Market Design for Land Trade: Evidence from Uganda and Kenya

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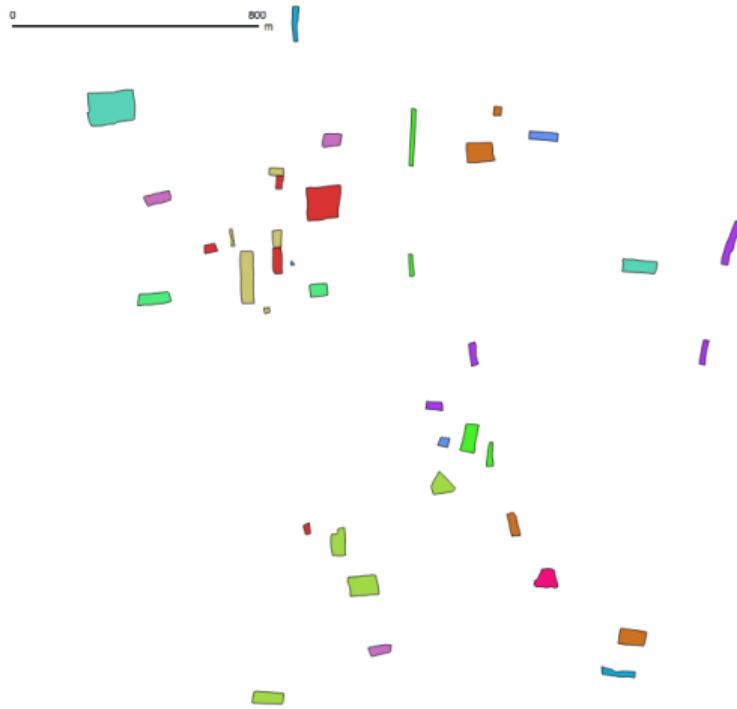
Motivation

- Farms in many low-income countries are small, fragmented, and unproductive.

  Gollin et al. (2002, 2004); Adamopoulos & Restuccia (2014); Deininger et al. (2014); Ali et al. (2015); Lowder et al. (2016); Gollin (2018); Suri & Udry (2022)

- Quantitative estimates suggest 20–360% returns to land reallocation.

  Adamopoulos & Restuccia (2014, 2020); Deininger et al. (2014); Restuccia & Santaeulalia-Llopis (2017); Foster & Rosenzweig (2017); Gollin & Udry (2021), Aragon et al. (2021); Britos et al. (2020); Adamopoulos et al. (2021); Bolhuis et al. (2021).

- Conventional land markets are (very) slow to realize them. Coase theorem fails.

  FAO (2003); Demetriou (2014); Bleakley & Ferrie (2014), Milgrom (2017), Smith (2019), Bartels et al. (2020); Chen et al. (2021)

- **Can we do better with better market design?**

Kisoro District, Uganda

Tororo District, Uganda

Our approach

- Set up a lab-in-the-field game that models the land trade problem.

- Show that farmers agree with the model's key properties.

- Demonstrate that "status quo" markets are not efficient.

- Demonstrate the potential of two interventions.
  - Simple: market centralization
  - Complex: a computerized "package exchange"

The model

Consolidation: contiguous farms more profitable than fragmented farms

Sorting: Better farmers produce more with better land

Span of control: Decreasing returns to total farm size

+ private information about own values

An initial allocation (A)   An efficient allocation (B)

The talk in a nutshell

- Model + initial allocation are a reasonable representation of status quo

- Getting to efficiency is **hard** in free-form trade

- Interventions (Centralization & Package Exchange) substantially increase efficiency

- ... by solving different parts of the problem

- Both **decrease** inequality

Why market design?

- Many governments enacted centrally-planned **land consolidation programs**:
  E.g. France (18th-20th C), Sweden (18th-19th C), Denmark (19th-20th C), Germany (20th C).
  FAO (2003); Demetriou (2014); Hartvigsen (2014) discusses 25 countries.

- Daunting in low-information, low state capacity, potentially coercive settings.

- Markets are voluntary, participatory mechanisms that leverage local information.

- Many success stories, allocating medical residencies, schooling, donor organs, radio spectrum, microcredit, sanitation

Why lab experiments?

- Engineering approach: need to tailor tools to realistic participants

  Roth (2002); Milgrom (2009); Duflo (2017)

- Land issues are incredibly sensitive.

- Can measure outcomes against known benchmarks.

- Abstract from property rights issues

  de Soto (2000); Field (2007); Galiani & Schargrodsky (2010, 2011); Deininger et al. (2011); Ali et al. (2011, 2015); Libecap & Lueck (2011); de Janvry et al. (2015); Lawry et al. (2017); Chen et al. (2017); Agyei-Holmes et al. (2020)

- Related experiments: Tanaka (2007), Gáfaro & Mantilla (2020)

8

Outline

The Constraints Survey

- 1,404 land-owning farmers in Masaka, Uganda (mostly coffee, maize, beans)

- Sample selection: pre-screened on potential interest in playing trading games over 3 weeks. Similar on observables to same-region LSMS.

- Active in the land market:
  - 10% bought/sold, 20% rented in/out in last 12 months.
  - 45% of cultivated land acquired on the market.

- Questions on:
  - **Fragmentation**
  - **Heterogeneity & complementarities**
  - **Returns to scale**
  - **Information structure**
  - Land market activity & market institutions
  - Culture & attitudes to trade
  - Beliefs about impact of different reforms

Validating the model

Consolidation: contiguous farms more profitable than fragmented farms

Sorting: Better farmers produce more with better land

Span of control: Decreasing returns to total farm size

+ private information about own values

Validating the model

Consolidation: contiguous farms more profitable than fragmented farms

- Costs and benefits of fragmentation long debated

    McCloskey (1972); Blarel et al. (1992); Deininger et al. (2014); Ali et al. (2015); Foster & Rosenzweig (2017)

- Largely viewed within the technical literature as a problem to be eliminated

    FAO (2003), Demetriou (2014), Hartvigsen (2014)

Our data:

- 64% have fragmented farms. 20–40 mins walk between plots
- 25% tried to consolidate; of which ½ succeeded
- **91% prefer 1×2 acre to 2×1 acre**
- **88% believe consolidation increases profits**
- Most point to travel time, labor management & cost

Validating the model

• Taken as given in the quantitative literature

Sorting: Better farmers produce more with better land

Our data:

• 99% think there is ability heterogeneity in the village
• Guess best farmers produce $\approx 3\times$ worst farmers
• 99% think there is land quality heterogeneity
• 99% think ability and quality are complements

Validating the model

Span of control: Decreasing returns to total farm size

- Largely taken as given in the quantitative literature
- Helps rationalize existence of many producers

Our data:

- 40% think they could not farm more than their current endowment
- 99% think there is heterogeneity in span of control (7:1 best/worst ratio)

13

Validating the model

- Ability is (partially) observable
  98% say "everyone knows who the best farmers are"
- But many sources of unobservable heterogeneity in WTA/WTP

Important: no concern about adverse selection (lemons)

- 3% think plot quality is difficult to assess
- 94% know how to assess quality of others' plots

$+$ private information about own values

14

Outline

Why is land trade hard?

**Farmer 16 wants
3 consolidated plots**

8	5	17	6	7	13
3	10	14	10	8	8
16	16	9	16	3	14

① **Thin markets**
  - Myerson & Satterthwaite (1983) $\Rightarrow$ efficient trades may not take place
② **Exposure risk**
      Goeree & Lindsay (2017)
  - Buy then sell? May get held up, or stuck with 4 plots.
  - Sell then buy? May get held up, or stuck with 2 plots.
③ **Transaction costs/complexity**
      Milgrom (2017)
  - Chains of transactions hard to find & implement
④ **Liquidity constraints**
  - Can't buy without selling first.

15

Outline

Experiment 1: Design Overview
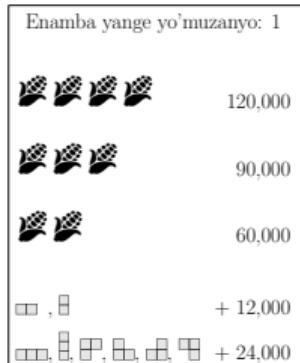
▸ Parameters ▸ Descriptives

- Land-owning farmers from 68 villages in Masaka, Uganda

- Game:
  - 18 players
  - 3 plots each
  - Paper game currency

- Strong monetary incentives.
 - 1 day's wage showup fee
  - + up to 2.2 days' wages in trade

- **Free-form bargaining over 7 days**

16

Timeline

Analysis

Gains from trade scaled by total potential gains:

$$\text{Efficiency} = \frac{\text{Final welfare} - \text{Initial welfare}}{\text{First best welfare} - \text{Initial welfare}} < 1$$

Decomposition:

$$\text{Efficiency} = \text{Consolidation} + \text{Sorting} - \text{Span of control}$$
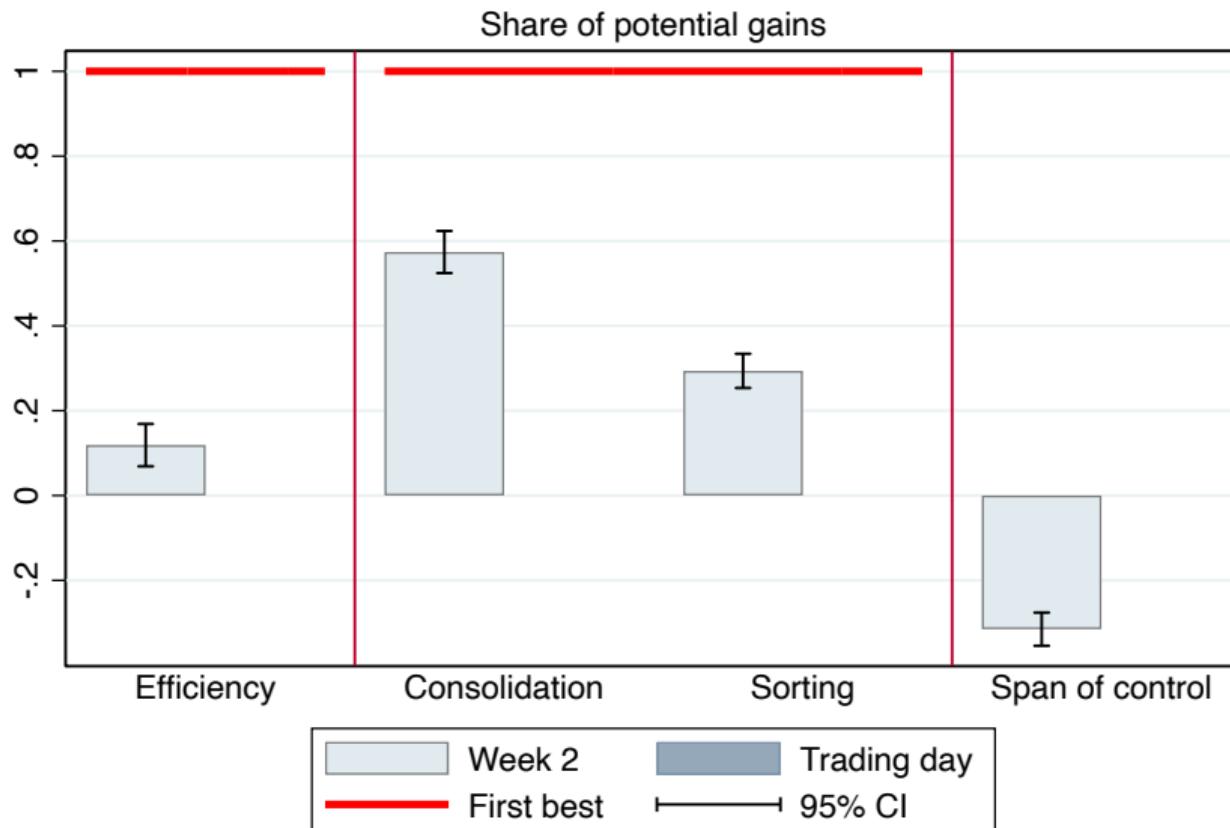
Result 1: Efficient trade is hard

Training games

- Standard lab market game based on Chamberlin (1948)

- Market game with multiple "titles" and span of control

Result 2: Some aspects are harder than others

Share of potential gains

Most gains from Consolidation

Substantial losses to "Span of control" – people left with too much or too little land

20
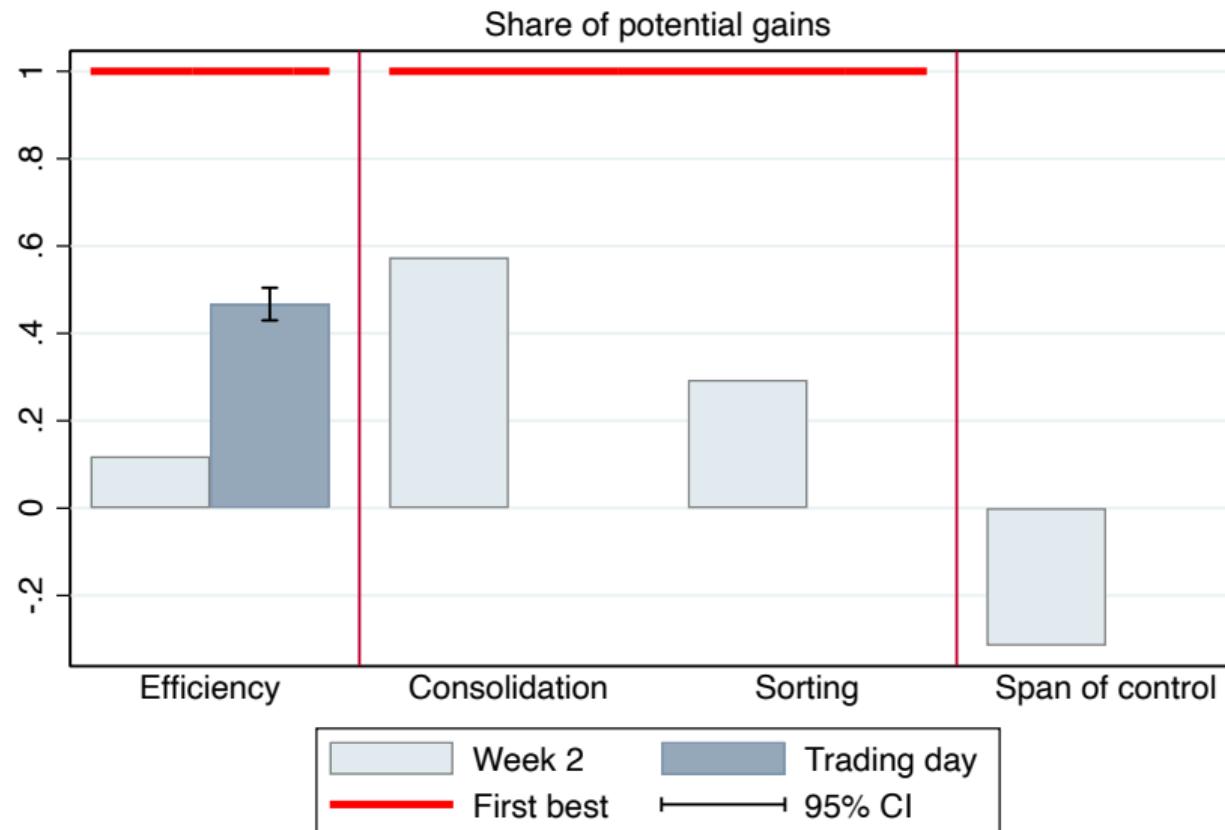
Market centralization intervention

- After week 2 trade, a **surprise** market centralization intervention: "Trading Day"
- Everyone comes to the lab, given as much time as needed for additional trade
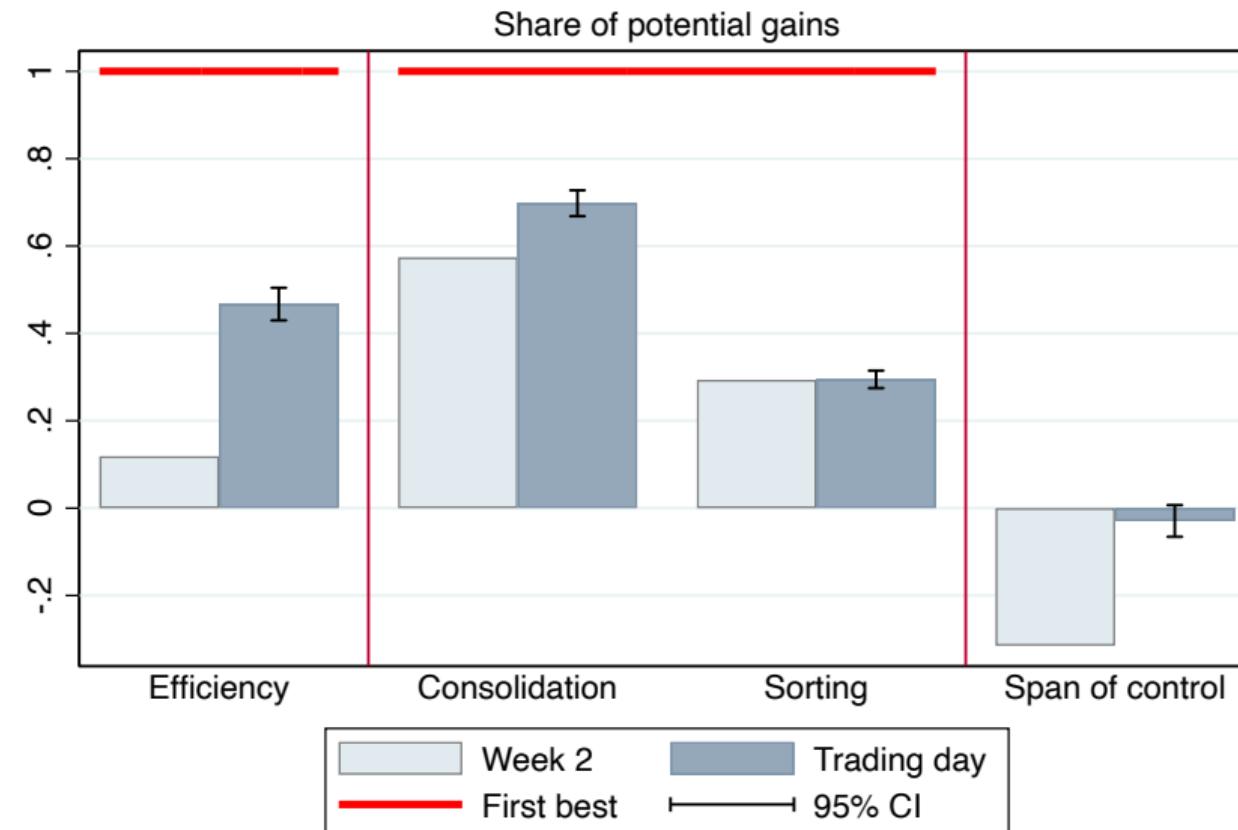
Centralization can help with all of the theoretical frictions
- By helping groups of individuals identify mutually beneficial sequences of trade
- By helping enforcement of chains

Result 3: Large efficiency gains from centralization

Share of potential gains

Result 4: Entirely driven by Consolidation and Span of control

Share of potential gains

Legend: Week 2, Trading day, First best, 95% CI

Summary of findings

- 57% of potential defragmentation gains $\rightarrow$ 70% in trading day

- 30% of potential sorting gains $\rightarrow$ no improvement in trading day.

- Large "span of control" losses $\rightarrow$ eliminated in trading day.

Outline

Experiment 2: Design overview

- 48 sessions with land-owning farmers in Kiambu county, Kenya
- Selected from a census of local villages
- Game: 6 participants $\times$ 2 plots each
- Session: eight 10-minute computerized "land auctions" (all paid)
- Incentives: \$3 show-up $+$ \$4 average earnings $\approx$ 1.5 days' wages

An initial allocation   An efficient allocation

Mechanisms

Three **continuous double auctions** with varying **package size**.[1]

- **CDA-Broker:** Buy or sell one plot at a time.
  - E.g. "Buy plot 3 for at most 300"

- **CDA-Swap:** can also bid to buy **and** sell one plot.
  - E.g. "Buy plot 3 and sell plot 7, pay at most 50"

- **CDA-Package:** can also bid to buy **and** sell up to two plots
  - E.g. "Buy plots 9 and 10, sell plots 2 and 5, receive at least 200"

- Software searches for implementable trades & sets prices in continuous time.

All treatments:

- Centralized trade
- "Bidding assistants" to operate software
- Verbal communication
- XOR bids

[1]Inspired by Goeree & Lindsay (2017)'s housing exchange

Potential advantages of the package mechanism

1. **Thickens** the market
2. Reduces **exposure risk**
3. Reduces **transaction costs**
4. Alleviates **liquidity constraints**

But...

- Bidding language is complex

- Space of potential packages is large
  - 20 sell-one-buy-one packages
  - 45 sell-two-buy-two packages

- Difficult to provide real-time feedback

Land Auction

Player 1

Type	Single	Adj. Bonus
▪	400	160
▪	300	120
▪	200	80

Current Allocation

1	2	3	4	400	0
5	6	7	8	300	0
9	10	11	12	0	0

Cash: 300

Total Profit: 1000

Alternate Allocation
🔄 reset

1	2	3	4	400	0
5	6	7	8	300	0
9	10	11	12	0	0

Cash: 300

Total Profit: 1000

You can select either one land to sell or one land to buy.

Submit a Bid

Sell Lots	Buy Lots	Total Price	
		● Receive (at least)	0
		○ Pay (at most)	

Submit

Your current open bids.

Sell Lots ⇕	Buy Lots ⇕	Price ⇕	Current Profit ⇕	Expected Profit ⇕	Action
		No data available in table			

8   30

Legend

⭐ For Sale   🔵 Offer to Buy   ⇄ Offer to Swap

Current Allocations and Offers

Lot: 1	Lot: 2	Lot: 3	Lot: 4
Owner: 1 ⭐	**Owner: 3**	**Owner: 2** 🔵	**Owner: 5** 🔵

Lot: 5	Lot: 6	Lot: 7	Lot: 8
Owner: 4 🔵	**Owner: 6**	**Owner: 1** ⭐	**Owner: 3**

Lot: 9	Lot: 10	Lot: 11	Lot: 12
Owner: 2 ⭐	**Owner: 5**	**Owner: 4**	**Owner: 6**
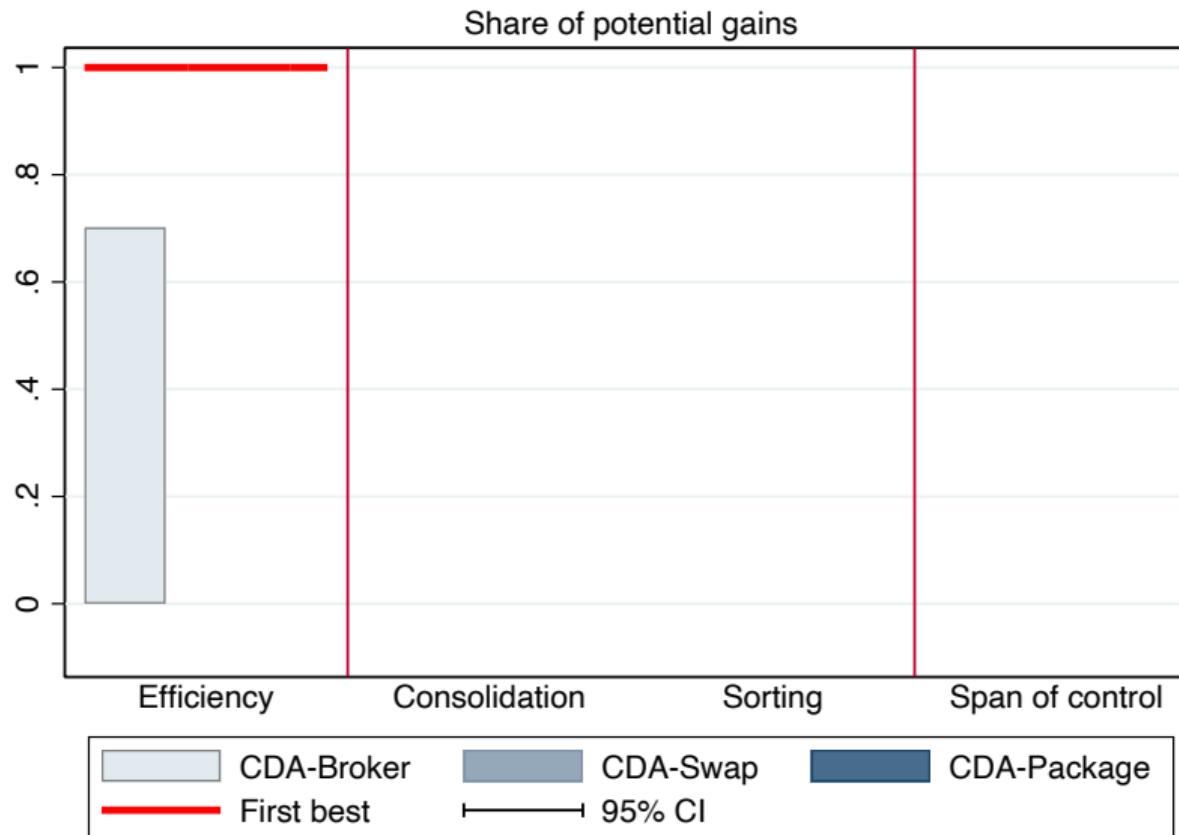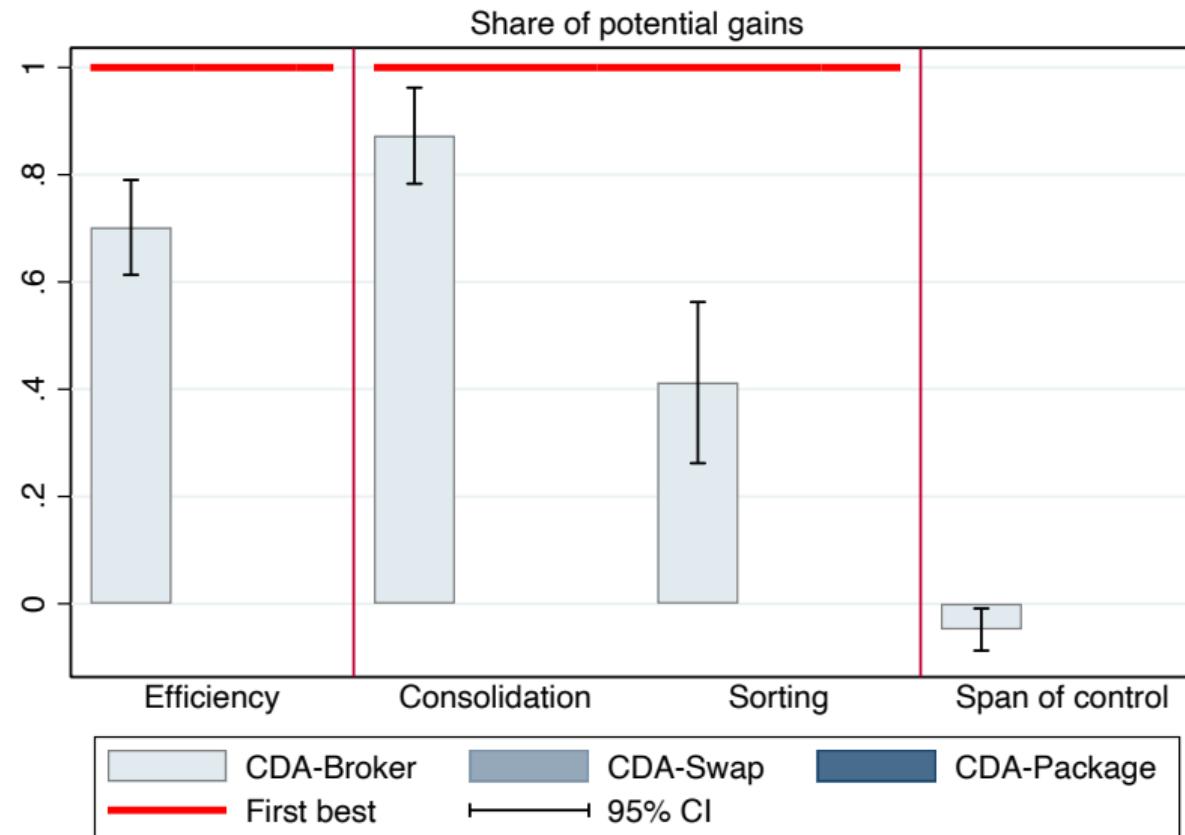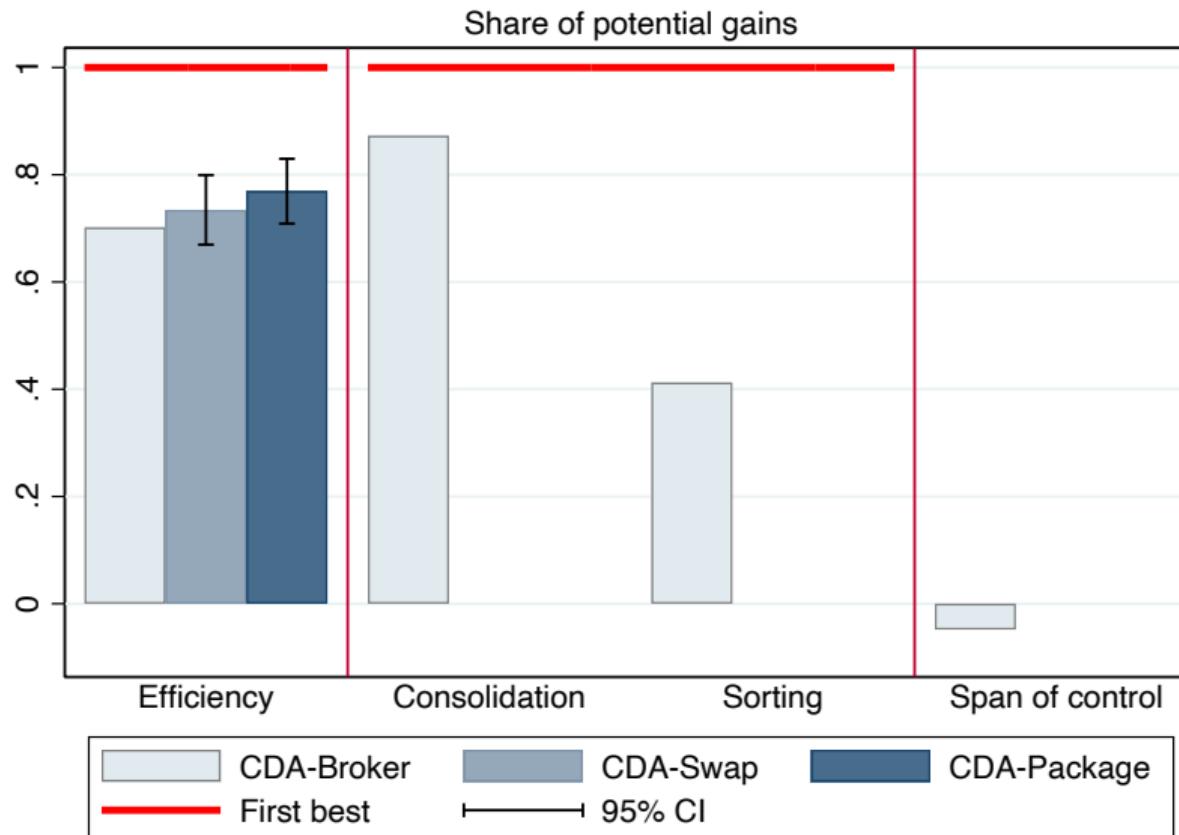
Result 5: High efficiency in benchmark treatment

Share of potential gains

Result 6: mostly from Consolidation

Share of potential gains
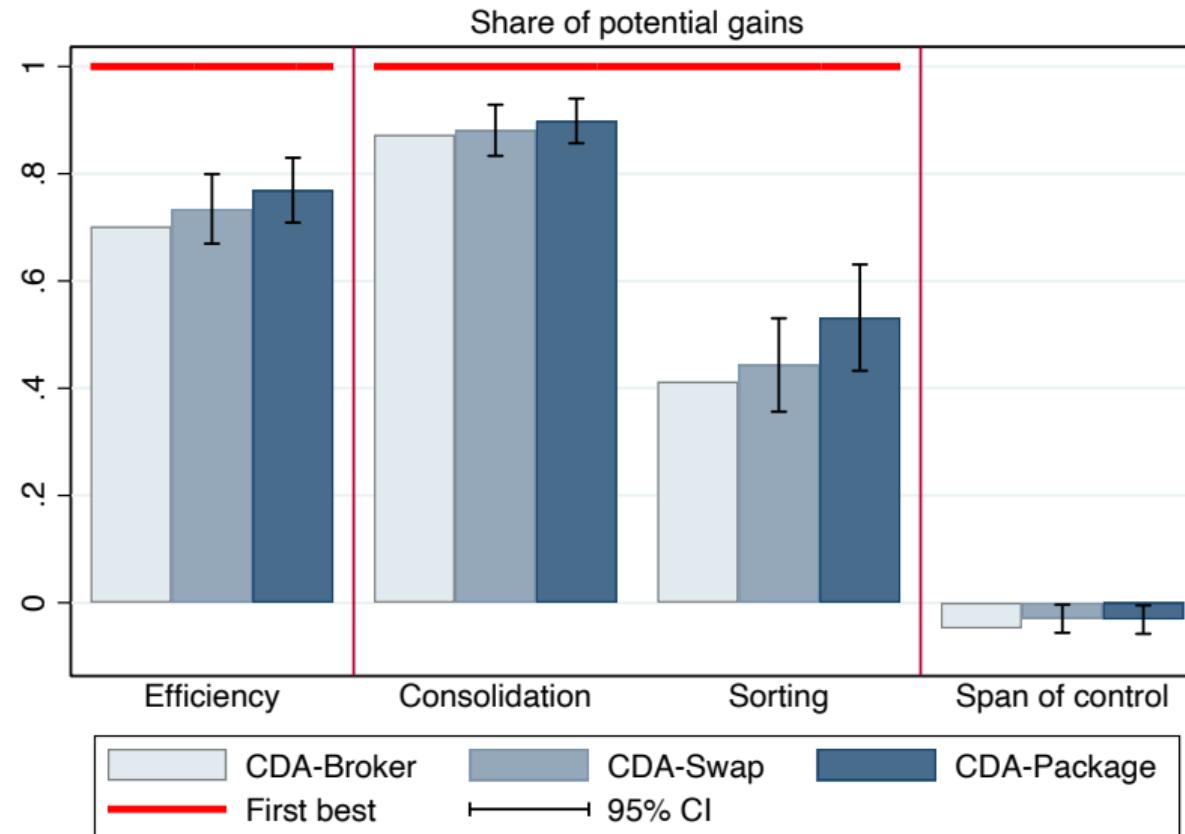
Result 7: Higher efficiency in package mechanisms

Share of potential gains

Legend: CDA-Broker, CDA-Swap, CDA-Package, First best, 95% CI

Result 8: Primarily driven by Sorting

▸ Robustness

Share of potential gains

Legend:
- CDA-Broker
- CDA-Swap
- CDA-Package
- First best
- 95% CI

X-axis categories: Efficiency, Consolidation, Sorting, Span of control

Summary of findings

- High efficiency: 70% in CDA-Broker $\rightarrow$ 77% in CDA-Package

- 87% of potential defragmentation gains $\rightarrow$ 90% in CDA-Package

- 41% of potential sorting gains $\rightarrow$ 53% in CDA-Package.

- Minimal "span of control" losses.

Outline

Inequality

- A significant potential concern: market design might exacerbate inequality.

- Particularly in complex mechanisms: sophisticates might profit at others' expense.[2]

- We compute the Atkinson Index of final assets (under log utility):

$$I^A = 1 - \exp\left(\sum_i (\ln y_i - \ln \bar{y})\right)$$

- Significantly **reduced** by both market design interventions.

- Seems to be primarily by reducing very bad outcomes

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[2]Related concerns in school choice: Abdulkadiroglu et al. (2006); Pathak and Sönmez, (2008).

Outline

Additional results

- Can't households just centralize the market themselves? ▸ Endogenous Trading Day
  - They try to!
  - More Consolidation and Sorting, but bigger Span of Control losses. Zero net gain.
  - Conjecture: big difference between complete and partial centralization

- Role of holdouts ▸ Simple vs Complex
  - Many plots may never be for sale
  - Experiment 1 randomized "Complex" maps with holes, and "Simple" maps without.
  - **Little effect on any dimension**. Perhaps because we are still far from 1st best

- Role of liquidity constraints ▸ Low vs High Cash
  - Experiment 2 randomized initial cash balances (Low vs High)
  - **Precise zero effects**. Maybe constraint not tight enough.

- Role of communication ▸ Verbal bargaining
  - We allow verbal communication in all treatments.
  - Package exchange seems to crowd out verbal bargaining.
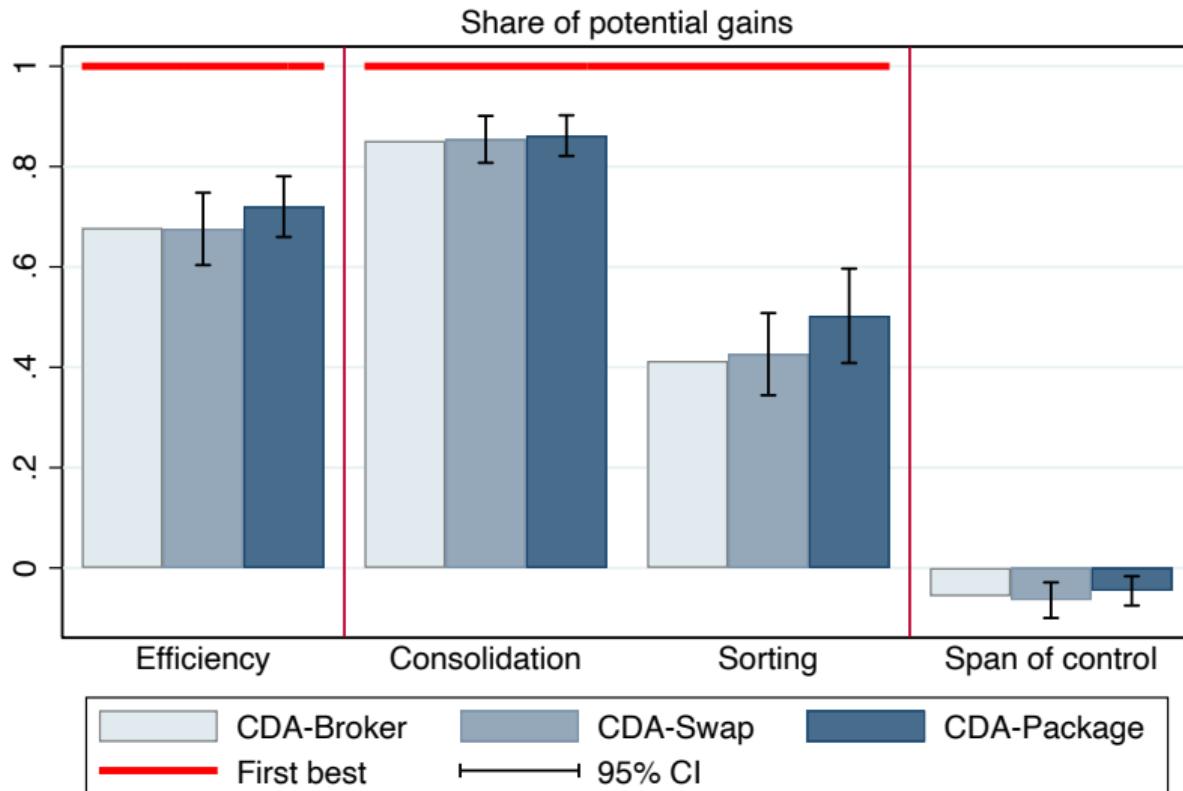
Conclusion

- We show the potential for implementable market design improvements to unlock gains from trade.

- Centralizing the land market eliminates losses to trade breakdown, helps with consolidation, but no impact on sorting.

- Package exchange mechanism can unlock sorting gains.

- No equity-efficiency tradeoff.

- Next step: field experiments.

Appendix

Share of potential gains

These regressions include block 1

Endogenous Trading Day ▸ Back

Share of potential gains

Efficiency | Consolidation | Sorting | Span of control
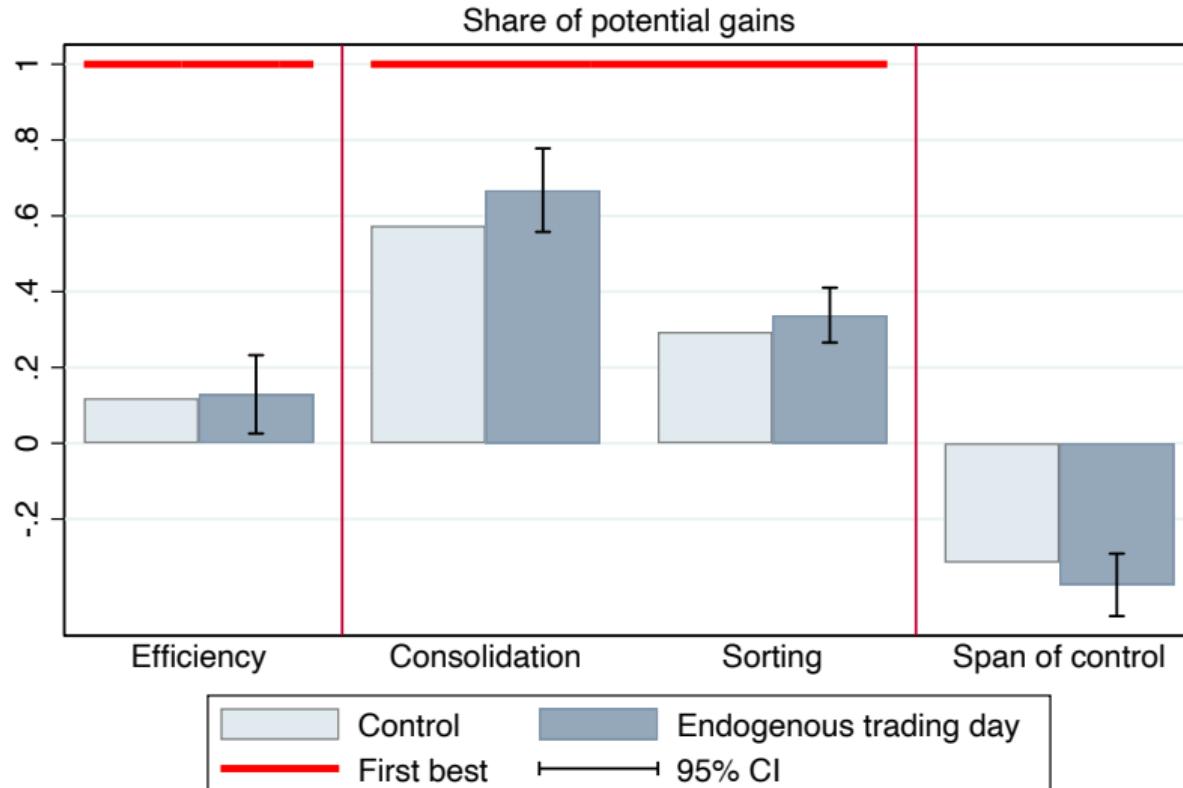
Control — Endogenous trading day
First best — 95% CI

Note: these regressions include week 2 (pre trading day)

Simple map

Complex map

Share of potential gains

Low vs High Cash

Share of potential gains

Table 1: Game parameters in the experiments

	Centralization experiment	Package exchange experiment
Mode of interaction	Free-form bargaining	Computerized trade
Market design variation	Decentralized/Centralized trade	CDA-Broker/CDA-Swap/CDA-Package
Other treatments	Simple/Complex maps	High/Low initial cash
Number of players	18	6
Number of tradable plots	54	12
Span of control	3 plots	2 plots
Land quality types	{Low, Med, High} = {1, 1.5, 2}	
Farmer ability types	Low {0.8, 0.9, 1, 1.1, 1.2} Med {1.3, 1.4, 1.5, 1.5, 1.6, 1.7} High {1.8, 1.9, 2, 2, 2.1, 2.2}	Low {1, 1} Med {1.5, 1.5} High {2, 2}
Value of a single plot	Land quality × Farmer ability	
Bonus for 2 adjacent plots	Farmer ability × 0.4	Land quality × Farmer ability × 0.4
Initial cash balance	6	Low cash treatment 2.5 High cash treatment 7.5
Information structure	Initial endowments are common knowledge, own values are private information.	
Verbal communication permitted?	Yes	
Potential efficiency gains from consolidation (% of first best)	50%	73.3%
Debt	Initial assets − 1.75	None
Incentives (per trading round)	8,000 UGX × (Final assets − Debt)	5 KES × Final assets
Trading rounds	2 (plus "trading day")	8
Duration of trading rounds	Free-form trade: 1 week Trading day: as much time as needed	10 minutes

Notes: parameters have been normalized such that the average value of a low-quality plot held by a low-ability farmer is 1. Share of efficiency gains from consolidation/sorting varies by initial allocation. In the centralization experiment we selected initial allocations to target a 50-50 split.

Table 24: Summary statistics: Buganda south and Ugandan farmers

| | | | | LSMS | | | | | |
| | Our sample | | | Buganda South | | | Uganda | | |
Demographics	mean	S.D.	obs	mean	S.D.	obs	mean	S.D.	obs
Age	43.76	13.52	1404	40.12	17.41	224	39.11	17.48	3338
Female	0.51		1404	0.56		224	0.51		3338
Head of household	0.65		1404	0.42		224	0.38		3338
Married: monogamous	0.63		1404	0.43		224	0.49		3338
Married: polygamous	0.06		1404	0.09		224	0.11		3338
Nr adults (inc respondent)	2.99	1.54	1404	2.40	1.25	96	2.60	1.27	1246
Nr children in household	3.37	2.07	1404	3.13	2.07	96	2.97	2.13	1246
Education									
Education (years)	7.16	3.21	1404	6.28	3.13	171	6.34	3.24	2551
Numeracy	0.76		1224						
Farm size and income									
How many plots do you own and cultivate?	2.10	1.15	1404	1.70	0.89	96	1.69	0.93	1246
Total land holdings cultivated (in acres)	2.95	3.32	1349	3.25	8.30	96	2.94	4.22	1244
Income from agriculture (1000 UGX/season)	1482	2174	1349	1087	1921	81	897	1995	847
Income from agriculture (USD PPP/season)	1365	2002	1349	1001	1770	81	826	1837	847
Farming ability (self-evaluated, relative to best in village)									
Farmer's total production	0.47		1403						
Max farm size (w/o hired labor)	0.59		1403						
Preferences (1-5 scale)							GPS		
Patience	4.35	0.66	1404				3.52	1.17	1000
Risk tolerance	4.09	0.90	1404				3.40	0.91	1000

▸ Back to Uganda

Table 25: Summary statistics: Kiambu and Kenyan farmers

| | | | | DHS | | | | | |
| | | | | Kiambu | | | Kenya | | |
Demographics	mean	S.D.	obs	mean	S.D.	obs	mean	S.D.	obs
Age	42.65	10.45	263	38.63	15.17	933	38.73	16.61	51535
Female	0.58		264	0.50		933	0.52		51535
Married	0.77		264	0.65		933	0.63		51535
Nr of people in household	4.06	1.71	264	3.57	1.93	429	4.31	2.48	23785
Education									
Education (years)	9.75	2.94	264	9.96	3.65	932	8.01	4.23	51416
Land tenure									
Owns two or more plots	0.22		264						
Total land ownership in acres	1.01	1.52	237	1.88	3.54	418	2.56	3.79	23230
Land trade									
Fraction of plots with joint ownership	0.61		303						
Fraction of plots that are far from home	0.24		303						
Fraction of plots with a title	0.64		303						
Fraction who bought a plot (last 12 months)	0.05		264						
If has bought land: How many acres	0.83	1.42	11						
Fraction who sold a plot (last 12 months)	0.02		264						
If has sold land: How many acres	7.62	11.80	4						
Fraction of sales due to emergencies	0.40		5						
Consolidation									
How important is it to have all your plots together? (1–10, 1 is better to have spread out)									
1	0.43		264						
2 – 9	0.08		264						
10	0.47		264						
Why?									
Why fragment? Less risky	0.25		264						
Why consolidate? More productive	0.38		264						
Preferences (1–5)							GPS		
Risk tolerance	3.95	1.42	264				3.49	0.93	998

▸ Back to Kenya