

The background features a light beige field with faint, repeating geometric patterns. Overlaid on this are several vibrant, hand-painted elements: orange and green foliage in the top left, green and black patterns in the top right, a green and black frond-like shape in the bottom left, and a red and black striped pattern with green foliage in the bottom right.

Sell Low and Buy High: Arbitrage and Local Price Effects in Kenyan Markets

M. Burke, L.F. Bergquist, & E. Miguel (2019):
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Outline

1. Introduction
2. Methodology, data and estimation
3. Results
4. Conclusion
5. Discussion



Introduction

Motivation

- ♦ Farmers often sell low immediately after harvest and buy high later
- ♦ Limited access to credit restricts farmers' ability to store grain and take advantage of arbitrage opportunities



Research Question

- ♦ How borrowing constraints affect smallholder farmers' storage decisions and seasonal consumption patterns in rural grain markets in Kenya?
- ♦ **Hypothesis:** The limited availability of credit constrains farmers from taking advantage of the arbitrage opportunities
- ♦ **What the researchers do:** offer randomly selected smallholder maize farmers a loan at harvest → study whether it improves their ability to use storage to arbitrage local price fluctuations
- ♦ **Main result:** Providing timely access to credit allows farmers to buy at lower prices and sell at higher prices, increasing farm revenues and generating a return on investment of 29%

Literature Review

- ◆ Credit constraints lead to suboptimal storage decisions among farmers in Kenya
- ◆ Allowing farmers to borrow against future harvests can increase lean-season consumption
- ◆ Changes in the timing of school fee payments in Malawi force credit-constrained HH to sell crops earlier at lower prices



Null results

no significant productivity gains from microfinance



Small subsets

significant effects only among small subsets of the recipients

Contribution to Dev't Econ

- ◆ Empirical evidence on the role of credit in enabling smallholder farmers to exploit intertemporal arbitrage opportunities





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Methodology, data & estimation

Setting

- ◆ In East Africa, 25–40% price increases post-harvest
- ◆ up to 87% - in smaller, rural markets
- ◆ 3.5% of the crop value spent on storage
- ◆ Inventories depletion within 5m post-harvest
- ◆ **Why are farmers not using storage?**

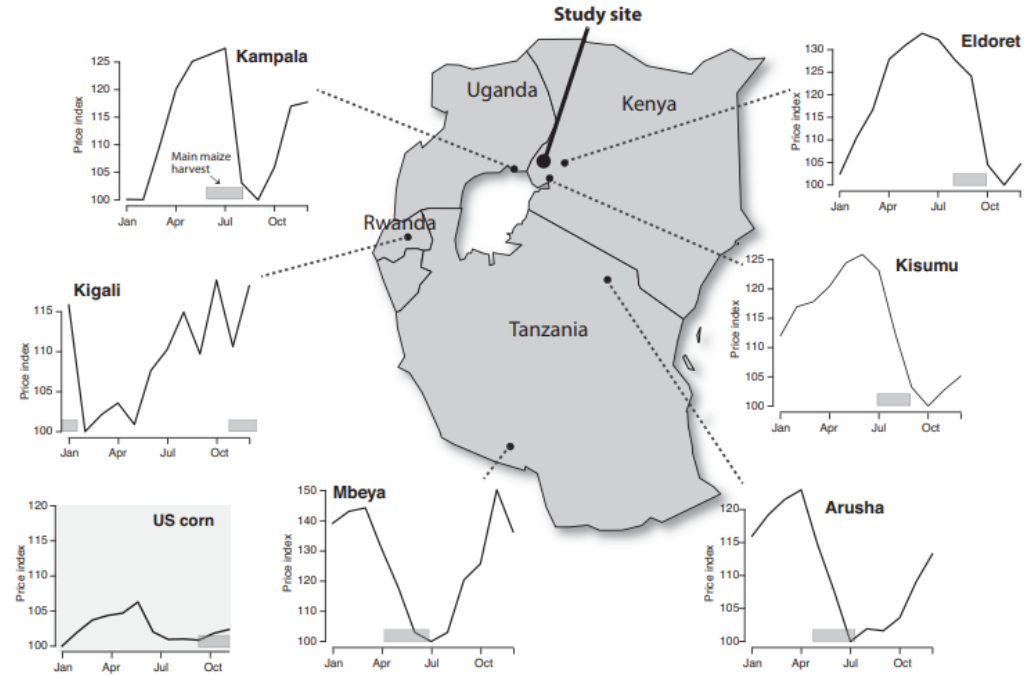


FIGURE I

Monthly Average Maize Prices

Monthly average maize prices, shown at East African sites for which long-term data exist, 1994–2011. Data are from the Regional Agricultural Trade Intelligence Network, and prices are normalized such that the minimum monthly price = 100. Our study site in western Kenya is indicated, and the gray squares represent an independent estimate of the months of the main harvest season in the given location. Price fluctuations for maize (corn) in the United States are shown in the lower left for comparison.

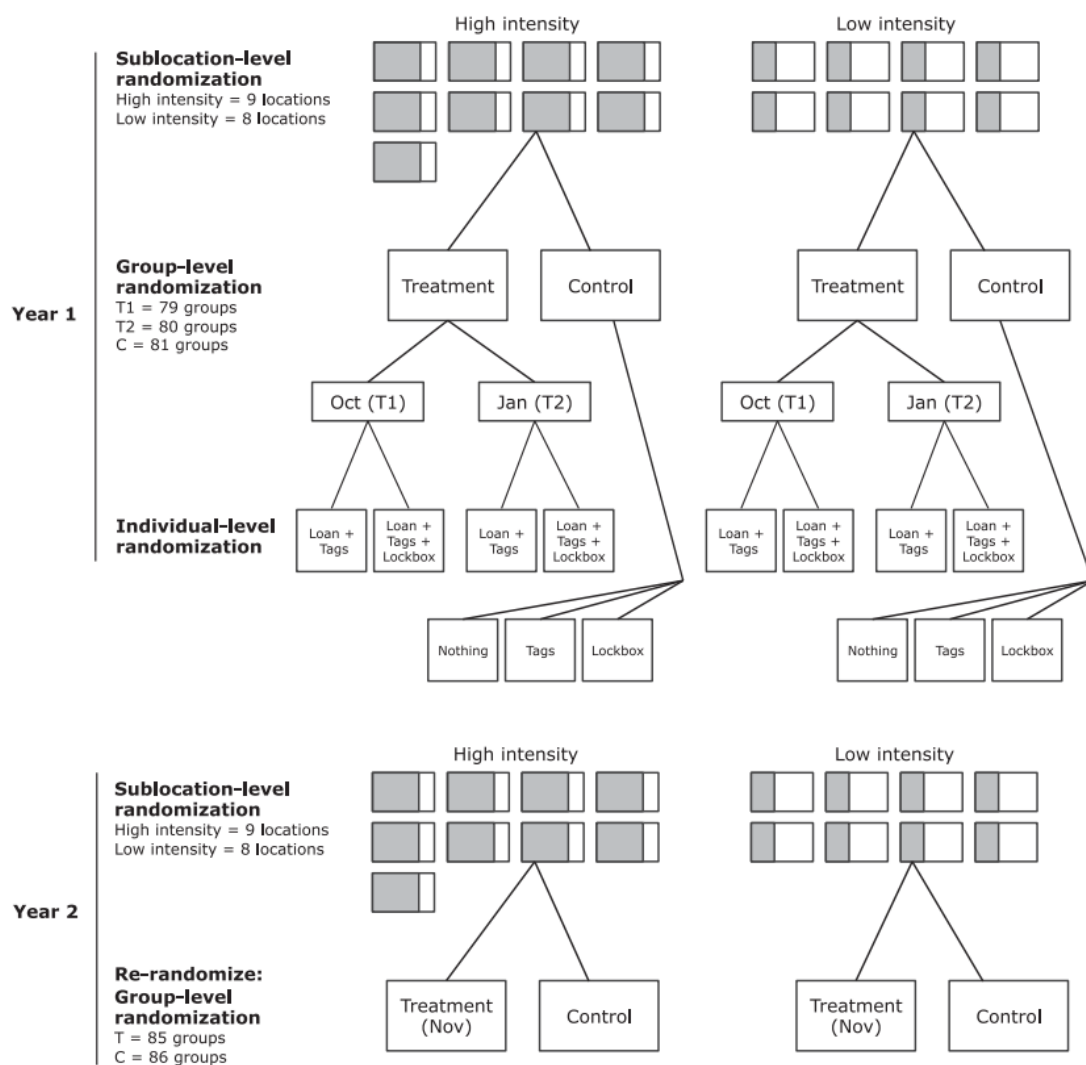
Focus groups prior to the experiment

Reasons why farmers do not use storage:

- ♦ Credit constraints
- ♦ High postharvest expenses (school fees, bills, etc.)
- ♦ Limited access to credit markets
- ♦ Impatience
- ♦ Sell due to urgent cash needs, buy due to consumption needs
- ♦ Myopic on storage costs due to credit constraints

Study Design

- ♦ Collaboration with One Acre Fund to provide loans
- ♦ Webuye & Matete districts in Kenya
- ♦ 3 levels of randomization: sublocation-level, group-level & individual-level r.
- ♦ 2012–2013 & 2013–2014 seasons



Identification Strategy

Treatment variation: The size of the loan was a linear function of the number of bags farmers had in storage at the time of loan disbursement

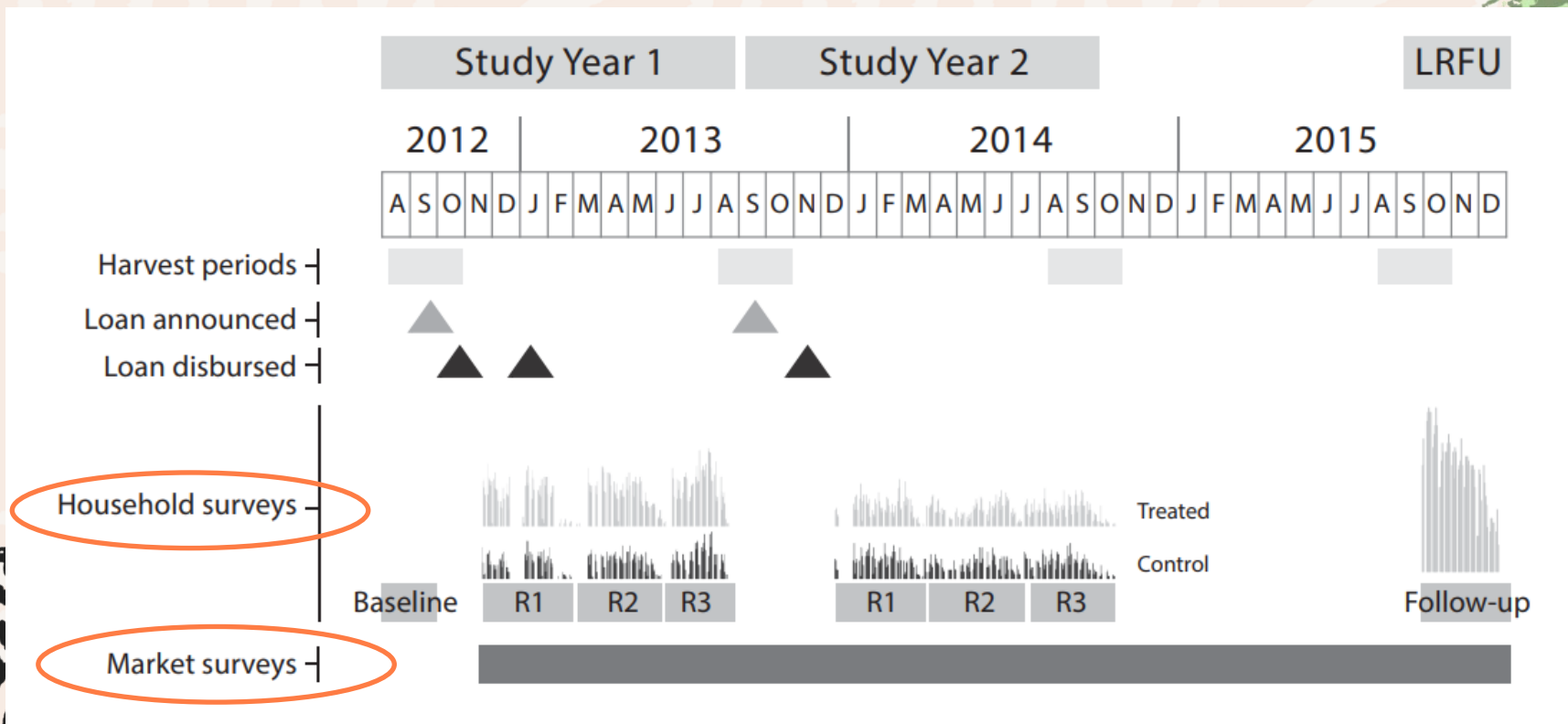
- ♦ **Loan Timing:** In Year 1: early loan (Oct) and later loan (Jan)
In Year 2: early loan (Nov)
- ♦ **Tags:** tags served as a behavioural "nudge" to encourage storing crops
- ♦ **Lockbox:** a physical savings device to help farmers save money by giving them a secure place to store cash

Control groups variation:

- ♦ **Nothing:** a true control group
- ♦ **Tags**
- ♦ **Lockbox**



Data and Estimation



Timing of the Main Harvest Periods, Study Interventions, and Data Collection Periods

Model

$$Y_{ijry} = \sum_{r=1}^3 \beta_r T_{jy} + \eta_{ry} + d_t + \gamma_s + \varepsilon_{ijry}$$

- ♦ Y_{ijry} the outcome of interest for individual i in group j in round r (1, 2, 3) in year y
- ♦ β_r intent-to-treat estimate in round r is identified from within-round variation between T and C groups
- ♦ T_{jy} whether group j was assigned to treatment in year y
- ♦ η_{ry} round year fixed effects
- ♦ d_t survey date
- ♦ γ_s stratification dummies

Model: Price effects

$$p_{msty} = \alpha + \beta_1 H_s + \beta_2 month_t + \beta_3 (H_s * month_t) + \varepsilon_{mst}$$

- ♦ p_{msty} maize sales price at market m in sublocation s in month t in year y
- ♦ H_s binary variable (randomly assigned) indicating whether sublocation s is a high-intensity sublocation
- ♦ $month_t$ is a time trend (in each year, Nov = 0, Dec = 1, etc.)
- ♦ If sufficient shift, then $\beta_1 > 0$ and $\beta_3 < 0$



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Results



(1) Individual- level results

Take-up of the loan treatments was quite high,
with 64% in Year 1 & 62% in Year 2



Inventory effects

- ◆ T-farmers hold more inventories for much of the year, on avg ~25% more than the C-group mean
- ◆ In R1, 50% of the loan was used to reduce net maize sales (or increase inventories)

	Y1		Y2		Pooled	
	Overall (1)	By rd (2)	Overall (3)	By rd (4)	Overall (5)	By rd (6)
Treat	0.57*** (0.14)		0.55*** (0.13)		0.56*** (0.10)	
Treat - R1		0.87*** (0.28)		1.24*** (0.24)		1.05*** (0.18)
Treat - R2		0.75*** (0.17)		0.30* (0.17)		0.55*** (0.12)
Treat - R3		0.11 (0.08)		0.08 (0.34)		0.09 (0.16)
Observations	3,836	3,836	2,944	2,944	6,780	6,780
Mean DV	2.67	2.67	1.68	1.68	2.16	2.16
Std. dev. DV	3.51	3.51	2.87	2.87	3.23	3.23
R squared	0.37	0.37	0.21	0.21	0.33	0.33
p-val Treat	<.01		<.01		<.01	
p-val Treat FWER	<.01		<.01		<.01	
p-val Treat - R1		<.01		<.01		<.01
p-val Treat - R1 FWER		<.01		<.01		<.01
p-val Treat - R2		<.01		.07		<.01
p-val Treat - R2 FWER		<.01		.17		<.01
p-val Treat - R3		.18		.81		.56
p-val Treat - R3 FWER		.33		.91		.63

Notes. The dependent variable is inventories, as measured by the number of 90-kg bags of maize held by the household at the time of survey. "Treat" is an indicator for being in a treatment group. "Treat - R_x" is an interaction between an indicator for being in a treatment group and an indicator for being in round *x*. Regressions include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. "Mean DV" and "Std. dev. DV" are the mean and standard deviation of the dependent variable among the control group. Standard and family-wise error rate (FWER) *p*-values are presented (family of outcomes is inventories, net revenues, consumption, and effective prices, as prespecified). Significant at 90% (*), 99% (***) confidence.

Revenue effects

- ♦ Net revenues are significantly lower immediately post-harvest and significantly higher later in the year
- ♦ Given uncond. avg loan size 5,476 Ksh, 1,573 Ksh is eq. to a **29% return**

NET REVENUE EFFECTS, INDIVIDUAL LEVEL

	Y1		Y2		Pooled	
	Overall (1)	By rd (2)	Overall (3)	By rd (4)	Overall (5)	By rd (6)
Treat	265 (257)		855*** (302)		533*** (195)	
Treat - R1		-1,165*** (323)		16 (445)		-614** (272)
Treat - R2		510 (447)		1,995*** (504)		1,188*** (337)
Treat - R3		1,370*** (413)		565 (403)		999*** (291)
Observations	3,795	3,795	2,935	2,935	6,730	6,730
Mean DV	334	334	-3,434	-3,434	-1,616	-1,616
Std. dev. DV	6,055	6,055	6,093	6,093	6,359	6,359
R squared	0.03	0.04	0.07	0.08	0.12	0.12
p-val Treat	.30		.01		.01	
p-val Treat FWER	.38		.01		.01	
p-val Treat - R1		<.01		.97		.02
p-val Treat - R1 FWER		<.01		.97		.04
p-val Treat - R2		.26		<.01		<.01
p-val Treat - R2 FWER		.38		<.01		<.01
p-val Treat - R3		<.01		.16		<.01
p-val Treat - R3 FWER		<.01		.26		<.01

Notes. The dependent variable is net revenues, as measured by the value (in Ksh) of maize sales minus the value of maize purchases that round. The exchange rate during the study period ranged from 80 to 90 Kenyan shillings per US\$. "Treat" is an indicator for being in a treatment group. "Treat - Rx" is an interaction between an indicator for being in a treatment group and an indicator for being in round x. Regressions include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. "Mean DV" and "Std. dev. DV" are the mean and standard deviation of the dependent variable among the control group. Standard and family-wise error rate (FWER) p-values are presented (family of outcomes is inventories, net revenues, consumption, and effective prices, as prespecified). Significant at 95% (**), 99% (***) confidence.

Consumption effects

- ♦ Much of the increase in net revenues may have gone to consumption, but lacking statistical significance

HH CONSUMPTION (LOG) EFFECTS, INDIVIDUAL LEVEL

	Y1		Y2		Pooled	
	Overall (1)	By rd (2)	Overall (3)	By rd (4)	Overall (5)	By rd (6)
Treat	0.01 (0.03)		0.06* (0.04)		0.04 (0.02)	
Treat - R1		- 0.03 (0.05)		0.06 (0.05)		0.01 (0.03)
Treat - R2		0.03 (0.04)		0.08* (0.04)		0.05* (0.03)
Treat - R3		0.04 (0.04)		0.05 (0.05)		0.04 (0.03)
Observations	3,792	3,792	2,944	2,944	6,736	6,736
Mean DV	9.48	9.48	9.61	9.61	9.55	9.55
Std. dev. DV	0.63	0.63	0.63	0.63	0.64	0.64
R squared	0.03	0.03	0.05	0.05	0.06	0.06
p-val Treat	.68		.08		.13	
p-val Treat FWER	.69		.10		.13	
p-val Treat - R1		.49		.17		.69
p-val Treat - R1 FWER		.49		.26		.69
p-val Treat - R2		.48		.08		.09
p-val Treat - R2 FWER		.49		.17		.13
p-val Treat - R3		.36		.27		.16
p-val Treat - R3 FWER		.47		.35		.21

Notes. The dependent variable is log HH consumption (measured in logged Ksh), aggregated from a detailed 30-day recall consumption module. "Treat" is an indicator for being in a treatment group. "Treat - Rx" is an interaction between an indicator for being in a treatment group and an indicator for being in round x. Regressions include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. "Mean DV" and "Std. dev. DV" are the mean and standard deviation of the dependent variable among the control group. Standard and family-wise error rate (FWER) *p*-values are presented (family of outcomes is inventories, net revenues, consumption, and effective prices, as prespecified). Significant at 90% (*) confidence.

Price effects

- ◆ Immediate post-harvest period net sales are significantly lower among the T-group, as sales ↓ / purchases ↑
- ◆ Later, this trend reverses

NET SALES AND EFFECTIVE PRICES, INDIVIDUAL LEVEL

	Net sales		Effective price	
	Overall	By rd	Purchase	Sales
Treat	0.19*** (0.06)		- 57.45** (27.16)	145.51*** (41.77)
Treat - R1		- 0.21** (0.10)		
Treat - R2		0.38*** (0.10)		
Treat - R3		0.37*** (0.09)		
Observations	6,740	6,740	2,014	1,428
Mean DV	- 0.41	- 0.41	3,084.78	2,809.76
Std. dev. DV	2.04	2.04	534.45	504.82
R squared	0.10	0.10	0.09	0.07
p-val Treat			.03	<.01
p-val Treat FWER			.04	<.01

Notes. The dependent variable in columns (1)–(2) is net sales (quantity sold minus quantity purchased, measured in 90-kg bags of maize) that round. Columns (1)–(2) include round-year fixed effects, strata dummies, and controls for survey date, with errors clustered at the group level. The dependent variable in column (3) is “effective purchase price,” which is constructed by dividing the total value of all purchases over the full year (summed across rounds) by the total quantity of all purchases over the full year. The dependent variable in column (4) is “effective sales price,” which is constructed similarly. Columns (3)–(4) include only one observation per individual (per year). Round fixed effects are omitted in these specifications to estimate the effect of treatment on prices paid and received, which change because of shifts in the timing of transactions; therefore round controls are not appropriate. Instead we include year fixed effects and strata dummies. In all columns, “Treat” is an indicator for being in a treatment group. “Treat - R_x” is an interaction between an indicator for being in a treatment group and an indicator for being in Round *x*. “Mean DV” and “Std. dev. DV” are the mean and standard deviation of the dependent variable among the control group. Standard and family-wise error rate (FWER) *p*-values are presented for effective prices (family of outcomes is inventories, net revenues, consumption, and effective prices, as prespecified). FWER *p*-values are not presented for net sales, which was not included in the prespecified main family of outcomes. Significant at 95% (**), 99% (***) confidence.

Key Findings on Nudge Only, Tag, and Lockbox Effects

- ♦ “Nudge only” treatment had no significant effect on storage behavior, inventories, revenues, or consumption. This suggests that credit itself is crucial in generating the observed effects from the main loan product
- ♦ In Year 1, the study included individual-level randomization of tag and lockbox treatments. These treatments were not included in Year 2 due to minimal effects observed in Year 1.

(2) General Equilibrium results



Market- level effects

MARKET PRICES FOR MAIZE AS A FUNCTION OF LOCAL TREATMENT INTENSITY

	Main specification (3 km)			Robustness (pooled)	
	Y1	Y2	Pooled	1 km	5 km
High	4.41* (2.09)	2.85 (1.99)	3.97** (1.82)	2.79 (1.72)	3.77* (1.82)
Month	1.19*** (0.36)	1.22*** (0.38)	1.36*** (0.35)	1.33*** (0.34)	1.54*** (0.29)
High intensity * Month	-0.57 (0.42)	-0.48 (0.46)	-0.57 (0.39)	-0.52 (0.39)	-0.83** (0.37)
Observations	491	381	872	872	872
R squared	0.08	0.03	0.06	0.06	0.06
p-val High	.052	.172	.044	.124	.056
p-val High bootstrap	.096	.196	.084	.152	.112
p-val Month	.005	.005	.001	.001	.000
p-val Month bootstrap	.040	.000	.034	.022	.000
p-val High * Month	.193	.316	.158	.200	.038
p-val High * Month bootstrap	.176	.316	.170	.218	.056

Notes. The dependent variable is price, as measured monthly following loan disbursal (Nov–Aug in Y1; Dec–Aug in Y2) in market surveys. Prices are normalized to 100 in Nov in low-intensity sublocations. “High” intensity is an indicator for a sublocation randomly assigned a high number of treatment groups. “Month” is a linear month time trend (beginning in Nov at 0 in each year). Standard errors are clustered at the sublocation level. To check robustness to small cluster standard error adjustments, *p*-values from the standard specification are compared to *p*-values drawn from the wild bootstrap procedure proposed by [Cameron et al. \(2008\)](#), clustered at the sublocation level. Significant at 90% (*), 95% (**), 99% (***) confidence.

GE



↑↑ **Storage**

Shift of the supply across time



Postharvest Price ↑↑

Prices rose by about 4% in high-intensity markets



Price Convergence

As the season progressed, prices in high-intensity areas converged with low-density markets, ending 2% lower



Early Season

Price effects were most pronounced early in the season



Lean Season

Price effects were smaller, likely due to staggered sales by treated farmers



Supply Contraction

Maize supply contracted by ~1.8%, leading to a price ↑ of ~1.6%



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Conclusion

Key takeaways

- ◆ Offering harvest-time loans to Kenyan maize farmers allows them to engage in arbitrage by delaying sales, storing maize, selling at higher prices
- ◆ Significant “+” effects on farmer revenues, when accounting for GE effects
- ◆ High treatment intensity areas experience substantial spillover effects
- ◆ It is needed to account for GE effects in evaluating interventions like credit access or agricultural technologies



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Discussion

Limitations

- ♦ Fragmented markets
- ♦ Measurement of long-run effects
- ♦ Lack of long-run storage by traders
- ♦ Heterogeneity in effects



Challenges in Fragmented Markets

- ♦ Impact on profitability
- ♦ Diminished revenue gains in areas with high loan saturation
- ♦ Distribution of welfare gains



THANKS!

DO YOU HAVE ANY QUESTIONS?