard errors.
*** p<0.01, ** p<0.05, * p<0.1.

Table A10: *Robustness Checks*

	(1)	(2)	(3)	(4)
	Rural	Literate	Education Level	HH Members
Program Intensity	0.037	0.017	0.017	0.017
	(0.074)	(0.057)	(0.057)	(0.057)
Observations	33,703	19,067	19,067	19,067
Mean Dep., Pre-program	0.586	0.485	3.486	6.453

Notes: Outcomes are aggregate by district year level. Literacy and education are averages across household heads within a district and year. Regressions include district and year fixed effects and district level linear trend, with robust standard errors.
*** p<0.01, ** p<0.05, * p<0.1.