Land Registration, Input Subsidies, and Agricultural Investment: Experimental Evidence from Women Farmers in Mozambique

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Motivation: Property rights and investment

Insecure property rights may constrain agricultural investment for smallholder farmers

Specifically, farmers may be reluctant or unable to invest due to:

- The risk of expropriation (and thus the risk of losing the return on investment)
- Inability to collateralize their land to support market transactions

However, evidence on the impacts of land registration on investment are mixed (Ali et al., 2014; Goldstein et al.,2018; Huntington et al., 2021)

Farmers may face other market failures, limiting the extent to which increased tenure security manifests in increased investment.

Motivation: Land Rights in Matrilineal Contexts

Several existing studies have focused on the potential to increase women's land rights in patrilineal contexts by encouraging co-titling (Cherchi et al., 2021)

Little is known about formalizing land rights in matrilineal contexts

- Are there systematic differences in self-reported tenure security?
- What are behaviors towards co-titling?
- Does tenure insecurity represent a binding constraint to agricultural investment?

Context: Smallholder Farmers in Mozambique

- Examine these questions in the context of an NGO-implemented sustainable agriculture program for smallholder farmers in Zambezia, Mozambique
- We focus on two project components: conditional land titling and an input package

Intervention: Conditional land titling

Randomly selected households were offered the opportunity to have one plot of land demarcated for a land-use permit

- Only largest plot of land was eligible (identified from baseline data)
- Required to include the head woman's name on the title

* All land in Mozambique is owned by the State and is not collateralizable

Intervention: Input package

The second intervention comprised a **discounted agricultural input package** offered to the head women

Package had a market value of US$330 and included:

- Maize and butter bean seed to cover 0.25 hectares, each
- Cassava, sweet potato cuttings
- Fruit-tree seedlings
- Fertilizer, insecticide, herbicide, and fungicide
- Training on climate smart agricultural practices to support sustainably investing in land

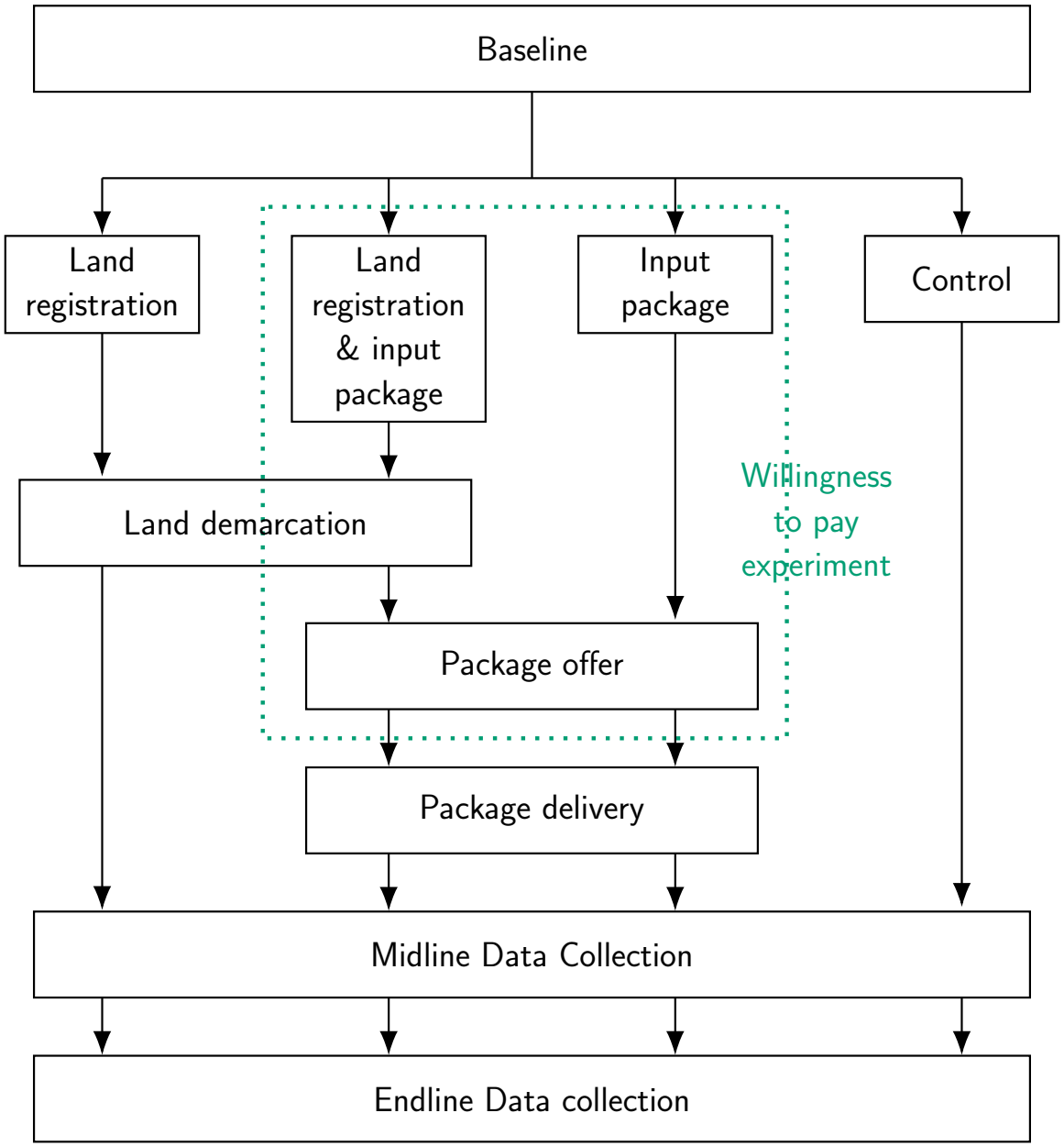
The package offer was framed around the woman: it was an opportunity for her to buy and use agricultural inputs.

Study Design Summary

We developed a two-stage experimental design centered around the land titling and input package:

- First, we cross-randomized the land titling and input package interventions
  - Measure the direct medium-term impacts on on-farm and off-farm investment behaviors
- Second, within the input package sample, we embedded a willingness-to-pay experiment
  - Measure the direct short-term impact of land registration on willingness to invest
  - Measure the impact of price subsidies on the effectiveness of land registration.

Study Design Illustrated



Sample characteristics and complaince

Sample women are broadly representative of women in the region:

- 37 years old, have 2 years of education, and live with 5.6 people
- 88% are married, 70% are matrilineal
- Household cultivates 2.6 ha of land
- Main crops include maize, pidgeon peas, and soy

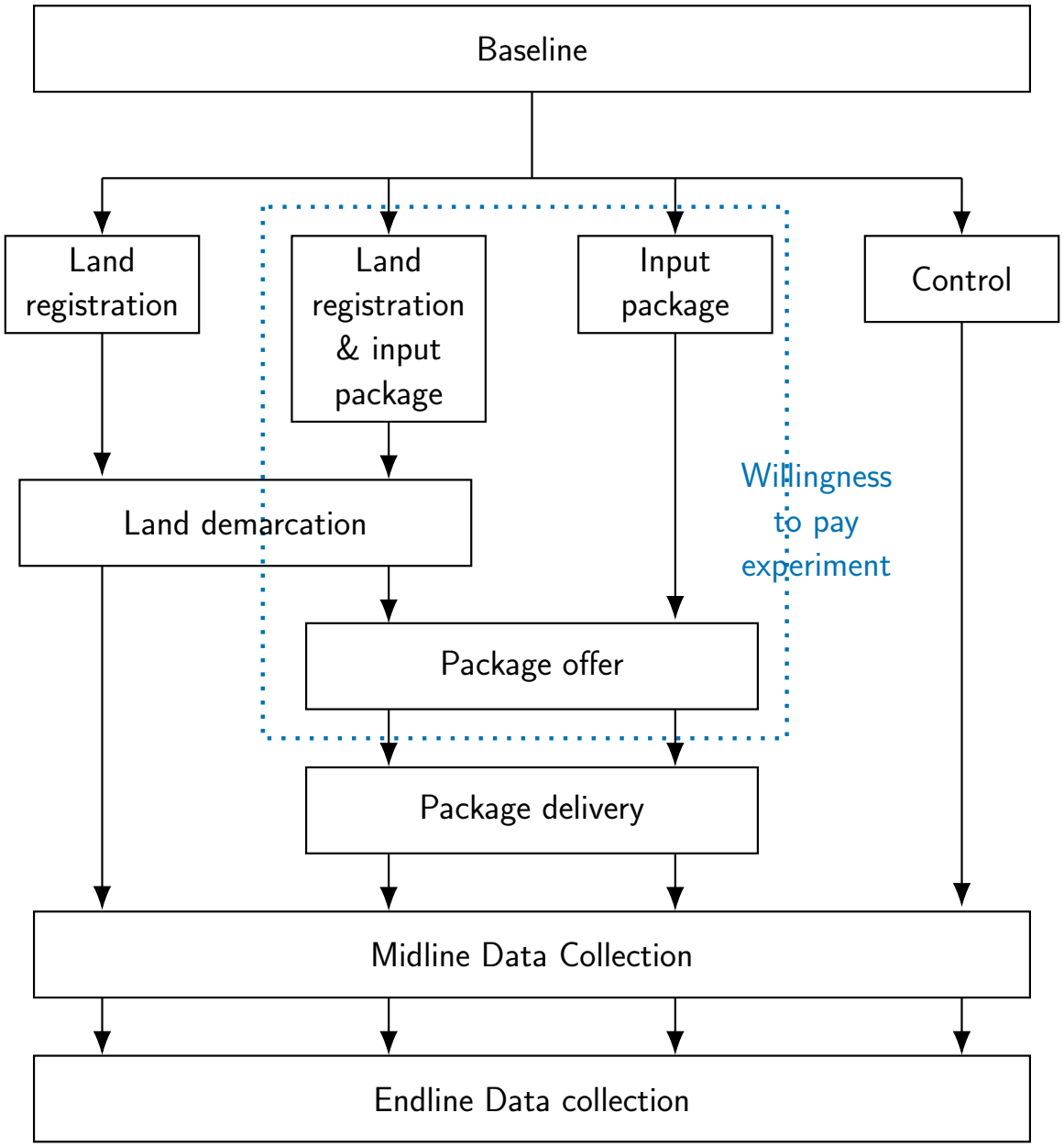
There was **high take-up of the conditional land-titling offer** with over 92% of the treatment group accepting (38% solo titled).

Similarly, 90% of households completed the willingness-to-pay experiment.

Finally, we collapsed the design after the willingness-to-pay experiment and 92% of households reported receiving the maize and beans.

Very short-term impacts of land demarcation and subsidies

Study Design Illustrated



WTP Empirical Approach: Take It Or Leave It Offer

Women received a TIOLI offer to purchase the package at one of 4 randomly selected subsidy levels: 87%, 79%, 71%, and 63%.

- Avoid short-term liquidity constraints by delaying and splitting payment across two future dates
- After reiterating and confirming that the women understood the offer, the final offer was presented and their response was recorded.
- Women who accepted the offer received a receipt indicating their price and decision.

Empirical Approach: Take It Or Leave It Offer

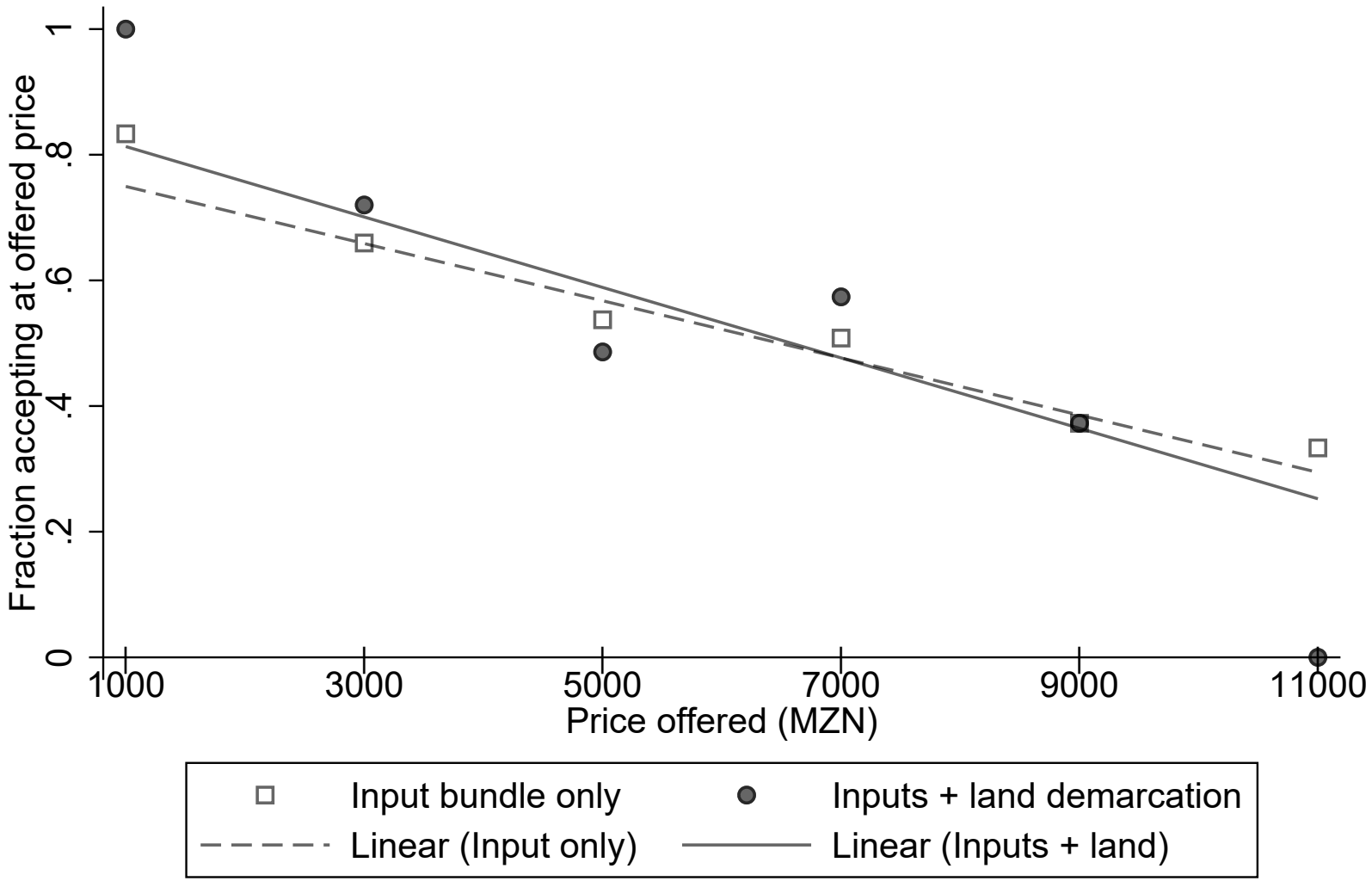
Focus on intent-to-treat estimates using acceptance data:

$$Y_i = \alpha + \beta \times \text{Treat}_i + \boldsymbol{\xi} \times \text{P}_i + \boldsymbol{\delta} \times (\text{Treat}_i x \text{P}_i) + \boldsymbol{\gamma} \times \text{X}_i + \delta_{stratum} + \varepsilon_i$$

- Y_i is an indicator variable for whether woman i accepted the package
- β measures the impact of the land demarcation activities on the likelihood of accepting the offer.
- ξ measures the impact of the subsidy

Measures the direct impacts of land demarcation on willingness to invest, and whether that changes by subsidy

Results: Take It Or Leave It Offer



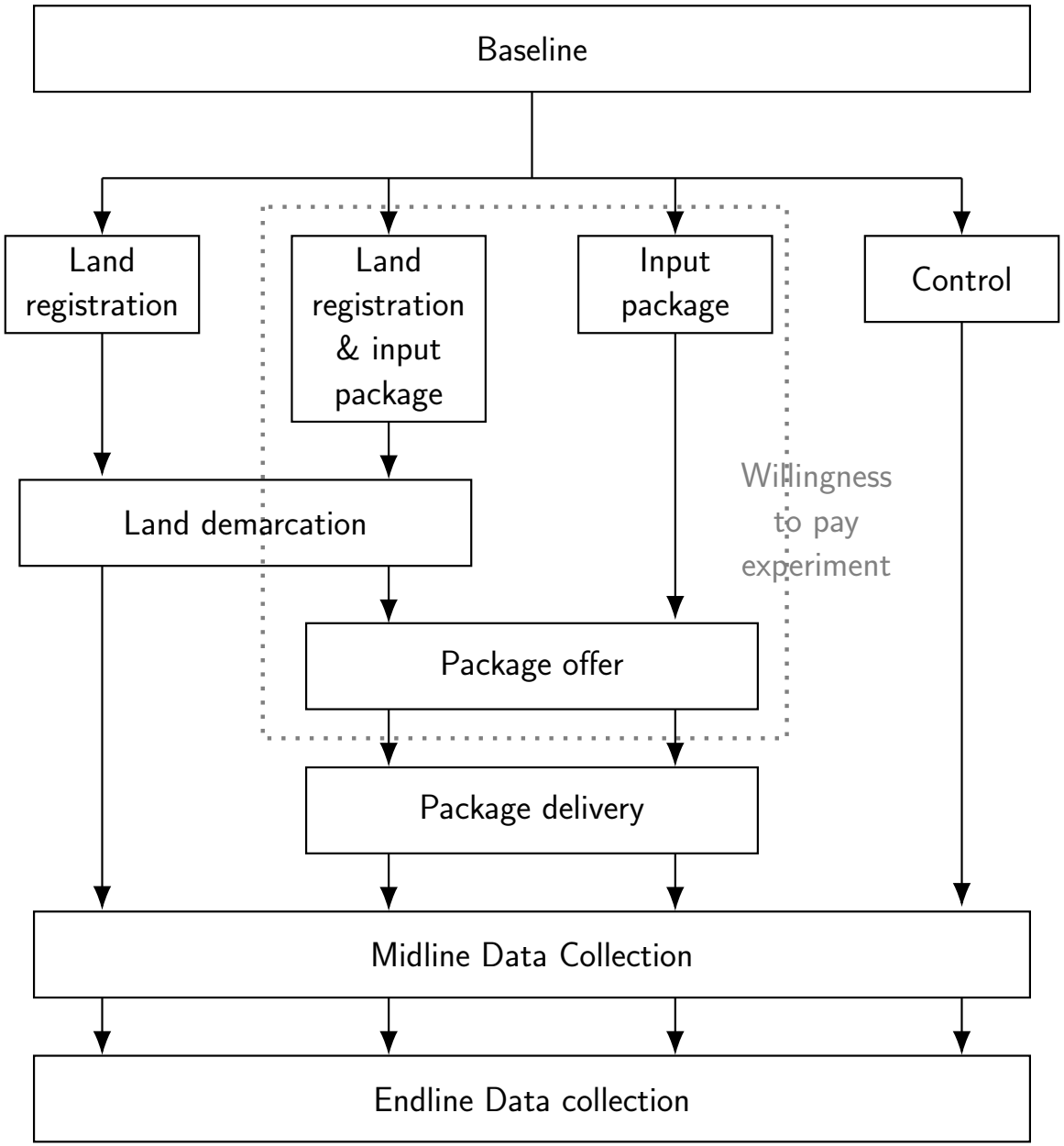
WTP: Impacts on accepting offer

	N [1]	Sample mean [2]	Impacts: OLS Coefficient Estimates: Land Registration [3]	Subsidy [4]	Registration × Subsidy [5]
OLS					
Purchases bundle	481	0.53	0.01	0.11	0.01
			(0.04)	(0.02)	(0.04)
			[0.866]	[0.000]	[0.865]
Probit					
Purchases bundle	481	0.53	0.01	0.11	0.00
			(0.04)	(0.02)	(0.04)
			[0.840]	[0.000]	[0.894]

Notes: Sample restricted to households offered the input package (input package and input package + land registration study arms). Robust standard errors in parentheses and associated p-values in brackets.

Medium(ish)-term impacts of demarcation and inputs

Study Design Illustrated



Empirical Approach: Intent-to-treat impacts

Focus on intent-to-treat estimates using 1-year and 2-year follow-up survey data:

$$\mathrm{Y}_{i,t} = \alpha_t + \theta \cdot \mathrm{Land}_i + \eta \cdot \mathrm{Inputs}_i + \mu \cdot (\mathrm{Land}_i \times \mathrm{Inputs}_i) + \lambda_{is} + \varepsilon_{i,t}$$

- $\mathrm{Y}_{i,t}$ is an outcome of interest
- Land_i is an indicator for random assignment to the land registration assistance offer
- Inputs_i is an indicator for random assignment to the input package offer

1-year impacts

Some evidence that **land registration** decreased land tenure insecurity ($p = 0.11$)

- No impacts on on-farm or off-farm investment behaviors.

The **input package** increased non-labor inputs and improved climate agricultural practices:

- But together, these yielded a **negative impact on harvest values**.
- Farmers shifted land from soy to butter beans but experienced high crop loss.
- Together yielded a drop in soy harvest and no increase in butter bean harvest.

Combined bundle yielded both sets of results

▸ 1-year results tables

2-year impacts

After two years, **land registration** impacts on land tenure insecurity largely wane

- Still no impacts on on-farm or off-farm investment behaviors.

Investment impacts (non-labor inputs, agricultural practices) of the **input package** also wane:

- But the **negative impact on harvest values** persists.
- Farmers abandoned butter beans and returned to soy but did not plant as much.
- Yielded a drop in soy harvest driving a decrease in aggregate harvest value

Again, limited evidence of complementarities with **combined bundle** yielding the combination of results

▸ 2-year results tables

Key Results and Discussion

Limited evidence supporting short-term investment impacts of demarcation

- No impacts on willingness to purchase short-term investment package
- No evidence of impacts on 1-year or 2-year investment behaviors

Input package as a cautionary tale:

- Temporary decrease in input cost shifted planting behaviors with persistent negative impacts
- Households also abandon climate-smart farming practices

Does not rule out longer-term impacts

- Land comprised demarcation and cadastral registration but titles were only delivered after the endline.

Thank you!

1-year results tables I

Back

	N [1]	Control mean [2]	Land Registration [3]	Inputs package [4]	Registration + Inputs [5]
Panel A: Tenure Security:					
Perceived land tenure insecurity index	969	-0.00	-0.12	-0.05	-0.13
			(0.08)	(0.07)	(0.08)
			[0.114]	[0.500]	[0.107]
Panel B: Household agriculture:					
On-farm labor (hours)$^{\diamond}$	971	1765.19	24.78	-5.96	8.98
			(133.46)	(122.71)	(115.29)
			[0.853]	[0.961]	[0.938]
Non-labor inputs index	971	0.00	0.04	0.54	0.59
			(0.09)	(0.09)	(0.10)
			[0.694]	[0.000]	[0.000]
Farming practices index	971	-0.02	-0.02	0.27	0.24
			(0.08)	(0.09)	(0.08)
			[0.822]	[0.002]	[0.003]
Has any tree	971	0.65	0.01	0.05	-0.01
			(0.04)	(0.04)	(0.04)
			[0.830]	[0.215]	[0.895]
Harvest value (USD)$^{\diamond}$	971	2405.87	157.77	-368.76	-204.05
			(265.92)	(219.87)	(228.40)
			[0.553]	[0.094]	[0.372]

Notes: Robust standard errors in parentheses and associated p-values in brackets. Columns 3-5 report regression coefficients controlling for randomization strata fixed effects. $\diamond$ denotes variables winsorized at the 1% level by treatment status. Non-labor inputs index comprises indicator variables for fertilizer, pesticide/herbicide/fungicide, and improved seed use. Farming practices index comprises indicator variables for the following climate smart agriculture practices: controlled burning, intercropping, minimum tillage, permanent basins, and crop rotation.

1-year results tables II

	N [1]	Control mean [2]	Land Registration [3]	Inputs package [4]	Registration + Inputs [5]
Has off-farm business	971	0.21	0.03	0.05	0.03
			(0.04)	(0.04)	(0.04)
			[0.389]	[0.174]	[0.348]
Household off-farm labor (hours)◇	971	17.94	9.72	9.35	13.87
			(7.37)	(7.15)	(7.93)
			[0.188]	[0.191]	[0.081]
Value of capital◇	971	171.52	87.41	87.25	10.55
			(90.27)	(97.88)	(86.60)
			[0.333]	[0.373]	[0.903]
Value of sales◇	971	80.35	23.17	17.00	15.71
			(35.00)	(34.74)	(31.53)
			[0.508]	[0.625]	[0.618]
Value of profits◇	971	35.48	5.97	-1.48	3.85
			(16.84)	(15.08)	(15.18)
			[0.723]	[0.922]	[0.800]

Notes: Robust standard errors in parentheses and associated p-values in brackets. Columns 3-5 report regression coefficients controlling for randomization strata fixed effects. ◇ denotes variables winsorized at the 1% level by treatment status.

1-year results tables III

	N [1]	Control mean [2]	Land Registration [3]	Inputs package [4]	Registration + Inputs [5]
Cultivated soya	971	0.69	-0.02	-0.07	-0.06
			(0.04)	(0.04)	(0.04)
			[0.574]	[0.066]	[0.087]
Cultivated butter beans	971	0.13	0.01	0.24	0.24
			(0.03)	(0.04)	(0.04)
			[0.652]	[0.000]	[0.000]
Area cultivated soya	971	0.55	0.00	-0.13	-0.11
			(0.08)	(0.07)	(0.06)
			[0.991]	[0.040]	[0.085]
Area cultivated butter beans	971	0.07	0.06	0.08	0.08
			(0.05)	(0.03)	(0.03)
			[0.176]	[0.003]	[0.001]
Harvest value: soya (USD)$^{\diamond}$	971	917.01	69.39	-169.92	-99.70
			(121.35)	(107.55)	(109.30)
			[0.568]	[0.114]	[0.362]
Harvest value: butterbeans (USD)$^{\diamond}$	971	78.68	12.38	-10.33	25.13
			(35.74)	(31.32)	(31.96)
			[0.729]	[0.742]	[0.432]

Notes: Robust standard errors in parentheses and associated p-values in brackets. Columns 3-5 report regression coefficients controlling for randomization strata fixed effects. $\diamond$ denotes variables winsorized at the 1% level by treatment status.

2-year results tables I

Back

	N [1]	Control mean [2]	Land Registration [3]	Inputs package [4]	Registration + Inputs [5]
Panel A: Tenure Security:					
Perceived land tenure insecurity index	953	0.02	-0.08	-0.04	-0.10
			(0.09)	(0.09)	(0.09)
			[0.351]	[0.679]	[0.232]
Panel B: Household agriculture:					
On-farm labor (hours)$^{\diamond}$	956	1550.34	160.14	111.19	98.57
			(109.41)	(96.22)	(97.02)
			[0.144]	[0.248]	[0.310]
Non-labor inputs index	956	0.01	-0.07	-0.03	0.05
			(0.09)	(0.09)	(0.09)
			[0.424]	[0.764]	[0.556]
Farming practices index	956	0.03	0.07	0.10	0.13
			(0.09)	(0.09)	(0.09)
			[0.449]	[0.264]	[0.140]
Has any tree	956	0.76	0.05	-0.00	-0.02
			(0.04)	(0.04)	(0.04)
			[0.145]	[0.990]	[0.603]
Harvest value (USD)$^{\diamond}$	956	2134.31	-83.89	-377.33	-315.92
			(199.42)	(184.78)	(180.79)
			[0.674]	[0.041]	[0.081]

Notes: Robust standard errors in parentheses and associated p-values in brackets. Columns 3-5 report regression coefficients controlling for randomization strata fixed effects. $\diamond$ denotes variables winsorized at the 1% level by treatment status. Non-labor inputs index comprises indicator variables for fertilizer, pesticide/herbicide/fungicide, and improved seed use. Farming practices index comprises indicator variables for the following climate smart agriculture practices: controlled burning, intercropping, minimum tillage, permanent basins, and crop rotation.

2-year results tables II

	N [1]	Control mean [2]	Land Registration [3]	Inputs package [4]	Registration + Inputs [5]
Has off-farm business	956	0.24	0.02	-0.02	0.05
			(0.04)	(0.04)	(0.04)
			[0.572]	[0.566]	[0.225]
Household off-farm labor (hours)◇	956	34.68	12.19	-3.85	14.91
			(10.42)	(9.48)	(10.49)
			[0.242]	[0.684]	[0.156]
Value of capital◇	956	257.22	-89.08	-96.87	-16.75
			(154.64)	(154.74)	(158.64)
			[0.565]	[0.531]	[0.916]
Value of sales◇	956	110.84	16.82	4.01	3.20
			(38.58)	(39.80)	(34.81)
			[0.663]	[0.920]	[0.927]
Value of profits◇	956	46.31	-4.18	-11.53	-7.97
			(15.01)	(14.36)	(14.83)
			[0.781]	[0.422]	[0.591]

Notes: Robust standard errors in parentheses and associated p-values in brackets. Columns 3-5 report regression coefficients controlling for randomization strata fixed effects. ◇ denotes variables winsorized at the 1% level by treatment status.

2-year results tables III

	N [1]	Control mean [2]	Land Registration [3]	Inputs package [4]	Registration + Inputs [5]
Cultivated soya	956	0.73	-0.03	-0.02	-0.00
			(0.04)	(0.04)	(0.03)
			[0.439]	[0.624]	[0.914]
Cultivated butter beans	956	0.14	-0.00	0.03	0.02
			(0.03)	(0.03)	(0.03)
			[0.951]	[0.282]	[0.450]
Area cultivated soya	956	0.72	0.07	-0.12	-0.07
			(0.10)	(0.08)	(0.07)
			[0.490]	[0.124]	[0.327]
Area cultivated butter beans	956	0.10	0.02	-0.01	0.04
			(0.04)	(0.03)	(0.04)
			[0.637]	[0.767]	[0.221]
Harvest value: soya (USD)$^{\diamond}$	956	999.37	-25.95	-259.19	-221.12
			(123.69)	(108.70)	(103.07)
			[0.834]	[0.017]	[0.032]
Harvest value: butterbeans (USD)$^{\diamond}$	956	74.90	-26.19	-37.42	-13.36
			(26.90)	(26.11)	(27.12)
			[0.331]	[0.152]	[0.622]

Notes: Robust standard errors in parentheses and associated p-values in brackets. Columns 3-5 report regression coefficients controlling for randomization strata fixed effects. $\diamond$ denotes variables winsorized at the 1% level by treatment status.