The Cost of Competition:
A City-Wide Experiment on Below-Market Prices in Tanzania

Job Market Paper

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Firms in low-income countries have been shown to avoid being competitive. This project runs a field experiment to measure firms' aversion to engaging in below-market pricing. It offers guaranteed profit margins to 561 maize flour retails in Tanzania, contingent on them selling at a price 10-12.5% or 20-25% below the lowest price near the firm. Only one-third were initially willing to be treated, requiring a 380% increase in daily profits from maize flour to lower their price 10-12.5% below-market and 600% increase to sell at 20-25% below-market. However, exposure to experimentally-induced price shocks decreased firms' aversion to engaging in below-market pricing. After three weeks of treatment, 33% more firms were willing to participate in a second round of treatment, requiring 35% less profit. Reluctance to engage in competitive pricing may help explain why firms in low-income countries remain small.

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1 Introduction

Firms in low-income countries are small and struggle to grow. A host of barriers to growth have been identified, such as difficulty accessing credit (Bazzi et al., 2023), finding suppliers (Grant and Startz, 2022), networking with business partners (Dimitriadis and Koning, 2024; Macchiavello and Morjaria, 2023), and accessing customers (Dillon et al., 2025). These barriers limit the potential of firms who want to grow.

However, there is evidence that firms might not want to grow. In urban fruit and vegetable markets in India, Banerjee et al. (2024) find that vendors are unwilling to sell a product that other vendors already sell, even after learning the profitability of selling the product. This aversion to engaging in profit-increasing behavior is highlighted by Breza et al. (2023) who find that unemployed laborers in India are unwilling to accept work below the prevailing wage in the presence of other laborers but will do so in private.

This paper uses a field experiment to measure the aversion to engaging in profit-increasing behavior among urban firms in Mwanza, Tanzania. The field experiment incentivizes firms to publicly sell a staple food at below-market prices, identifying the firms that are willing to undercut nearby firms and estimating the profit these firms require to do so.

The field experiment offered all 561 firms selling dona maize flour, a staple food in the region, a guaranteed profit margin for three weeks contingent on these firms selling it a price $10 - 12.5\%$ or $20 - 25\%$ below the lowest price near the firm. A firm was randomly assigned treatment with high or low probability conditional on the lowest profit margin they were willing to accept to sell at a treatment price. Firms were assigned to high or low probability to balance pre-treatment characteristics between both *ex ante* treated and untreated firms and between *ex ante* untreated firms near treated firms and untreated firms far from treated firms.

Only 184 (33%) of these firms are willing to publicly lower their price to below-market levels. Among these firms, they require an average 380% increase in daily profits from dona maize flour to lower their price 10-12.5% below-market and 600% increase to sell at 20-25% below-market. 108 firms are randomly assigned treatment for three weeks; after this period, 33% more firms are willing to participate in a second round of treatment, and they require on average 35% less profit to participate.

Treatment effects are muted, though treatment is estimated to roughly doubles the number of customers per day purchasing dona maize flour at treated firms compared to untreated firms. The increase in sales is reduced by $\frac{2}{3}$ for treated firms whose nearest neighbor is also treated.

This project contributes to research experimenting with firms in low-income countries. First, this experiment incentivizes firms to change prices, while previous experiments incentivize firms to enter markets or start selling products (Annan, 2024; Banerjee et al., 2024; Bartkus et al., 2022; Bergquist et al., 2024; Bergquist and Dinerstein, 2020; Busso and Galiani, 2019). This allows for the direct estimation of the effects of price shocks without relying on first-order entry responses. Second, this experiment varies the probability that firms are assigned treatment in a way that not only balances characteristics between firms expected to be treated and untreated, as is common

when randomizing treatment assignment (Bruhn and McKenzie, 2009; Casaburi and Reed, 2022), but also balances characteristics between firms expected to be untreated who are exposed to treated firms and untreated firms not exposed to treated firms. This explicitly designs for the estimation of spillovers, which are typically addressed by varying the intensity of treatment (Miguel and Kremer, 2004).

Section 2 derives the measure of the private cost of competition estimated in the experiment, characterizes how firms price dona maize flour in Mwanza, Tanzania, describes the experimental design, and covers the implementation of the experiment. Section 3 presents the distribution of the private cost of competition among firms in the sample and estimates of the effect of treatment on firms in the sample. Section 4 interprets the findings of the project, and Section 5 summarizes the project.

2 Experimental Design

2.1 Model of the Private Cost of Price Competition

This section describes how the experiment is designed to measure the total daily profit from a good that a firm requires to sell it at below-market prices. First, it develop a model of an entrepreneur who evaluates utility at a given price, where utility is daily profits at that price minus a money-metric private cost to the entrepreneur they incur when selling at that price. The model derives how the entrepreneur's private cost relates to the lowest daily profit the firm will make selling at that price. Second, this section shows how the model-derived measure of the private cost of selling at a price is estimated using experimentally-derived measures.

2.1.1 Modeling the Private Cost of Price Competition

An entrepreneur sells at a price p. The quantity they sell at price p is given by a demand curve $D(p)$. The total revenue they make at p is given by $pD(p)$. The firm pays a constant marginal cost, c, regardless of their price. The total cost of selling at p is given by $cD(p)$. Combined, the total profit the firm makes at p is $pD(p) - cD(p)$.

However, the entrepreneur might consider more than profit when selling at a price p. For example, they believe they could incur social penalties if other entrepreneurs consider p to be lower than an implicit price floor. The entrepreneur's other considerations that come with selling at a price p are modeled by a money-metric function $S(p)$ that gets subtracted from the firm's total profits from selling at p.

Consider giving the entrepreneur a chance to sell at a price p. The entrepreneur shares a profit margin π they are willing to accept to sell at p. If a firm is willing to sell at p for profit margin π, then the profit they make from it, $pD(p) - (p - \pi)D(p)$, must be greater than or equal to the other considerations they have from selling at that price, $S(p)$. The lowest profit margin $\underline{\pi_p}$ the firm is willing to accept to sell at p is such that $pD(p) - (p - \underline{\pi_p})D(p) = S(p)$. Solving for $S(p)$ shows that it is equal to $\underline{\pi_p}D(p)$. The other considerations the entrepreneur has from selling at p – the

private cost of selling at a price p – is identified by the smallest profit they accept to sell at p and the quantity sold at p, $D(p)$.

The next subsection shows how the experiment elicits $\underline{\pi}$ and measures the expectation of $D(p)$.

2.1.2 Estimating the Private Cost of Price Competition

The private cost of selling at price p for a firm is given by $\underline{\pi}D(p)$, where $\underline{\pi}$ is the lowest profit margin the entrepreneur is willing to accept to sell at p and $D(p)$ is the quantity sold at p.

However, the entrepreneur does not know exactly what demand will be at a given price, replacing $D(p)$ with the entrepreneur's expectations of demand, $\mathrm{E}[D(p)]$. However, the entrepreneur can approximate $\mathrm{E}[D(p)]$ by combining the difference between the given price p to their current price p^0, their current sales $D(p^0)$, and their knowledge about how sales respond to prices. This knowledge is the price elasticity of demand; it is defined as the percent change in quantity sold when going from p^0 to p divided by the percent change in price from p^0 to p. This might not be perfectly known, though the entrepreneur might have an idea about how demand responds around their current price, ε_{p^0}. This allows for the first-degree approximation of $\mathrm{E}[D(p)] \approx \frac{p-p^0}{p^0}\mathrm{E}[\varepsilon_{p^0}]D(p^0)$. This approximation assumes that the local demand change the firm expects at p^0, $\mathrm{E}[\varepsilon_{p^0}]$, does not vary as price changes to p.

The experiment measures the private cost of selling at three different prices. The first price is to match the lowest price around them, which is denoted by $\underline{p}$. The second is to sell at 100 Tanzanian Shillings per kilogram less than $\underline{p}$ at $p_{100} = \underline{p} - 100$, and the third is 200 Tanzanian Shillings per kilogram less than $\underline{p}$ at $p_{200} = \underline{p} - 200$. It does this by offering to guarantee the firm's profit margin at one of those prices and elicits the smallest profit margin they accept to sell at each of three prices.

The experiment bounds $\underline{\pi}$ because profit margins offered to treated firms are increments of 50 Tanzanian Shillings. The firm can only pick the profit margins they are willing to accept in increments of 50; if $\underline{\pi}$ is the profit margin for them to break even at p, they are only able to pick $\lceil\underline{\pi}\rceil$, the lowest integer multiple of 50 above $\underline{\pi}$. Accordingly, $\lfloor\underline{\pi}\rfloor$ is the highest integer multiple of 50 below x_l. In this way the experiment bounds the firm's private cost: $S(p) \in [\lfloor\underline{\pi}\rfloor D(p), \lceil\underline{\pi}\rceil D(p)]$.

For each firm I calculate the lowest upper bound on the private cost of selling at each $p \in \{\underline{p},\, p_{100},\, p_{200}\}$:

$$\underbrace{\widehat{S_i(p)}}_{\substack{\text{Estimate of}\\ \text{private cost of}\\ \text{selling at } p}} \equiv \underbrace{\lceil\underline{\pi}(p)\rceil}_{\substack{\approx \text{Smallest}\\ \text{profit margin}\\ \text{accepted at } p}} \cdot \underbrace{\overbrace{\left(\frac{p-p^0}{p^0}\right)}^{\substack{\text{Difference}\\ \text{between}\\ \text{current price}\\ \text{and } p}} \cdot \overbrace{\mathrm{E}[\varepsilon_{p^0}]}^{\substack{\text{Believed}\\ \text{current}\\ \text{demand}\\ \text{elasticity}}} \cdot \overbrace{D(p^0)}^{\substack{\text{Current}\\ \text{demand}}}}_{\approx \text{Expected daily sales at } p} \tag{1}$$

2.2 Experiment Overview

The experiment in this paper took place in Mwanza, Tanzania, the second-largest city in Tanzania. The subjects in the experiment were all 561 small retail firms located near markets, neighborhood centers, and roads who sell dona maize flour, a staple food in Mwanza.

The treatment in this experiment temporarily set a firm's price and profit margin for one kilogram of dona maize flour. Treatment prices were either 100 Tanzanian Shillings or 200 Tanzanian Shillings below the lowest price nearby treated firms, which are 10-12.5% and 20-25% decreases, respectively. Treatment profit margins were either 50, 100, 150, or 200 Tanzanian Shillings per kilogram, which cover the range of profit margins firms reported pre-treatment.

Treatment prices were randomized at the level of the ward, an administrative unit. This creates variation in the size of the exogenous decrease in prices experienced within a ward. Treatment profit margins were decided based on a draw from a random distribution containing 50, 100, 150, and 200 Tanzanian Shillings.

Treatment assignment was random conditional on the profit margin a firm was willing to accept to sell at a price. Firms were randomized to receive treatment with high or with low probability before the elicitation of the profit margins they require to sell at a price. This assignment is an incentive-compatible method of eliciting the lowest profit margin a firm requires to sell at a price, which allows for the estimation of the daily profit a firm requires to sell at a price. There are two back-to-back treatment periods in the experiment, which allows for the estimation of the change in the daily profit that a firm requires to sell at a price as a function of treatment status and treatment exposure in the first treatment period.

The assignment to this probability randomization balanced pre-treatment characteristics across high and low probability firms and across low probability firms whose nearest neighbors were high probability firms and those whose nearest neighbors were low probability firms, allowing for estimation of an average treatment effect of low prices on treated firms and spillover effects of treatment on untreated firms.

2.3 Setting

Mwanza is the second-largest city in Tanzania, with a population of 1,100,000 ("Population and Housing Census", 2022). People in Mwanza have over 30% of their calories provided by maize flour (Cochrane and D'Souza, 2015).There are 1,134 retailers selling maize flour and 134 milling machines supplying maize flour spread across Mwanza, as shown in Figure 1.

2.3.1 Prices of Dona Maize Flour

The price of dona maize flour in Mwanza varies across retail firms and milling machines. Retailers price using nominal markups over input price; they do not take into account the prices at other retailers nor customers' expectations. Price differences do not reflect differences in quality, and prices are not posted by retailers.

Figure 1: Location of Retail Firms and Milling Machines in Mwanza

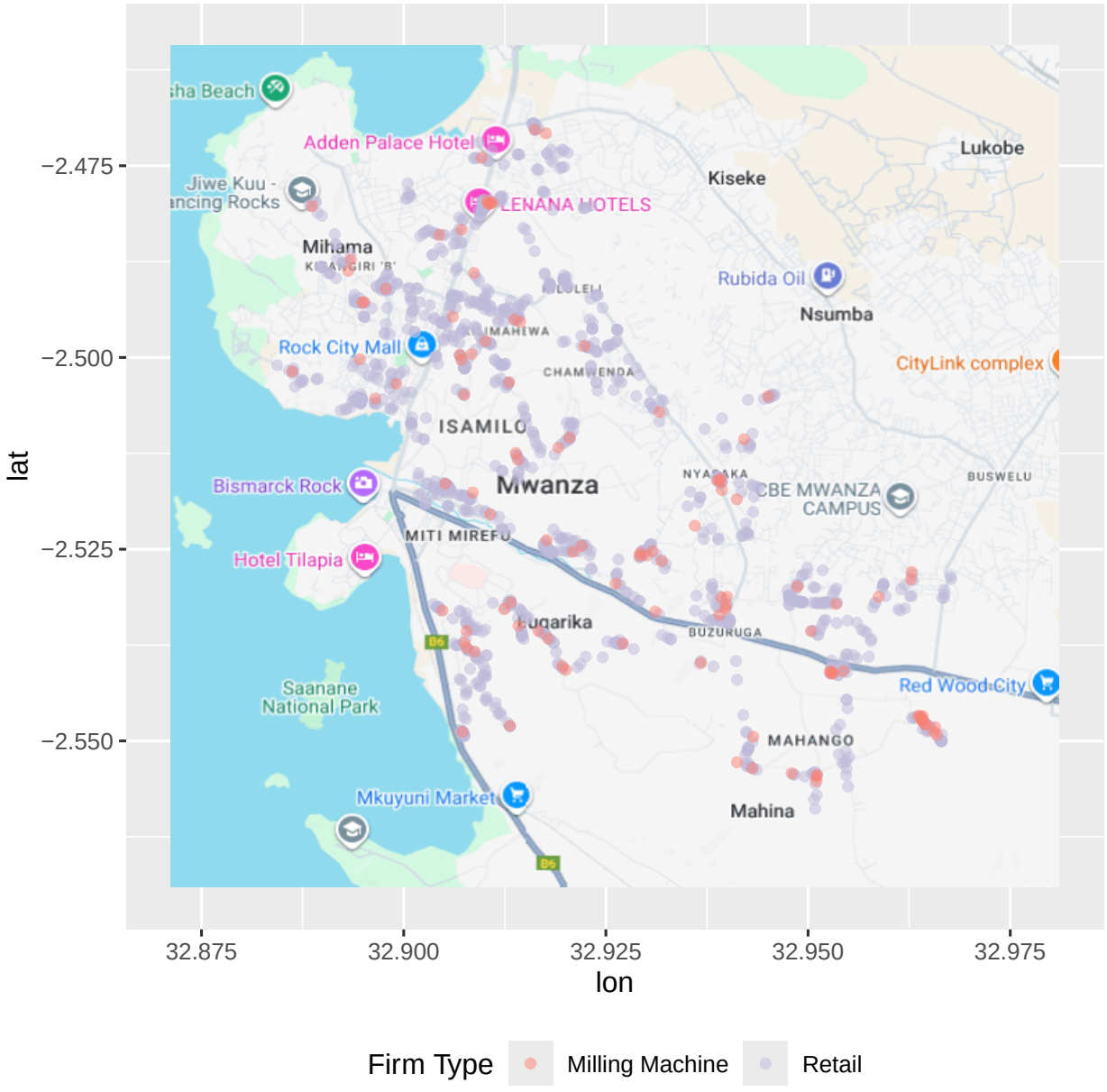


Figure shows the location of retail firms selling dona maize flour and milling machines supplying dona maize flour in Mwanza, Tanzania. Locations were measured during the retail firm listing and milling machines listing.

Table 2 shows that retail firms in Mwanza sell dona maize flour for as little as 600 Tanzanian Shillings per kilogram and as high as 1,800 Tanzanian Shillings per kilogram, while Table 2 shows that milling machines sell wholesale dona maize flour for as little as 540 Tanzanian Shillings per kilogram and as high as 800 Tanzanian Shillings per kilogram, while the price of dona maize flour from maize sold by these milling machines ranges from 600 to 1,200 Tanzanian Shillings per kilogram.

Table 1: Summary Statistics of Milling Machines in Listing

Statistic	N	Mean	St. Dev.	Min	Median	Max
Sells Maize	116	0.91	0.28	0	1	1
Per-kg Price Dona from Maize	105	713.02	73.37	595.24	714.29	1,190.48
Sells Wholesale Dona	116	0.19	0.39	0	0	1
Per-kg Price Wholesale Dona	21	741.67	65.90	540	750	800

Table shows proportion of milling machines that sell maize and that sell wholesale dona maize flour and per-kilogram price of dona milled from maize and per-kilogram price of dona sold wholesale. Data are from the listing survey of milling machines supplying maize flour in Mwanza, Tanzania.

Table 2: Summary Statistics of Retail Firms in Listing

Statistic	N	Mean	St. Dev.	Min	Median	Max
Sells Dona Maize Flour	1,134	0.88	0.32	0	1	1
Per-kg Price Dona	988	894.59	108.45	600	900	1,800
Nearest Per-kg Cost Dona	1,054	718.39	65.01	595.24	714.29	1,190.48
Age of Dona, Days	543	4.36	3.77	0	3	35
Sells Sembe Maize Flour	1,134	0.86	0.35	0	1	1
Per-kg Price Sembe	904	1,246.96	138.73	900	1,200	2,200
Posts Prices	989	0.01	0.10	0	0	1
Has a Name	1,134	0.26	0.44	0	0	1
Is a Kiosk	1,134	0.89	0.32	0	1	1
Is a Market Stall	1,134	0.07	0.26	0	0	1
Is a Convenience Store	1,134	0.04	0.19	0	0	1

Table shows descriptive characteristics of retail firms selling maize flour in Mwanza, Tanzania. Characteristics include whether the firm sells the two types of maize flour, dona and sembe, the price of one kilogram of each maize flour, the lowest cost of dona maize flour at the nearest milling machine supplying maize flour, the age in days of dona maize flour, whether the firm posts prices, whether the firm has a visible name, and whether the firm is a kiosk, a stall in a market, or is a mini-convenience store. Data are from the listing survey of retail firms selling maize flour in Mwanza, Tanzania.

The variation in retail prices of dona maize flour do not reflect variation in the input cost of maize flour at nearby milling machines. Table 3 shows that the lowest input price of maize flour at the nearest milling machine to a retail firm has no effect on the price of maize flour at the retail firm.

Table 4 shows detail on variation in price, input cost, and profit margin of dona maize flour at retail firms. While the per-kilogram price ranges from 700 to 1,300 Tanzanian Shillings, 20% of

	Retail Price of 1kg Dona Maize Flour
Input Price of Dona at Nearest Milling Machine	0.054
	(0.049)
R^2	0.001
Num. obs.	985

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table 3: Table shows the results from regressing a retail firm's price of dona maize flour on the price of dona maize flour at the nearest milling machine. Data were collected during a listing of all retail firms and milling machines selling dona maize flour in Mwanza.

firms have a price of 800 Tanzanian Shillings per kilogram, 31% price at 900 and 44% at 1,000. The per-kilogram input cost at these firms ranges from 575 to 1,100 Tanzanian Shillings. Calculating the per-kilogram profit margin shows that firms sell at a 200 Tanzanian Shilling loss to firms selling at an almost 500 Tanzanian Shilling gain. However, firms report per-kilogram profit margins on dona that range from 10 to 300 Tanzanian Shillings.

The dispersion in prices could be in part due to firms using nominal markups over input costs that also exhibit dispersion variation. Prices are determined by retailers without taking into account other costs, competitors' prices, or customers' expectations. Table 5 shows that 100$ of firms price taking into account input costs, while 2% account for other costs, 2% account for the prices at other firms, and 1% account for customer expectations. That variation in prices reflect variation in markups over variation in input cost is illustrated in Figure 2. It shows three distributions of the input cost per kilogram for firms based on their per kilogram price of dona maize flour. The figure is restricted to firms that have a per kilogram price of 800, 900, or $1,000$ Tanzanian Shillings per kilogram in the baseline survey. The figure shows two key facts about dona maize flour in Mwanza: firms that share the same input cost per kilogram sell at different prices, and firms that sell at the same price have different input cost per kilogram.

While variation in prices could be driven by quality differences, there is little to differentiate dona across retailers. There is only one type of dona maize flour. It is sold from unbranded 25, 50, or 100-kilogram sacks. The source of the maize does not factor into perception of its quality, unlike rice or unmilled maize kernels, whose region has an influence over its quality perception and price. Milling machines do not have names associated with them, and the technology used to mill maize does not differ across milling machines. In theory, age can contribute to quality differentiation across dona of different age; dona is a whole-wheat flour, and the extra fat content from the germ goes rancid after two to three months, depending on storage conditions, lowering the quality (Galliard, 1986). However, Table 2 shows retail firms in the listing sell dona maize flour that is on average 4.36 days old and Table 4 shows this retail firms in the baseline survey sell dona maize flour that is on average 5.69 days old.

This variation in prices is in part sustained because firms do not post prices of maize flour.

Figure 2: Baseline Distribution of Input Cost based on Price

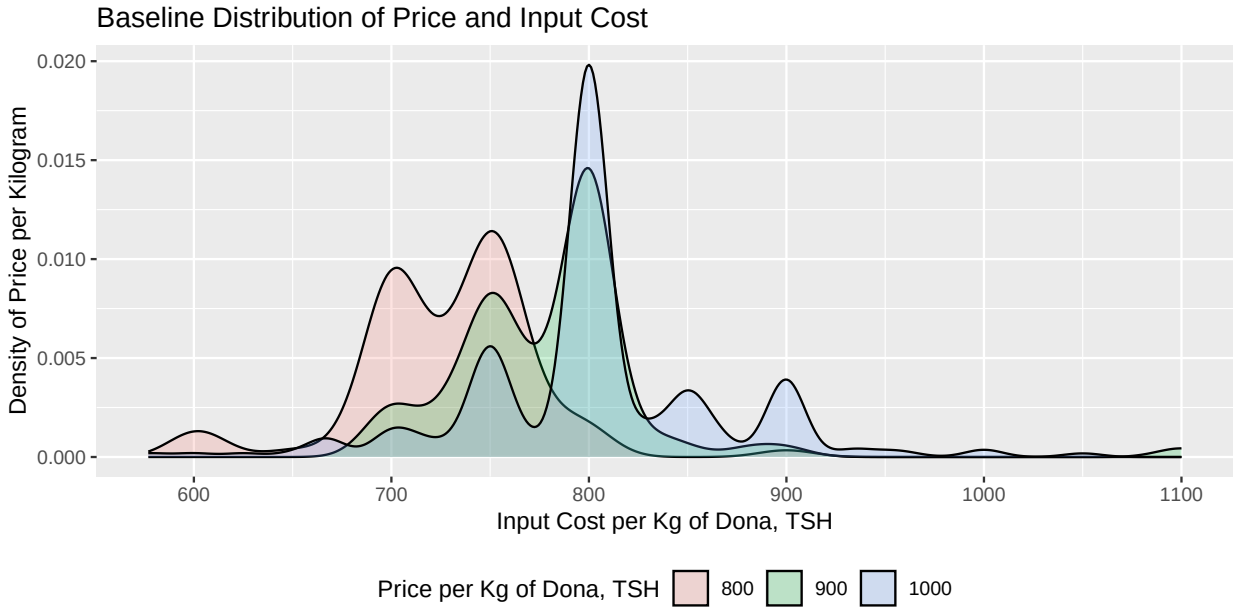


Figure shows the empirical probability density function of the input cost per kilogram of dona maize flour. One distribution is plotted for each focal price of dona maize flour: 800 Tanzanian Shillings per kilogram, 900 Tanzanian Shillings per kilogram, and 1,000 Tanzanian Shillings per kilogram. Data are measured in the baseline survey.

Table 4: Price, Input Cost, Profit Margin, and Age of Dona

Statistic	N	Mean	St. Dev.	Min	Median	Max
Price	555	939.91	96.54	700	900	1,300
Price = 800 TSH	555	0.19	0.39	0	0	1
Price = 900 TSH	555	0.31	0.46	0	0	1
Price = 1,000 TSH	555	0.44	0.50	0	0	1
Calculated Input cost	490	788.28	72.84	576.92	800.00	1,100.00
Calculated Profit margin	490	156.42	84.88	−200.00	150.00	477.78
Stated profit margin	494	110.41	55.95	10.00	99.00	300.00
Age of dona, days	531	5.69	5.70	0	4	60

Table shows summary statistics of the per kilogram price, input cost, profit margin, and stated profit margin of dona maize flour and the age of dona maize flour. Data are from the baseline survey of retail firms selling dona maize flour.

Table 2 and Table 5 show that just 1% of retail firms in the listing and 0.2% of retail firms in the baseline survey post prices. This makes it so that customers and firms cannot learn prices at businesses without interacting with either the shopkeeper of the business or a customer of the business.

2.3.2 Firms that Sell Dona Maize Flour

Firms that sell maize flour in Mwanza are typically small, do not have names, and sell a variety of non-perishable foods and consumer packaged goods. Table 5 shows that firms have on average 1.5 employees while the median firm has just one employee. The median firm has daily revenue of 40,000 Tanzanian Shillings, which is $14.82 at the time of the baseline survey. 90% of firms are kiosks, one-room buildings in which customers cannot enter. A kiosk is displayed in Figure 3. Only 27% of firms display a name.

Table 5: Summary Statistics of Firms in Sample

Statistic	N	Mean	St. Dev.	Min	Median	Max
Number of Employees	559	1.53	0.64	1	1	4
Daily Revenue, Tanzanian Shillings	198	57,373.74	51,644.74	0	40,000	200,000
Has a Name	561	0.27	0.45	0	0	1
Is a Kiosk	561	0.90	0.30	0	1	1
Is a Market Stall	561	0.08	0.28	0	0	1
Is a Convenience Store	561	0.02	0.14	0	0	1
Sells Staple Foods	561	1.00	0.04	0	1	1
Sells Luxury Foods	561	0.89	0.31	0	1	1
Sells Household Products	561	0.66	0.47	0	1	1
Displays Prices	544	0.002	0.04	0	0	1
Prices Account for Input Cost	513	1.00	0.00	1	1	1
Prices Account for Other Costs	513	0.02	0.13	0	0	1
Prices Account for Prices at other Firms	513	0.02	0.12	0	0	1
Prices Account for Customer Expections	513	0.01	0.09	0	0	1

Table shows summary statistics of characteristics of firms selling dona maize flour in Mwanza. Data are from the baseline survey of retail firms selling dona maize flour.

2.4 Treatment

The treatment used in this experiment set a firm's price and profit margin for one kilogram of dona maize flour. The price at treated firms was printed out and affixed to their place of business. The first treatment period started after a baseline survey measuring outcomes and lasted for three weeks. During this three-week period all dona maize flour sold at the firm was at their set price. The firm was required to restock dona maize flour themselves, after which the survey team subsidized their input cost to yield the firm their treatment price and profit margin. After three weeks the survey

Figure 3: A Firm Selling Maize Flour in Mwanza, Tanzania.



Figure shows a kiosk, a type of small firm selling nonperishable staple foods, packaged goods, and household products. Prices of goods are not displayed by the firm. Picture taken by the author.

team ran an endline survey at firms, re-measuring outcomes, after which the second treatment period lasted for one week.

A treated firm's price of one kilogram of dona maize flour set at either 100 or 200 Tanzanian Shillings below the lowest price per kilogram of dona maize flour the firm thought to be sold within 100 meters of their place of business. The size of the treatment price decrease was randomized at the level of the ward, an administrative unit smaller than a district but larger than an "mtaa" or neighborhood. In some wards, all treated firms had their price per kilogram set 100 Tanzanian Shillings below the lowest price nearby, and in the other wards all treated firms instead had price decreases of 200 Tanzanian Shillings per kilogram. This was done to create variation in the aggregate size of the price shock across different geographical areas. Wards were randomly assigned to the price decreases to balance the number of firms assigned to each price decrease. While the set price at a treated firm depended on their beliefs, the distribution of beliefs do not differ across firms assigned to price decrease sizes. Prices were relative to the firm's belief because their willingness to lower their own price and accept a profit margin is a function of what their beliefs are about the lowest price nearby. Basing treatment prices relative to measured prices measured prices instead of believed prices would additionally bundle information provision into the treatment by revealing the true lowest price nearby the firm.

A treated firm's profit margin for dona maize flour was drawn from a distribution of possible profit margins. These profit margins included 50, 100, 150, and 200 Tanzanian Shillings per kilogram, which cover the range of profit margins typically experienced for dona maize flour. Before pulling a profit margin from a distribution, the survey team recorded, for three different prices, the firm's willingness to accept a profit margin to sell at that price. The possible prices to sell at were the lowest price the firm thought nearby, a price 100 Tanzanian Shillings less than the lowest, and a price 200 Tanzanian Shillings less than the lowest. The possible profit margins were 50, 100, 150, 200, 250, and 300 Tanzanian Shillings per kilogram. If the firm said that they would sell at the pulled profit margin at their assigned treatment price they were treated; if not, they were not treated. This elicited - for each possible price - the lowest profit margin the firm would be willing to accept to sell at that price.

A firm was randomly assigned to be treated conditional on elicited profit margins they were willing to accept to sell at their assigned treatment price. Firms were randomized into receiving treatment with high probability or with low probability. These assignments mimicked treatment and control groups while allowing for the elicitation of willingness to accept profit margins at more firms. It also gave all firms a chance of receiving treatment, which increases goodwill between subjects and experimenters.

The randomization into receiving treatment with high or with low probability balanced firms' pre-treatment characteristics across two comparisons. First, it balanced the characteristics of high probability firms with that of low probability firms. This helps with estimating the effect of treatment on treated firms. Second, it balanced characteristics of low probability firms whose nearest neighbor were assigned high probability with that of low probability firms whose nearest neighbor

was assigned low probability. This helps with estimating the spillover effects of treatment on untreated firms. This was achieved using an algorithm that identified and randomly picked one of the assignments that balanced both comparisons.

2.4.1 Treatment Price

A treated firm's price of one kilogram of dona maize flour set at either 100 or 200 Tanzanian Shillings below the lowest price per kilogram of dona maize flour the firm thought to be sold within 100 meters of their place of business.

Prices were relative to the firm's belief because their willingness to lower their own price and accept a profit margin is a function of their beliefs about prices, not actual prices. Consider a firm who thinks the lowest price nearby to be 900 per kilogram when instead the lowest price nearby is actually 800 Tanzanian Shillings per kilogram. The firm might be willing to accept a profit margin of 50 Tanzanian Shillings per kilogram to sell at a price 100 Tanzanian Shillings per kilogram below the lowest price nearby; the firm thinks they will sell at $900 - 100 = 800$ Tanzanian Shillings per kilogram for a profit of 50 but instead will be selling at a price of $800 - 100 = 700$ Tanzanian Shillings per kilogram if the price at treated firms was relative to actual prices, not firms' knowledge of prices. This is a problem for three reasons: First, the firm might not be willing to accept the same profit margin to sell at 700 as they would at 800. Second, this would create error in the elicited measure of the profit margin a firm is willing to accept to lower their price some amount below the lowest price around them. Third, this would additionally bundle information provision into the treatment by revealing the true lowest price nearby the firm.

The size of the treatment price decrease was randomized at the level of the ward, an administrative unit smaller than a district but larger than an "mtaa" or neighborhood. In some wards, all treated firms had their price per kilogram set 100 Tanzanian Shillings below the lowest price nearby, and in the other wards all treated firms instead had price decreases of 200 Tanzanian Shillings per kilogram.

This was done to create variation in the aggregate size of the price shock across wards. Untreated firms in wards assigned to the price decrease of 100 were exposed to treated firms selling at prices that were 100 Tanzanian Shillings below the lowest price nearby the firm, while untreated firms in wards assigned to the price decrease of 200 were exposed to treated firms selling at prices 200 Tanzanian Shillings below the lowest price nearby the firm.

2.4.2 Treatment Profit Margin

A treated firm's profit margin for dona maize flour was drawn from a distribution of possible profit margins. These profit margins included 50, 100, 150, and 200 Tanzanian Shillings per kilogram, which cover the range of profit margins typically experienced for dona maize flour. The profit margin was framed to the firm as conditional on them lowering their prices as part of the treatment; the research team was willing to lower down their input costs, but this was conditional on them publicly lowering their prices.

Before pulling a profit margin from a distribution, the survey team recorded, for three different prices, the firm's willingness to accept a profit margin to sell at that price. The possible prices to sell at were the lowest price the firm thought nearby, a price 100 Tanzanian Shillings less than the lowest, and a price 200 Tanzanian Shillings less than the lowest. The possible profit margins were 50, 100, 150, 200, 250, and 300 Tanzanian Shillings per kilogram. If the firm said that they would sell at the pulled profit margin at their assigned treatment price they were treated; if not, they were not treated.

This elicited - for each possible price per kilogram- whether the firm would be willing to accept a profit of 50 Tanzanian Shillings per kilogram to sell at that price, whether they would be willing to accept a profit margin of 100 to do the same, and so on up to a profit margin of 300 Tanzanian Shillings. The profit margins of 250 and 300 Tanzanian Shillings were included to further elicit the support of the firm's willingness to accept a profit margin to sell at a price beyond the range of typical profit margins seen in the population. Under this elicitation, the profit margin at which a firm started saying they would accept that profit margin to sell at that price is the lowest profit margin the firm would be willing to accept to sell at that price.

2.4.3 Price Randomization

Wards were randomly assigned to the price decreases to balance the number of firms assigned to each price decrease. The list of wards was randomized and the first k wards were assigned to the price decrease of 100, where k is defined such that if n is the total number of eligible firms in all wards, then $\frac{n}{2}$ is between the total number of firms in wards 1 through $k-1$ and the total number in wards 1 through k. While the number of firms in wards assigned to the small price decrease and to the large price decrease will not be exactly equal, this method has more randomization of firms to price decreases than assigning wards to price decreases with the objective of minimizing the difference between the number of firms in wards assigned to different price decreases.

2.4.4 Profit Margin Randomization

A firm had their treatment profit margin pulled from one of two distribution of profit margins. The first profit margin distribution was $\{50, 50, 50, 50, 50, 50, 50, 100, 150, 200\}$ and the second profit margin distribution was $\{50, 100, 150, 200, 200, 200, 200, 200, 200, 200\}$. This randomization made it so that firms assigned to the first distribution were offered a profit margin of 50 with 70% probability and a profit margin of 100, 150, or 200 each with 10% probability, while those from the second distribution were offered a profit margin of 200 with 70% probability and a profit margin of 50, 100, or 150 each with 10% probability. This created variation in size of profit margin at treated firms.

2.4.5 Treatment Assignment

All firms were eligible to be treated. All firms were offered the chance to participate in the experiment as a treated subject. The member of the research team offered explained to the respondent that the treatment involved the research team subsidizing the firm's input cost of maize flour but to ensure that customers benefited from the lowered input costs the firm would have to publicly sell at a low price which would be decided as part of the experiment. If the respondent was willing to participate, the treatment assignment module of the survey commenced, which explained the treatment further, elicited their willingness to accept profit margins at the three possible prices, revealed their assigned treatment price, pulled a random profit margin, and, if they had said they would accept that profit margin at their assigned treatment price, gave them further instructions about restocking, contacting the research team, and receiving the treatment price sign one week post-baseline survey.

Typical experimental design would instead suggest that some firms are assigned to treatment while other firms are assigned to control. This would present an issue and fall short relative to offering all firms a chance to receive treatment while varying the probability across firms.

First, it would not be possible to elicit the willingness to accept a profit margin to sell at a given price in an incentive-compatible way at any firm; control firms would never actually receive treatment regardless of revealing their true willingness to accept it, while treated firms would receive treatment even if they did not reveal their true willingness to accept it.

Second, it might engender ill-will among control firms. Firms and their workers talk, especially when they see researchers at their firms. If word about respondent's interactions with interviewers spread across firms, that all firms were offered the chance to receive treatment where their profit margin was randomly drawn out of an unknown-to-the-respondent distribution is better than the survey team offering treatment to some respondents and not offering it to other respondents. This sort of ill-will can push firms to not cooperate with survey teams.

Third, by offering all firms a chance to receive treatment and letting them self-select into participating in treatment, this identifies the extensive margin of willingness to be publicly competitive: Whether a firm is even willing to publicly lower their prices. The type of firm who is not willing to publicly lower their price is different than the type of firm who is; it is among this latter group where the profit from maize flour required to publicly sell at a specific price is defined.

The key tradeoff with offering all firms a chance to receive treatment is the lack of control in picking and choosing who exactly receives treatment. This can be mitigated by assigning each firm to receive treatment with high probability or with low probability. Those assigned to receive with high probability are akin to a treatment group in expectation, while those assigned to receive with low probability are akin to a control group in comparison.

2.4.6 Profit Margin Distribution Assignment

Each firm was assigned to receive treatment with high or with low probability. Those assigned to high probability had their treatment profit margin drawn out of the $\{50, 100, 150, 200, 200, 200, 200, 200, 200, 200\}$

distribution, D_h, while those assigned to low drew out of the $\{50, 50, 50, 50, 50, 50, 50, 100, 150, 200\}$ distribution, D_l. To illustrate how these map to treatment assignment, consider a firm willing to accept a profit margin of 50 to sell at a price p. They will receive treatment with probability 1 if assigned to D_h or to D_l. However, if their WTA is 100, then they receive treatment with probability .9 under D_h but only 0.3 under D_l; the probability of receiving treatment for WTA of 150 and 200 are, under each distribution, 0.8 and 0.2, and then 0.7 and 0.1.

The probability assignment was designed to help estimate the effect of the treatment on treated firms and the spillover effects of treatment on untreated firms. Firms were randomly assigned to D_h or D_l to balance pre-treatment characteristics along two comparisons. The first balanced those assigned to D_h and those assigned to D_l; this comparison is needed to estimate the effect of the treatment on treated firms. The second balanced those assigned to D_l whose nearest competitor was assigned to D_h and those assigned to D_l whose nearest competitor was assigned to D_l; this comparison is needed to estimate the spillovers effects of treatment on untreated firms.

The pre-treatment characteristics were collected during the listing of all firms who sell dona maize flour. The variables are indicators for whether the firm's price of one kilogram of dona maize flour was less than or equal to 800 TSH, was 900 TSH, or was 1000 TSH or greater, whether the firm sells sembe maize flour, a more expensive staple, whether the firm is in or is adjacent to a market, and the ward in which the firm is located. To the extent that differences in these observable characteristics are indicative of differences in firm's responses to either being treated or reacting to treatment. For example, a firm who sells at the high end of $1,000$ Tanzanian Shillings per kilogram might have customers who respond differently to price decreases than customers at firms who price at the low end of 800.

The design stratified firms by the four characteristics and denoted for each firm its nearest neighboring firm who also sold dona maize flour. The nearest firm was calculated based on the location of the firm measured during the listing.

First, random assignments that balanced high and low probability firms within strata were added to a set of possible assignments. These balanced pre-treatment characteristics between the expected set of treated firms and expected set of untreated firms.

Next, low probability firms in each possible assignment were split into those whose nearest neighbor were assigned high probability and those whose nearest neighbor were assigned low probability. A t-test of the mean of each of the pre-treatment indicators except for the ward location was ran, yielding five p-values. Additionally, a joint F-test of the regression of being in the former group on each pre-treatment variable was ran. A possible assignment was kept only if these statistical tests indicated the two low probability groups were balanced across these comparisons. An assignment was kept if the p-value of the F-statistic in the regression was above a level of significance and every t-test was above the same level of significance adjusted for the number of comparisons. The design used a 5% level of significance and had five comparisons, so each p-value was above $0.25 = (0.05)(5)$. This balanced pre-treatment characteristics between the expected set of untreated firms whose nearest firm was treated and the untreated firms whose nearest neighbor

was untreated.

The assignment implemented in the experiment was chosen at random from the resulting set of assignments that balanced both comparisons in expectation.

The algorithm determining assignment to treatment probability is described below. A schematic of the treatment assignment is described in 4.

1. Create a set of possible treatment assignments $S = \emptyset$.

2. Specify a level of significance α. Treatment assignment for this experiment uses $\alpha = 0.05$. Specify a number n of random assignments to consider. Treatment assignment uses $n = 50$. Specify a proportion p of firms to be assigned treatment with high probability. Treatment assignment uses $p = 0.30$.

3. Form strata based on the listing characteristics of a firm. These are the ward, whether their per-kilogram price of dona maize flour is less than or equal to 800 Tanzanian Shillings, is 900 Tanzanian Shillings, or is greater than or equal to $1,000$ Tanzanian Shillings, whether the firm is located in or next to a market, and whether the firm also sells sembe maize flour.

4. Randomly pull a stratified assignment s based on the proportion of firms assigned to receive treatment with high probability; this assigns firms to receive treatment with high (h) or low (l) probability. Stratification ensures that s balances listing characteristics across h and l firms.

   (a) Based on s, split firms in l into those whose nearest firm is assigned to receive treatment with high probability, l_1, and those whose nearest neighbor is assigned to receive treatment with low probability, l_0.

   (b) For all five strata variables besides ward, run a t-test of the mean between firms in l_1 and firms in l_0 and store the p-values.

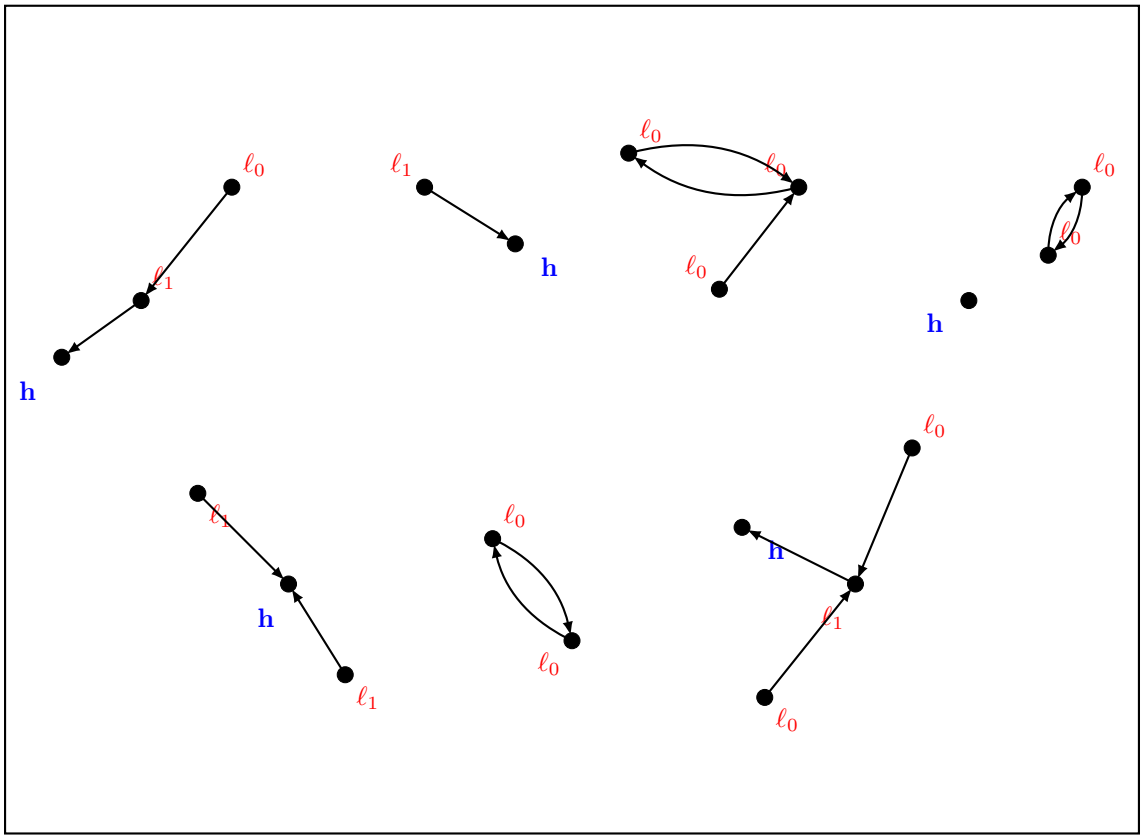
   (c) Regress whether a firm is in l_1 on all strata variables besides ward and store the p-value of the joint significance of the strata variables in predicting l_1.

   (d) Adjust the level of significance α for the number of comparisons; there are five strata variables to balance, so the adjusted level of significance is $\tilde{\alpha} = \alpha * 5 = .25$.

   (e) If the p-value of the t-test of the mean of every comparison is above the adjusted level of significance and the p-value of the joint significance of the strata variables in predicting l_1 is above the unadjusted level of significance, add s to S. This means that s also balances listing characteristics across the firms assigned to receive treatment with low probability whose nearest neighbors are assigned to receive treatment with high probability with the firms assigned to receive treatment with low probability whose nearest neighbors are assigned to receive treatment with low probability.

5. Repeat Step 4 until S has the number of random assignments specified in Step 2.

Figure 4: Schematic of Location-Based Treatment Assignment



Legend: h: firm assigned treatment with high probability
ℓ_1: low-probability firm whose nearest neighbor is high probability
ℓ_0: low-probability firm whose nearest neighbor is also low probability

This figure provides an example showing how firms are assigned to treatment probability based on the proximity of nearby firms. Arrows indicate each firm's nearest neighbor. Mutual nearest-neighbor pairs are connected with curved arrows.

6. Randomly pick one $s' \in S$. This assignment s' balances listing characteristics across two comparisons:

   (a) Treatment Assignment: Firms assigned to receive treatment with high and with low probability.

   (b) Exposure to Treatment: Firms assigned to receive treatment with low probability whose nearest neighbor is assigned to receive treatment with high probability and with low probability.

2.5 Implementation of the Experiment

Field work for the experiment lasted between June and November of 2024. It started with a city-wide listing of all retail firms selling and milling machines supplying maize flour. Based on characteristics collected during the listing, retail firms were randomized to receive treatment with high or low probability. Next, all eligible retail firms in an geographic area were offered treatment as part of a survey measuring baseline values of outcomes. Treatment in this area lasted for the three weeks post-baseline survey. After treatment finished in an area, outcomes were re-measured in an endline survey.

2.5.1 Retail Firm Listing

The retail firm listing was done on foot and consisted of survey team members going to all firms along streets and paths in assigned areas and checking if they sold maize flour. Firms eligible for the listing were any firm with a permanent location and not a supermarket. This left kiosks, mini convenience stores, market stalls, and stalls alongside roads. The listing collected the firm's district, ward, mtaa, the type of maize flour sold, whether it was sold scooped or packaged, the price of one kilogram of scooped maize flour, whether prices were posted for scooped maize flour, how recently the firm bought scooped maize flour, the same questions for packaged maize flour, whether the firm had a visible name, the type of store, the GPS units of the firm, and contact information of the respondent.

The milling machine listing was conducted on foot concurrently with the retail firm listing. All firms that milled maize kernels into maize flour were eligible for the milling machine listing. The milling machine listing measured whether a milling machine sold dona maize flour and sembe maize flour, the cost of wholesale dona and sembe, whether the firm sold maize, and the cost of maize. It also collected the GPS units of the milling machine and contact information of the respondent.

2.5.2 Baseline Survey

The baseline survey was given to all eligible listed firms in areas chosen for inclusion in the field experiment. A firm was eligible if it sold scooped dona maize flour and provided contact information during the listing. The baseline survey measured pre-treatment outcomes and included a module that offered and assigned treatment to firms.

The baseline survey collected information including when the business opened, which types of goods the store sold, services the business offered, days of the week when the business is open. Business characteristics also measured labor outlay over previous two weeks prior to the survey. These included how many unpaid family members or friends, paid full-time employees, and paid part-time employees workers at the business, how many hours per week a typical part-time employee worked, how much the business paid in labor cost to employees, how much money had been taken from the business for personal needs, like food, rent, and school fees, and the value of in-kind goods taken from the business, like food or soap.

The baseline survey collected information on how prices were set at the business and those of dona maize flour and sembe maize flour. The information on pricing included whether the respondent knew how prices were decided, and, if so, whether pricing considered input and transportation costs, other costs like rent, utilities, and labor, the prices at other businesses, and customers' expectations about prices. If the firm considered prices at other shops, the survey collected whether the firm set prices the same, higher, or lower than those at other businesses, and whether that depended on the good being priced. The baseline measured the price of commonly-sold weights of dona maize flour sold scooped out of open 100-kilogram sacks. These are $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, 2, 3, and 5 kilograms. It measured the same for sembe maize flour if the firm sold it.

The baseline survey measured demand for maize flour and demand at the firm. It measured, for each size of each type of maize flour for which price was elicited, how many customers come to the store on a typical day and buy that size. It measured, on a typical day, how many customers made purchases at the shop, the the proportion of customers who buy dona maize flour, and the proportion who buy sembe maize flour if the firm sold sembe maize flour.

The baseline survey measured information about the costs associated with the most recent restocking of maize flour at the firm. It measured, for dona and for sembe, how recently they had restocked, the amount they restocked, and the price they paid.

The baseline survey measured daily revenue, and revenue from dona maize flour and sembe maize flour, and profit margins for dona maize flour and sembe maize flour. It measured the amount of revenue the shop makes on a typical day. If the respondent did not give a specific number, they were prompted to pick out a revenue range from a list from $0 - 10,000$ to $90,000 - 100,000$ Tanzanian Shillings per day in $10,000$ increments, then $100,000 - 150,000$, $150,000 - 200,000$, and at least $200,000$ Tanzanian Shillings per day. These ranges were picked to provide granular cover over the revenue range seen during the qualitative interviews yet capture firms with larger revenues. To measure profit margins, the baseline survey asked how much profit was left over for the shop on $10,000$ Tanzanian Shillings of sales from dona maize flour after accounting for input and transportation costs. If the respondent did not give a specific number, they were prompted to pick a range from $\{(0 - 500), [500 - 900), [900 - 1,300), [1,300, 1,700), [1,700 - 2,100), [2,100 - 2,500), [2,500, \infty)\}$. These ranges were picked to cover the range of profit margins measured during the qualitative survey. The breakpoints were picked to clearly delineate firms who priced at common markups of 50, 100, 150, 200, and 250 Tanzanian Shillings per kilogram. It measured the same for sembe maize flour if they sold it.

The baseline survey measured the number of sales of one kilogram of maize flour the firm made on a typical day. It then asked the respondent the number of sales of one kilogram of maize flour they think they would have if their price per kilogram were to decrease by 100 Tanzanian Shillings. The baseline survey measured the respondent's belief about the number of firms within 100 meters of their shop selling dona maize flour. It measured what the respondent believed to be the lowest per-kilogram price of dona maize flour within this radius.

The baseline survey offered treatment to all respondents. If a respondent was willing to participate in treatment, the baseline survey measured the profit margins the firm was willing to accept to sell at the lowest price the respondent thought near their firm, a price 100 Tanzanian Shillings less, and a price 200 Tanzanian Shillings less. Based off the procedure described in Subsection 2.4.2 a firm was assigned treatment at their treatment price if they were willing to accept their randomly-pulled treatment profit margin.

2.5.3 Price and Profit Setting

Treated firms had their price of dona maize flour publicly set for three weeks. Immediately after being assigned to treatment in the baseline survey, the respondent was given the opportunity to set up a restock of dona maize flour to be able to sell it the following week. At the start of the following week a member of the research team contacted respondents who were assigned treatment, again reminding them about the treatment and confirming their participation. A member of the research team traveled to each treated firm the week following the baseline survey with multiple signs in Swahili translating to "Dona flour - [Treatment Price] per kilogram". A picture of a sign is shown in Figure 5. The research team member reintroduced themselves to the manager, picking out spots around the physical store or stall to affix the signs. The locations were chosen to be visible to passers-by. These included walls, counters, and gates, and in the case of market stalls, rafters, posts, and tables. A picture of a treated firm with signs attached is shown in Figure 6. The research team checked that treated firms continued to post the price sign throughout the course of the three weeks if they were continuing to be treated. That is, a firm could only continue to receive a guaranteed profit margin if they sold at their treatment price. This meant having the price sign affixed to their shop and sell at that price to customers. While firms in the sample were free to sell at whichever price they wanted to, the research team talked with customers at treated firms to check what price they had bought at from the firm. There were no cases of customers reporting prices that differed from the posted treatment price.

2.5.4 Endline Survey

The survey team revisited all firms in an area after treatment had run for three weeks in that area. The team attempted to survey all firms included in the baseline survey, re-measuring all outcomes measured during the baseline survey described in Subsection 2.5.2. The experiment again offered all firms a chance to receive treatment; this re-measured which firms were willing to publicly lower their prices and the profit margin they required to do so. This second treatment period lasted for the week after the endline survey.

2.5.5 Balance Across Treatment

This experiment offered treatment to all firms selling dona maize flour in areas of the city selected to be in the experiment. It randomly assigning treatment conditional on the profit margins firms

Figure 5: Sign Displaying Price at a Treated Firm



Figure shows a sign displaying the price at a treated firm. The translation is: "Dona flour - 900 Tanzanian Shillings per kilogram.

Figure 6: Treated Firm in a Market



Figure shows a treated firm located in a market. The firm has a sign displaying their treatment price. The sign translates to "Dona flour - 700 Tanzanian Shillings per kilogram".

would accept to publicly lower their prices only among the firms who were willing to participate in treatment and publicly lower their prices. This flexibility creates two margins along which the characteristics of firms might differ: between firms willing to be treated and those not willing to be treated and between firms assigned treatment and those not assigned treatment.

Table 6: Balance of Outcomes at Baseline

	All	Unwilling (U)	Willing (W)	Treated (T)	Untreated (UT)	p U–W	p UT–T
Price (TSH, 1kg)	939.91	935.91	947.83	946.73	938.23	0.156	0.352
Input Cost (TSH, 1kg)	788.28	787.59	789.70	793.56	787.00	0.762	-0.427
Profit Margin (TSH, 1kg)	156.42	153.49	161.45	156.44	156.30	0.327	0.989
Stated Profit Margin (TSH)	110.41	113.03	105.86	105.96	111.68	0.165	0.350
Daily Customers	32.10	33.54	29.55	31.54	32.31	0.049	0.727
Daily Volume Sold (kg)	30.17	31.82	27.26	29.36	30.46	0.043	0.654
Belief: Lowest Nearby Price	879.06	877.23	882.42	883.02	878.01	0.500	0.589
Belief: Demand Elasticity	-8.93	-8.49	-9.75	-9.21	-8.84	0.432	0.849
Price Sembe (TSH, 1kg)	1255.39	1252.71	1262.02	1263.16	1253.94	0.487	0.600
N (observations)	561	374	184	107	451		

Table shows means of outcomes at baseline for all firms, firms willing to be treated and those unwilling to be treated, and treated firms and untreated firms. Table shows the difference in means for each of those two groups and the p-value of a t-test of the difference in means. Data come from the baseline survey. All prices are in Tanzanian Shillings.

Table 6 show that firms that are not willing to be treated have 4 more customers per day and sell 4.56 kilograms per day more than firms that are willing to be treated. These are both statistically significant at the 0.05 percent level. However, there is no statistically significant difference between the number of customers or amount of dona sold between untreated firms and treated firms.

3 Results

This section shares findings from the experiment. First, it explore the private cost of competition, the smallest profit that firms require to sell at a given price. Second, it shows the estimated effects of treatment on treated and untreated firms.

3.1 Private Cost of Price Competition

Subsection 2.1.2 showed how the experiment estimates the private cost to an entrepreneur of selling at a given price p. This private cost is the smallest profit they are willing to accept to sell at that price. Its first-order approximation is:

$$\underbrace{\widehat{S_i(p)}}_{\substack{\text{Estimate of}\\ \text{expected profit}\\ \text{selling at } p}} \equiv \underbrace{\underline{\lceil \pi(p) \rceil}}_{\substack{\approx \text{Smallest}\\ \text{profit margin}\\ \text{accepted at } p}} \cdot \underbrace{\overbrace{\left(\frac{p-p^0}{p^0}\right)}^{\substack{\text{Difference}\\ \text{between}\\ \text{current price}\\ \text{and } p}} \cdot \overbrace{\mathrm{E}[\varepsilon_{p^0}]}^{\substack{\text{Believed}\\ \text{current}\\ \text{demand}\\ \text{elasticity}}} \cdot \overbrace{D(p^0)}^{\substack{\text{Current}\\ \text{demand}}}}_{\approx \text{Expected daily sales at } p} \tag{2}$$

The baseline survey and endline surveys measure all variables used to estimate the private cost

of selling at p. The firm's current price is directly measured by the survey team. Daily sales at the current price are calculated by adding up the number of sales the respondent reported at each weight of maize flour sold by the firm. The lowest profit margin the entrepreneur is willing to accept to sell at p is elicited as described in Subsection 2.4.2. The respondent's belief about demand elasticity at their current price is calculated by dividing the percent change in sales the respondent thinks they will get at a price 100 Tanzanian Shillings less than their current price from their current sales by the percent change from their current price to the price 100 Tanzanian Shillings less. To compare the profit that firms require to price at below-market levels across firms, I divide it by the current daily profit from dona maize flour that firms report making. This is because the effective size of a private cost of $10,000$ Tanzanian Shillings per day is different at a firm with a current profit of $15,000$ than a firm with a current profit of $5,000$.

Figure 7 displays the baseline and endline distribution of the percent change in daily profit from dona maize flour that firms require to publicly match the lowest price nearby, sell at 100 Tanzanian Shillings per kilogram less, and 200 Tanzanian Shillings per kilogram less. Figure 7 shows two findings. First, firms require large increases in daily profit from dona maize flour to publicly lower their prices to below-market levels. On average, firms require increases of 202%, 379%, and 597% to price at, respectively, the lowest price within 100 meters of their firm, 100 Tanzanian Shillings less than the lowest price, and 200 Tanzanian Shillings less. Second, firms require smaller increases in profit at endline than at baseline. At endline, firms require increases of 93%, 246%, and 384% to price at the same levels; smaller than the baseline values by 54%, 35%, and 36%.

To illustrate how the private cost of selling at a price depends on an entrepreneur's belief about demand elasticity and the profit margin they are willing to accept to sell at that price, Figure 8 plots the endline distribution of the percent change in profit the respondent requires to publicly sell at 200 Tanzanian Shillings less than the lowest price around them using the baseline value of the respondent's belief about demand elasticity, the distribution using the baseline value of the smallest profit margin the respondent is willing to accept to sell at 200 Tanzanian Shillings less, and the distribution using endline values of both variables.

Figure 8 shows two findings. First, it shows that using baseline beliefs about elasticity produces smaller estimates of the private costs; respondents participating at both baseline and endline increased their belief about how responsive customers are to price changes. Second, it shows that using the baseline profit margin that firms require to price at 200 Tanzanian Shillings less than the lowest price around them produces larger estimates of the private costs; respondents participating at both baseline and endline are willing to accept smaller profit margins at endline to sell at 200 Tanzanian Shillings less than the lowest price around them than at baseline.

3.2 Effects on Outcomes at Treated and Untreated Firms

This section presents estimates of the effect of treatment on outcomes at treated and at untreated firms. The outcomes include sales of dona maize flour, per-kilogram price, input cost, and profit of dona maize flour, daily revenue, input cost, and profit from dona maize flour sales, beliefs about the

Figure 7: Baseline and Endline Distribution of Percent Change in Profit to Publicly Lower Price

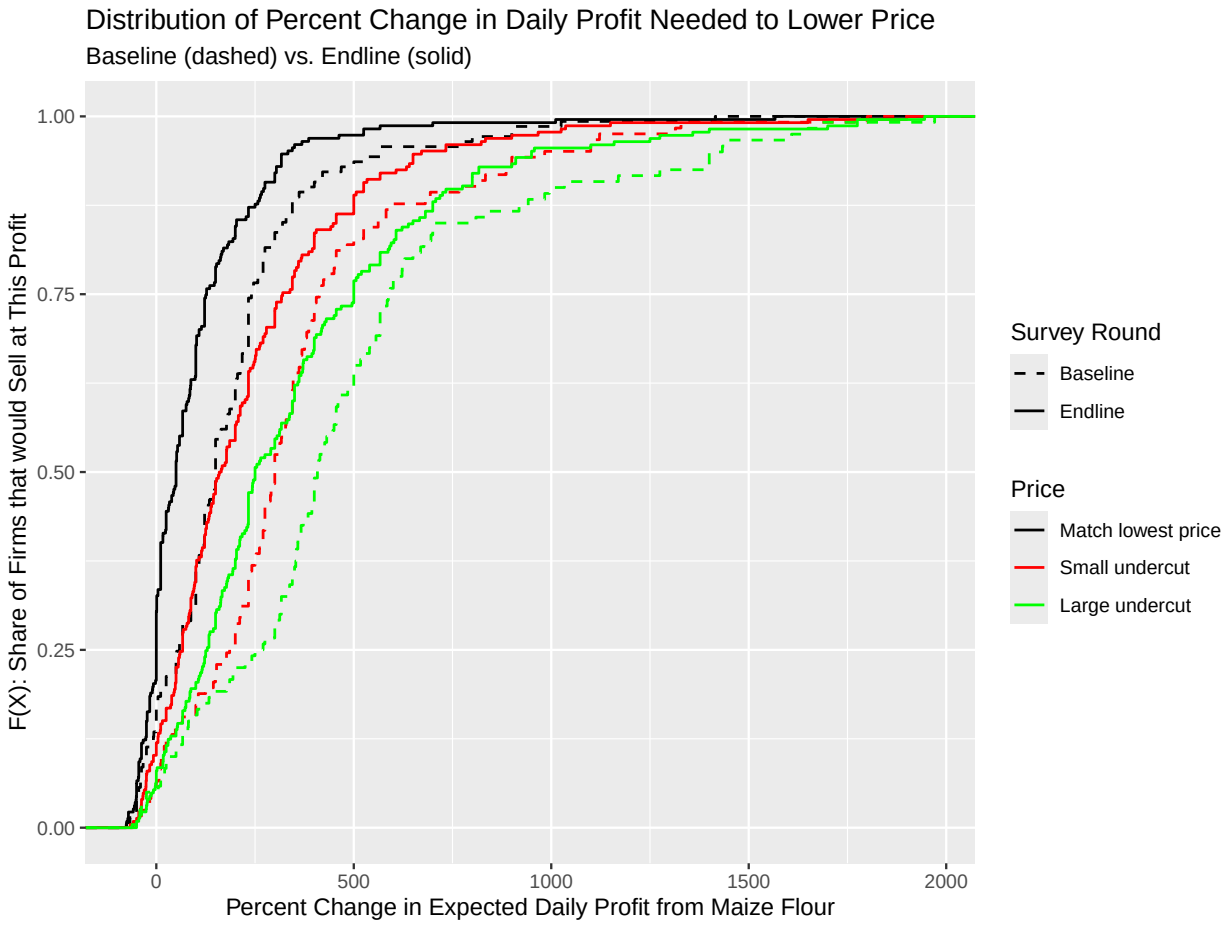


Figure shows the baseline and endline empirical cumulative distribution of the percent change in expected daily profit from dona maize flour that firms require to publicly lower prices to match the lowest price within 100 meters of their firm, price 100 Tanzanian Shillings less, and price 200 Tanzanian Shillings less.

Figure 8: Counterfactual Distribution of Percent Change in Profit to Publicly Lower Price 200 Tanzanian Shillings Below the Lowest Nearby Price

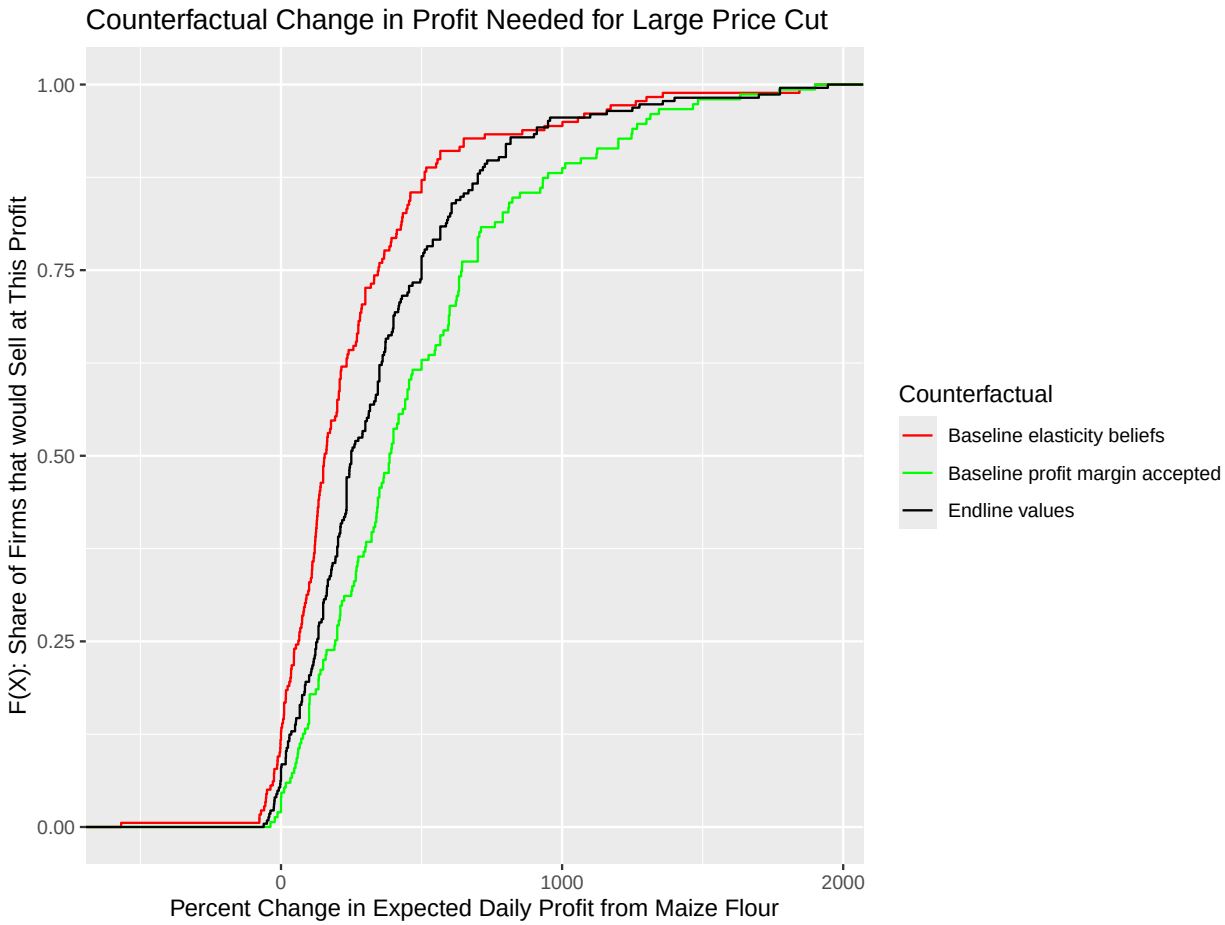


Figure shows the counterfactual empirical cumulative distribution of the percent change in expected daily profit from dona maize flour that firms require to publicly lower prices 200 Tanzanian Shillings below the lowest price 100 meters near the firm. The black line is calculated using just endline values, the red line is calculated using the baseline value of what the firm believes to be the price elasticity of demand for dona maize flour, and the green line is calculated using the baseline value of the smallest profit margin that firms require to at this price.

demand elasticity of and lowest nearby price of dona maize flour. The estimation accounts for the experiment allowing firms to opt out of being treated by instrumenting for whether a firm is treated with whether a firm was assigned to receive treatment with high probability. The estimation allows for the effects of treatment to effect nearby treated firms by accounting for whether a firm's nearest neighbor was assigned treatment.

In a typical experiment, a unit is randomly assigned to receive treatment; if they are not assigned to treatment they are untreated. The causal effect of the treatment on outcomes at treated firms can be estimated by comparing the mean of the outcome among treated firms to the mean of the outcome among untreated firms. That regression looks like

$$Y_{iw}^{1} = \alpha + \beta D_{iw} + \varepsilon_{iw} \tag{3}$$

In this setup, β is the causal impact of treatment on the outcome Y. However, this assumes there is no selection into treatment status; if a unit is able to affect their chance of receiving treatment, that willingness might be indicative of unobservable characteristics of the firm that influence the outcome Y. In this experiment treatment is assigned conditional on the profit margins a firm is willing to accept to lower their price; this creates selection, in that firms who are willing to accept lower profit margins are more likely to receive treatment than firms who require higher profit margins to lower their prices. Selection into treatment is discussed in Subsection 3.2.1.

Further, the causal interpretation of β assumes that there are no spillover effects from the treatment onto outcomes at untreated firms. Firm i's treatment status should not affect outcomes at firm j. The treatment in this experiment includes publicly lowering one's price of maize flour to a below-market price. Untreated firms exposed to treated firms are exposed to exogenous price shocks relative to untreated firms; this is also plausible for treated firms exposed to other treated firms. The flow of customers across firms depends on the distribution of prices across firms; treatment affects the distribution of prices across firms, so whether or not a firm is treated is likely going to affect outcomes at nearby firms. Spillovers of treatment are discussed in Subsection 3.2.2.

3.2.1 Selection into Treatment

In this experiment, a firm's treatment status was random conditional on the profit margins they were willing to accept to sell at their assigned treatment price. This assumes that if a firm is willing to accept a profit margin to sell at a given price, they are also willing to accept a larger profit margin. For example, if a firm will accept 50 Tanzanian Shillings per kilogram to sell at a price, they are willing to accept a profit margin of 100, 150, etc. Under this assumption, the probability that a firm is assigned treatment is higher the lower the profit margin they are willing to accept to sell at a price. If the size of profit margin a firm is willing to accept to sell at a given price is indicative of some characteristic of the firm that might affect other outcomes, there is positive selection along the dimension of willingness to accept a profit margin. To circumvent this, firms are randomly assigned to receive treatment with high probability or with low probability; taking a

Table 7: Conditional Probability of Treatment Assignment

Lowest Profit Margin Willing to Accept To Sell At Treatment Price	Probability of Treatment Assignment	
	High Probability Distribution	Low Probability Distribution
50	100%	100%
100	90%	30%
150	80%	20%
200	70%	10%
$\geq$ 250	0%	0%

Table shows the probability that a firm receives treatment based on the lowest profit margin they are willing to accept. Probabilities are shown for firms assigned to receive treatment with high probability and for firms assigned to receive treatment with low probability.

firm's lowest profit margin they are willing to accept to sell at a price as given, there is a higher likelihood they are treated if they are assigned to high probability and a higher likelihood they are untreated if they are assigned to low probability. A typical experiment can be thought of a special case of this in which firms assigned to high probability receive treatment with 100% probability and those assigned to low probability receive treatment with 0% probability. Table **??** shows how the probability that a firm is receives treatment varies with their lowest profit margin they are willing to accept to sell at a given price and whether they were assigned to receive treatment with high probability or low probability. Holding probability distribution constant, reading either column top to bottom shows that firm's probability of receiving treatment decreases as the lowest profit they are willing to accept increases. Holding willingness to accept constant, a firm receives treatment with at least as large probability if they are randomly assigned to the high probability distribution than the low probability distribution. Note that, under this setup, if a firm has 50% Tanzanian Shillings as their lowest WTA, they receive treatment regardless of their assigned probability distribution, and if a firm has 250 Tanzanian Shillings or larger as their lowest WTA they do not receive treatment regardless of their assigned probability distribution. Given this, the probability distribution assigned to a firm can be an instrument for whether they are treated.

An instrument should have two characteristics. First, it should affect treatment; exposure to the instrument should affect the probability of being treated. This effect should be monotonic; there is no unit for which exposure to instrument decreases the likelihood they are treated. The probability distribution to which a firm is assigned satisfies this mechanically; a firm assigned to the high probability distribution is at least as likely to be treated than if they are assigned to the low probability distribution. Second, an instrument should affect an outcome Y only through its effect on the likelihood of being treated. Whether a firm was assigned to high probability or low probability was done in a way to balance the proportion of treatment and control within strata defined by the firm's pre-treatment characteristics.

Table 8: Effect of Treatment Probability on Treatment Assignment

	Received Treatment
Assigned High Probability	0.21***
	(0.03)
R^2	0.07
Num. obs.	561

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Table shows the first stage instrumental variable regression. It regresses whether a firm was treated on whether the firm was assigned to receive treatment with high probability.

Let $High_i \in \{0, 1\}$ be an indicator that equals 1 if firm i was assigned to receive treatment with high probability and 0 if it was assigned to receive treatment with low probability. Let X_i be characteristics of firm i. How treatment probability assignment effects whether a firm is treated is estimated in the following regression:

$$D_i = \alpha + \beta High_i + \varepsilon_i \tag{4}$$

The result of this regression is shown in Table 8. Firms assigned to receive treatment with high probability are 21% more likely to be treated than firms assigned to receive treatment with low probability. This is statistically significant at the 1% level, indicating that treatment probability assignment is a strong instrument for being treated.

3.2.2 Spillovers of Treatment

Let S_i be a measure of exposure to the treatment for firm i. In general, this is a function of indicators for whether firms were treated or the price of treated firms within some radius or over the nearest-neighbor matrix of firm locations.

Let L be the matrix of firm locations, where l_{ij} is the distance in meters between firm i and j. Note that L is symmetric, in that $l_{ij} = l_{ji}$. Let N be the nearest-neighbor matrix, where n_{ij} is an indicator for whether firm j is the closest firm to firm i; $n_{ij} = 1$ if and only if firm $l_{ij} \leq l_{ij'} \, \forall \, j'$ and is equal to 0 for all other j'. Let P^1 be the vector of endline prices and P^0 be the vector of baseline prices. The treatment price of treated firms are those in P^1. Let D be the vector of treatment status.

The simplest measure of exposure is whether the firm nearest to firm i was assigned treatment: $S_i \equiv d_j \cdot n_{ij}$.

3.2.3 Estimates of Treatment Effects

The joint estimation of the effect of treatment on treated and untreated firms requires both instrumenting for treatment status and allowing for spillovers from treated firms onto other firms. This is shown in Equation 5:

$$Y_i^1 = \alpha + \beta D_i + \rho S_i + \theta(D_i \cdot S_i) + \gamma Y_i^0 + \Upsilon \cdot \text{FE}_i + \varepsilon_i \tag{5}$$

In Equation 5, the endline value of outcome Y for firm i, Y_i^1, is regressed on three measures of treatment: an indicator for whether firm i was treated D_i; an indicator for whether the firm nearest to firm i was treated, S_i; and the interaction of whether firm i was treated and its nearest neighbor was treated $D_i \cdot S_i$. Included as controls are the baseline value of outcome Y for firm i, Y_i^0 and included as fixed effects in FE_i are the strata of firm i and a linear time trend. The interaction θ allows the effect of exposure to treatment to vary for untreated and treated firms.

Tables 9, 10, 11, and 12 show the estimates from these regressions. The endline and baseline values of outcomes are winsorized at the 1% and 99% level. Standard errors are clustered at the level of the firm. Treatment assignment is instrumented with whether a firm was assigned to receive treatment with high probability or with low probability.

Table 9 shows effects on customers per day buying dona maize flour and the kilograms of dona maize flour sold per day. The instrumental variable estimates suggest that receiving treatment increased a firm's sales, while being exposed to a treated firm attenuated these increases in sales. Table 10 shows effects on the per-kilogram price, input cost, and profit of dona maize flour. It suggests that receiving treatment decreases a firm's price and profit margin, and being exposed to a treated firm increased these effects. It also suggests a small increase in price and decrease in input cost at untreated firms exposed to treatment, increasing their profit margins. Table 11 combines the effects on daily sales and prices, input cost, and profit margin and shows the effects on daily revenue, input cost, and profit from dona maize flour. It suggests that daily revenue, input cost, and profit increased at treated firms, but being exposed to a treated firm decreased revenue and profit for treated firms. Untreated firms near treated firms saw modest increases in daily revenue and decreases in input cost, yielding a small increase in daily profit from maize flour. Table 12 shows the effects on beliefs about demand elasticity for dona maize flour and the lowest price of dona maize flour the respondent believed to be within 100 meters of their shop. The panel on demand elasticity suggests that being treated and near a treated firm caused firms to adjust downwards their belief about demand elasticity. The panel on beliefs about nearby prices show that being treated or being untreated near a treated firm caused a firm to think that nearby prices were lower, while being near a treated firm attenuated the treatment effect on treated firms.

Table 9: Effects of Treatment on Sales of Dona Maize Flour.

	Customers Per Day		Volume Sold Per Day	
	OLS	IV	OLS	IV
Treated	−0.67	33.02	1.18	32.40
	(4.26)	(31.02)	(4.15)	(24.55)
Nearest Treated	−2.77	7.91	−2.67	5.17
	(3.16)	(11.36)	(3.40)	(9.37)
Treated × Nearest Treated	12.59	−23.60	8.30	−18.61
	(8.48)	(37.88)	(7.79)	(31.39)
Control mean (untreated)	29.06	29.06	26.61	26.61
IV F-stat	NA	12.365	NA	12.458
R^2	0.20	0.11	0.27	0.17
Num. obs.	474	474	474	474

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Table shows coefficients from ANCOVA and 2SLS regressions of outcome endline value on an indicator for treatment assignment, an indicator for whether a firm's nearest neighbor was assigned treatment, and the interaction of the two indicator variables. All regressions include as controls the baseline outcome value, strata fixed effect, and time fixed effect. Treatment assignment is instrumented with whether a firm was assigned to receive treatment with high probability or low probability. Standard errors are clustered at the firm level. Outcome variables are winsorized at the 1 and 99% level. Customers per day is the total number of customers reported to buy dona maize flour on a typical day. This is calculated by summing the number of customers reported to buy each weight of maize flour sold by the firm. Volume sold per day is the kilograms of dona maize flour sold on a typical day. This is calculated by multiplying the number of customers reported to buy a weight of maize flour on a typical day by the weight and summing over each weight sold by the firm.

Table 10: Effects of Treatment on Price, Input Cost, and Profit Margin of Dona Maize Flour.

	Price		Input Cost		Profit Margin	
	OLS	IV	OLS	IV	OLS	IV
Treated	11.60	−69.57	3.24	−59.56	9.78	−0.52
	(8.47)	(53.85)	(8.47)	(39.66)	(8.64)	(41.02)
Nearest Treated	3.78	6.19	−9.27	−7.50	18.61	23.81
	(9.57)	(21.79)	(9.59)	(21.09)	(10.58)	(21.45)
Treated × Nearest Treated	−18.04	−20.59	15.59	10.74	−44.64*	−62.15
	(16.75)	(73.66)	(19.38)	(68.14)	(18.84)	(70.23)
Control mean (untreated)	964.14	964.14	815.22	815.22	157.51	157.51
IV F-stat	NA	11.981	NA	12.616	NA	12.7
R^2	0.60	0.48	0.48	0.35	0.48	0.47
Num. obs.	504	504	424	424	424	424

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Table shows coefficients from ANCOVA and 2SLS regressions of outcome endline value on an indicator for treatment assignment, an indicator for whether a firm's nearest neighbor was assigned treatment, and the interaction of the two indicator variables. All regressions include as controls the baseline outcome value, strata fixed effect, and time fixed effect. Treatment assignment is instrumented with whether a firm was assigned to receive treatment with high probability or low probability. Standard errors are clustered at the firm level. Outcome variables are winsorized at the 1 and 99% level. All values are in Tanzanian Shillings. Price is the price for one kilogram of dona maize flour. Input cost is the average input cost of one kilogram of dona maize flours. This is calculated by dividing the total cost of maize flour most recently restocked by the number of kilograms purchased. Profit margin is the per-kilogram profit margin of one kilogram of dona maize flour. This is calculated as the difference between the firm's price and calculated average input cost.

Table 11: Effects of Treatment on Daily Revenue, Input Cost, and Profit from Dona Maize Flour.

	Daily Revenue		Daily Input Cost		Daily Profit	
	OLS	IV	OLS	IV	OLS	IV
Treated	1457.79	26419.31	580.24	9838.73	143.47	1576.76
	(3810.97)	(21167.61)	(3169.89)	(11357.86)	(658.99)	(2402.24)
Nearest Treated	−2819.28	3498.77	−4013.11	−1467.65	−318.46	442.63
	(3228.32)	(8179.60)	(3056.48)	(5299.77)	(677.38)	(966.63)
Treated × Nearest Treated	7573.26	−14090.75	9637.56	1276.53	1112.83	−1370.81
	(7281.88)	(27450.38)	(6760.59)	(17709.48)	(1313.80)	(3455.05)
Control mean (untreated)	25371.79	25371.79	21051.90	21051.90	3924.91	3924.91
IV F-stat	NA	12.41	NA	13.342	NA	14.842
R^2	0.28	0.20	0.36	0.34	0.28	0.27
Num. obs.	474	474	403	403	398	398

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Table shows coefficients from ANCOVA and 2SLS regressions of outcome endline value on an indicator for treatment assignment, an indicator for whether a firm's nearest neighbor was assigned treatment, and the interaction of the two indicator variables. All regressions include as controls the baseline outcome value, strata fixed effect, and time fixed effect. Treatment assignment is instrumented with whether a firm was assigned to receive treatment with high probability or low probability. Standard errors are clustered at the firm level. Outcome variables are winsorized at the 1 and 99% level. All values are in Tanzanian Shillings. Daily revenue is the total revenue the firm makes in a typical day from dona maize flour sales. This is calculated by multiplying the price of a weight of maize flour sold by the number of customers reported to purchase that size on a typical day, then summing that product over each weight of maize flour sold by the firm. Daily input cost is the total input cost of the dona maize flour sold by the firm on a typical day. This is calculated by multiplying the total volume of maize flour sold on a typical day by the average input cost of maize flour. The total volume of maize flour is calculated by multiplying the number of customers reported to buy a weight of maize flour on a typical day by the weight and summing over each weight sold by the firm. The average input cost of maize flour is calculated by dividing the total cost of maize flour most recently restocked by the number of kilograms purchased. Daily profit is the total daily profit accrued to the firm by sales of dona maize flour. This is calculated by subtracting the daily input cost of maize flour sold from the daily revenue from maize flour sold.

Table 12: Effects of Treatment on Beliefs about Demand Elasticity and Lowest Nearby Price of Dona Maize Flour.

	Demand Elasticity		Lowest Price Nearby	
	OLS	IV	OLS	IV
Treated	−2.25	35.72	1.25	−82.85
	(2.34)	(23.53)	(10.82)	(55.78)
Nearest Treated	−2.49	10.46	−7.63	−25.79
	(2.32)	(9.50)	(10.06)	(24.25)
Treated × Nearest Treated	1.24	−38.81	−2.60	60.50
	(3.66)	(28.15)	(16.04)	(77.49)
Control mean (untreated)	−10.94	−10.94	916.99	916.99
IV F-stat	NA	9.948	NA	10.468
R^2	0.18	−0.46	0.53	0.43
Num. obs.	363	363	462	462

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. Table shows coefficients from ANCOVA and 2SLS regressions of outcome endline value on an indicator for treatment assignment, an indicator for whether a firm's nearest neighbor was assigned treatment, and the interaction of the two indicator variables. All regressions include as controls the baseline outcome value, strata fixed effect, and time fixed effect. Treatment assignment is instrumented with whether a firm was assigned to receive treatment with high probability or low probability. Standard errors are clustered at the firm level. Outcome variables are winsorized at the 1 and 99% level. Demand elasticity is the respondent's measured belief about the price elasticity of demand for dona maize flour. This is calculated by first asking the respondent how many customers per day purchase one kilogram of dona maize flour; all firms sell this weight and it is the most commonly sold on average. Next, respondents report how many customers they think would purchase one kilogram of dona maize flour per day if their price were to decrease by 100 Tanzanian Shillings. The outcome then is the percent change in customers at their current price compared to at the lower price divided by the percent change from their current price to the lower price. Lowest price nearby is lowest price of one kilogram of dona maize flour the respondent believes to be sold within 100 meters of their shop.

4 Discussion

This project contributes to our understanding of why firms in low-income countries remain small by measuring the incidence and size of an entrepreneur's private cost of selling at below-market prices. First, it finds that $\frac{2}{3}$ of firms in Mwanza, Tanzania are unwilling to publicly sell a staple food at below-market prices, even when guaranteed a large, positive profit. Second, it further documents that the $\frac{1}{3}$ of firms willing to publicly lower their prices require unrealistically large increases in daily profit three to six times above their current daily profit.

This project demonstrates that experimentally-induced price competition can increase firms' willingness to publicly sell at below-market prices. After three weeks of treated firms selling a staple food at below-market prices, 33% more firms are willing to lower their prices as part of a second treatment period. These firms require smaller profit margins to sell at below-market prices, translating to them requiring smaller increases in daily profit two to four times above their current daily profit.

This project also demonstrates that firms can learn the benefit of posting prices. No retail firms in Mwanza posted prices prior to the experiment. The experiment included posting the price of dona maize flour at treated firms for three weeks. After treatment, firms started posting the price of additional goods, as shown in Figure 9. Firms learned that customers prefer prices to be posted; 81% of 443 customers surveyed after the experiment prefer prices to be posted. However, frictions still prevent the transmission of price information; 53% of the customers of treated firms knew about the below-market prices, compared to only 12% of customers at untreated firms.

The muted effects of treatment underline the fact that the success of interventions intended to help firms grow ultimately rests on the shoulders of the entrepreneurs running these firms. The treatment in this experiment guaranteed the profit margin of all of a staple food sold by a firm during a three-week period; while the below-market price was displayed at the firm, the onus was on the entrepreneur to make the sales. This subject-level participation in treatment effects creates wildly varying firm-level treatment effects. For example, while treated firms sold on average 0.43 more kilograms of the staple food per day at endline than at baseline, the worst-off treated firm reported selling 56 fewer kilograms per day at endline and the best-off reported selling 76 more kilograms per day at endline.

Finally, this project provides methods running experiments with firms in low-income countries. First, the subjects in the experiment are the population of firms selling a staple food, not a random sample from the population. This allows for measuring population-level outcomes and spillovers. Second, the treatment is offered to every firm in the population. This allows for identifying the firms in the population who are willing to participate in treatment. Third, treatment is randomly assigned conditional on a firm's willingness to accept the treatment. This allows for measuring the distribution of willingness to accept treatment among firms willing to be treated. Fourth, firms are assigned to receive treatment with high or low probability using a double-balance algorithm that balances both the characteristics of *ex ante* treated and untreated firms and *ex ante* untreated firms exposed to treatment and untreated firms not exposed to treatment. This design allows for

Figure 9: Firms Started Posting Prices for Goods





The figure shows two chalkboards displaying prices at firms in the sample. Goods whose prices are posted by these firms include beans, dona maize flour, dried sardines, cooking bananas, cooking gas, cooking oil, sugar, and salt. Pictures taken by the survey team.

estimation of the effects of treatment on treated firms and the estimation of spillover effects of treatment onto untreated firms. Fifth, the treatment in this experiment incentivizes firms to adjust their prices, in contrast to incentivizing firms to enter into new markets or start selling new products. This explicitly takes as given the firms population of firms already selling a good and just varies its price, allowing for estimating the effects of price shocks without having to rely on firms and customers to adjust to new markets or products.

5 Conclusion

This paper provides experimental evidence on the private costs of competition faced by firms in a low-income country. Using a field experiment with urban maize flour retailers in Mwanza, Tanzania, it shows that only a third of firms are initially willing to publicly cut prices below market levels, and that those who do require extremely high profits to do so. Even though treatment temporarily

creates competitively-low pricing, effects on sales are modest and dissipate when nearby firms are also treated. However, exposure to below-market prices increases the number of firms willing to publicly lower prices in a second treatment period by 33% and reduces the profits they require to do so by 35%.

This experiment highlights how private costs shape firms' willingness to engage in profitable activities. Reluctance to engage in competitive pricing, rather than traditional barriers like credit or customer access, may help explain why firms in low-income economies remain small.

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