Flood Risk and Differential Firm Investment: Evidence from Dakar, Senegal*

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August 29, 2025

Abstract

Rapid urbanization in sub-Saharan Africa is increasing exposure to and damage from flooding. Many firms located in flood prone areas suffer yearly losses, but they face limitations in their ability to make defensive investments. In a randomized experiment with small firms in Dakar, Senegal, I decrease the cost of investment through vouchers for either cement or wooden pallets. Some firms make their voucher choice in a group setting to highlight potential spillovers from investments. Firms who receive vouchers make defensive investments at significantly higher rates. However, only firms who receive vouchers in a group setting experience less flood losses and are less likely to close due to a flood. Furthermore, firms located downhill of other firms who got vouchers individually are more likely to close due to a flood. These results suggest that coordination matters for defensive investments since uncoordinated investments can create negative spillovers for those nearby.

*This document is an output from the research initiative 'Structural Transformation and Economic Growth' (STEG), a program funded by the Foreign, Commonwealth, & Development Office (FCDO), contract reference STEG_LOA_3155_Doruska and an output from the research initiative 'Private Enterprise Development in Low-Income Countries' (PEDL), a programme funded jointly by the by the Centre for Economic Policy Research (CEPR) and the Foreign, Commonwealth and Development Office (FCDO), contract reference PEDL_LOA_10267_Doruska. The views expressed are not necessarily those of CEPR or FCDO. This research is supported by the Einaudi Center for International Studies at Cornell University, and the Cornell Graduate School. I thank Chris Barrett, Brian Dillon, Cathy Kling, Matthew Gibson, Molly Lipscomb, Ben Norton, Tess Lallement, and seminar participants at Camp Resources XXXI, the 2025 AAEA & WAEA joint annual meeting, the 2025 AERE Summer Conference, the College of the Holy Cross, and Cornell University for their valuable feedback and comments. I also acknowledge the support of Samba Mbaye, Assane Ndiaye, and the staff at Le Centre de Recherche pour le Développement Économique et Social in Senegal. The study was approved by the Cornell University IRB under protocol number IRB0147609. The experiment was pre-registered at the American Economic Association Registry for randomized control trials (AEARCTR-0013840). The main experimental analysis was pre-registered, but the spillover analysis is an extension that was added after the trial (Doruska, 2024). The findings, interpretations, and conclusions expressed in this study are entirely those of the author. All errors are my own.

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1 Introduction

Urban flooding is a widespread and costly phenomenon across sub-Saharan Africa. World Bank (2022) estimates that rainwater flooding causes more than $130 million USD in damage in sub-Saharan Africa each year and an estimated $204 million of urban infrastructure is at risk from flooding each year. Additionally, urban settlements in flood-prone areas are expanding faster than flood-safe settlements (Rentschler et al., 2023). Urban flooding will likely also increase as urban populations expand and climate change increases the likelihood of heavy rain events (Caretta et al., 2022; Rentschler et al., 2023). Despite the growing problem, there is little evidence on how individual firms adapt to urban flooding and whether or how these individual adaptation measures may have implications for others in their communities.

This paper explores how individual defensive investments in flood mitigation technologies impact the firm making the investment and other firms nearby. I conduct a randomized control trial in which small retail firms received vouchers for either cement or wooden pallets to exogenously lower the cost of investing in flood mitigation technology. These vouchers allow firms to erect a barrier to impede floodwaters inundating their store or to lift inventory off the ground to protect against small-scale flooding. I randomly vary whether a firm makes their voucher choice (either bags of cement or wooden pallets) individually or in a group setting with neighboring business owners. This group exercise increases the salience of the potential externalities from investment as firms make their voucher choice. I use the experiment to answer the following questions: Does reducing the cost of investment induce firms to make defensive investments and do these investments generate adverse externalities? If so, how big are the spillovers? And, does making investment decisions collectively (partly) mitigate negative spillovers?

Regular, urban flooding is a common problem that plagues certain areas of Dakar, Senegal during the annual rainy season. Flooding following heavy rainfall traps people in their homes or businesses as it restricts movement throughout the city and is hard to predict (C40 CFF, 2021). For firms in this study, flooding forces them to close, destroys inventory, and can decrease customer traffic. Inventory losses from flooding in the past year are on average 38% of median firm monthly profit and firms that flooded experience almost a 30% decrease in customer traffic about nine months later. However, many firms do not make defensive investments to protect their business from damage even though they could potentially flood each year.

Firms located in flood-prone areas face a decision about whether or not to invest in flood mitigation technology prior to the rainy season. However, a firm's investment may impact

others as well. Some technologies, like wooden pallets or shelving, are placed inside the firm and do not impact nearby structures. But, if a firm builds a barrier or raises their firm higher up with concrete to divert floodwater from their store, the new structure often diverts water away from their firm and towards their neighbors. These types of investments can increase the flood risk of others. Individual firms making their own decisions may not fully internalize the externality of greater flooding for nearby firms, possibly resulting in over-investment in technologies with spillovers from individually profit-maximizing firms.

The experimental design directly leverages these facts as firms in the two treatment arms got their choice of a small (less than 5% of median firm monthly revenue), equal-valued voucher for two bags of cement or two wooden pallets.[1] Yet, these vouchers provide a firm with the ability to build a small barrier to protect the entrance of their firm or to lift most of their inventory off the ground. For firms randomly assigned to get a voucher, I randomly vary the environment in which they made their voucher choice. Some firms make their voucher choice individually while other firms gather in a group of four to six nearby firms. In a group, firms discuss which voucher type is best for their group before making a group choice. If at least 70% of the group agree with the group's decision, the entire group each receives the same type of voucher. This threshold functions like a provision point mechanism (Rondeau et al., 1999). These group meetings are designed to make the potential spillovers or externalities from investment more salient to better understand potential spillovers from individual firm defensive investments.

For firms assigned to receive a voucher, 94% got a voucher, 84% got a voucher for two bags of cement and 65% of firms redeemed that voucher. Across the control and two treatment arms, 31% of firms make some defensive investment during the study. Firms that make their voucher choice individually were 26 percentage points more likely to make a defensive investment while firms that make their voucher choice in a group were 21 percentage points more likely to make a defensive investment relative to the control, respectively. The difference in rate of investment between the two treatment arms is not statistically different and most investments came from firms building or improving existing barriers. However, firms that receive vouchers in a group were more likely to build new structures as opposed to improving or reinforcing existing structures.

Firms that receive vouchers for flood control technologies in a community setting saw

[1]Two wooden pallets can elevate two stacks of bags of rice or two stacks of cases of a snack off the ground. While this is not the entire inventory of stores in this context, these pallets should allow them to get most of their baseline stock on the ground off the ground. Two bags of cement can help reinforce an existing barrier or could build a small lip within an entry way to keep water out. Firms are only provided with cement and are not given additional materials or help hiring labor to build anything. The cement voucher subsidized, but did completely pay for, investment in a concrete barrier to keep water out.

a significant decrease in firm flooding and flood damage. Those firms flooded 0.358 fewer times that rainy season, on average, relative to the control group. Furthermore, these firms report, on average, 10,174 FCFA (around $17 USD) less in flood losses. This decrease in flood losses is about 3.4% of median baseline firm monthly revenue or 10% of median baseline firm monthly profit. And, these same firms closed for 0.386 fewer days due to a flood, on average. There is no statistically significant effect on flood losses and firm closures due to flooding for firms that made their voucher choice individually relative to the control group and the point estimates are statistically different between the two treatment groups. Firms make investments with the vouchers that reduced flood damage only when firms make their voucher choice in a community setting. Short community meetings that increase the salience of likely spillover effects gently foster coordination and improve outcomes.

To better understand the role of investment, I use treatment assignment as an instrument for making an investment in a flood mitigation technology. This instrumental variable analysis allows me to consider the direct channel of investment on flooding and firm performance outcomes; however, it does not differentiate between firms that receive their voucher individually and firms that receive their voucher in a group setting. Firms who invest are 32 percentage points less likely to close due to a flood. Firms that invest also report large increases in customer entrances and transactions per day. Yet, firms that invest also have lower monthly revenue but no statistically significant decrease in monthly profit. A firm's monthly revenue and profit comes four months after firms received their vouchers, so it is possible that endline data collection was too soon to fully understand the overall effects on firm performance.

While firms redeem vouchers and build at similar rates across both treatment groups, more small groups of firms assigned to make their voucher choice individually have a higher percentage of group members build something during the experiment. I test for heterogeneity based on the concentration of people that build within the small group of firms. Firms located in groups with a higher concentration of builds are 12.7 percentage points more likely to flood. These firms also experience 0.428 more floods, and their average flood was 0.288 days longer. Firms located in a group with more people who build experience an almost 37,000 FCFA ($60 USD) or about a 27% reduction in monthly profit on average. Together, these results highlight that others' decisions impact the effectiveness of a firm's investment in preventing flood losses, as those located in places where people build more experience worse outcomes suggesting there are negative spillover effects from investments.

Spillovers within the study are not likely limited to firms within the same group. To directly study the impact of spillovers, I include the count of firms within 200 meters that are in each treatment group in the main estimating equation. Firms with an additional firm

within 200 meters assigned to make their voucher choice individually are 5% more likely to have to close due to a flood and their firm closure lasted longer. These firm closures are driven by investments from firms located uphill, suggesting that individual investments do cause spillovers onto nearby neighbors as additional water gets diverted downhill.

These results highlight two key findings. First, most firms will invest in flood mitigation technologies when they are given the opportunity, and these investments can decrease flood-related losses. However, there is clear evidence of spillovers and small community meetings prior to firms making investment decisions can help mitigate these spillovers. Thus, individual firms deciding to invest in flood mitigation technology may not optimally reduce flooding or flood damage for all as these types of investments do increase flooding for others. Therefore, policy makers should pay particular attention to potential externalities when considering policies that incentivize individual defensive investments to mitigate damage from natural disasters.

This paper builds upon previous research that focuses on large-scale flooding events or extreme weather shocks that are rare (Balboni, 2025; Balboni et al., 2024; Dasgupta et al., 2011; Desmet et al., 2021; Chen et al., 2017; Gandhi et al., 2022; Jia et al., Forthcoming; Kocornik-Mina et al., 2020; Rentschler et al., 2021; Sajid and Bevis, 2021). Unlike larger scale flooding events, this research instead focuses on "everyday disasters" or the impacts of flooding that results from average, predictable patterns of seasonal rainfall. Therefore, this research considers a fundamentally different kind of shock that has a higher likelihood of occurring but often results in more localized impacts than the previous work focused on larger, but rarer, flooding events. Additionally, larger-scale flooding likely has less potential for inter-firm spillovers. Focusing on smaller-scale floods allows this work to directly speak to potential spillovers between firms.

This paper also contributes to the literature on firm adaptation to weather shocks (Balboni et al., 2024; Gandhi et al., 2022; Hsiao, 2025; Jia et al., Forthcoming; Rentschler et al., 2021; Patel, 2024). Gandhi et al. (2022) and Hsiao (2025) consider the aggregate impacts and adaptation for cities, while I look at the individual firm level like Rentschler et al. (2021), Jia et al. (Forthcoming), Balboni et al. (2024), and Patel (2024). However, unlike Jia et al. (Forthcoming), this paper focuses on a low-income country setting with less developed flood risk assessment and insurance products. Both Rentschler et al. (2021) and Balboni et al. (2024) focus on supply chain responses of firms after flooding events. This project focuses on firm investments before flooding to reduce impacts and studies a different part of firm adaptation strategies. This work also relates to Brooks and Donovan (2020) who highlight the market impacts of building bridges to reduce flood damage in Nicaragua and Leeffers (2024) who demonstrates that information can induce individual action to reduce

flood risk in Malawi. The work on spillovers expands upon Leeffers (2024) by demonstrating how individual and small group actions can impact the flood experience of others nearby.

This paper also builds on work around coordination of private investments and common property resource management (Baland and Platteau, 2003; Ostrom, 1990). More specifically, this paper relates to work on managing wells and irrigation systems (Bhandari et al., 2022; Jones et al., 2022; Ostrom, 1990; Ostrom and Gardner, 1993). I apply the ideas developed in work on irrigation to this setting where the common pool resource is flood mitigation. Furthermore, the experiment specifically focuses on the role communities and spillovers within technology adoption. Additionally, introducing a community meeting to highlight the role of externalities is similar to ideas developed in the microfinance literature (Banerjee et al., 1994; Besley and Coate, 1995; Feigenberg et al., 2013; Morduch, 1999). This paper builds upon the ideas of social sanctions within the context of firm investments that may push firm owners to consider how their actions could impact those around them.

Finally, this work relates to experimental designs that explore the role of communities on technology adoption and food security. Bhandari et al. (2022) uses a community structure in part of their randomization design on water conservation adoption, but they provide limited discussion of the role of local groups. Additionally, this paper leverages ideas around peer monitoring developed Lentz et al. (2016) in a rural context focused around food security. This experiment explicitly focuses leveraging community to potentially mitigate the negative spillovers from individual firm defensive investments within an urban environment.

This paper continues as follows. Section two describes the context and then introduces a model of firm investment to fix ideas on the decisions firms make when deciding to make defensive investments prior to the rainy season. Section three describes the experimental design while section four discusses the empirical strategy. Section five presents the main experimental results while section six addresses spillovers. Finally, section seven discusses and concludes.

2 Context and Model

2.1 Urban Flooding in Dakar

The broader Dakar region faces widespread risk from urban flooding during the rainy season (July – October). Unlike river flooding, urban, or pluvial flooding, arises from heavy rainfall coupled with insufficient or blocked drainage systems. In Dakar, floodwaters pose a multitude of challenges for people living in flood-prone areas by trapping people in their homes, increasing the risk of many diseases, and even causing death (C40 CFF, 2021).

This study focuses on small retail firms located in flood-prone areas in the departments

of Pikine and Guédiawaye.[2] As expected, firms in the sample report frequent flooding. Prior to the intervention, 84% of firms report that the streets around their firm flooded during the last rainy season and 36% of firms report that the firm itself flooded.[3] For streets that flooded in the previous rainy season, on average they flooded at least five different times and for about five days at a time. For firms that flooded in the previous rainy season, the firm flooded three times, on average and the water lasted around two days for each flood. These patterns underscore that there is spatial and temporal variation in the regular experience of flooding within this region.

Prior to any intervention, flooding is associated with lower firm performance and higher flood damage. Controlling for remotely sensed flood risk (European Space Agency, 2019), firms that flooded between July 2023 and July 2024[4] report significantly more flood damage. Firms with the same flood risk that flooded in the last year have almost 38,000 FCFA ($63 USD) more in flood inventory losses (Table A.1). This loss in inventory is 12% of baseline median firm monthly revenue or 38% of baseline median firm monthly profit. Firms that flooded are also more likely to close due to a flood and their flood closures are longer relative to firms that did not flood in the last year. In the last month during the dry season, firms that flooded report fewer customers entering the store per day and have fewer transactions per day (Table A.2). Customer traffic was 30% lower per day nine months to a year after the firm flooded. These firms also report lower monthly revenue and profit and their weekly sales for their two most sold items are also lower than firms that did not flood (Table A.2). Importantly, these baseline data cover firm performance outcomes in June 2024, so firms that flooded experience large decreases in demand, revenue, and profit almost a year after they flooded in the previous rainy season spanning July to October 2023.

2.2 Model

I begin by consider the investment decisions made by an individual firm playing a non-cooperative, single shot game and contrast these decisions with the setting where a neighborhood of firms cooperate and coordinate around their flood mitigation choices. The difference between these two settings highlights how individual firm investments can generate externalities and mirrors the different problems firms face in the two treatment groups when

[2]Flood prone areas were identified using a flood map developed by European Space Agency (2019) and corroborated by talks with local officials to further validate that the sample covered areas that face persistent flooding during the rainy season.

[3]In this paper, street flooding is defined as any standing water that covers the majority of the street and persists for at least a few hours. Most street flooding is around ankle to mid-calf deep. A firm floods if any water enters the store.

[4]The rainy season runs from July to October, so these firms likely flooded between July and October 2023.

making their voucher choices. I then consider different variants of the game where there is mutual insurance against flood losses in the neighborhood or firms punish their neighbors for increasing the flood risk of others to highlight ways other than coordination of investment choices that cooperation can arise in this setting.

Consider small, price-taking firms. There are two states of the world: rain causes a flood for firm i in neighborhood n with probability r_{in} and no rain that does not cause a flood for the firm with probability $(1 - r_{in})$. A firm's flood risk is the composite of the neighborhood flood risk r_n and their individual flood risk r_i where $r_{in} = r_n + r_i$. The neighborhood flood risk r_n lies in the interval 0 and 1, inclusive. The individual flood risk component, r_i, is an adjustment to the neighborhood flood risk that depends on unique characteristics of the firm, like being on a small ridge or at the bottom of a hill, and any adoption of barriers (b) by the firm (b_i)[5] or other firms in the neighborhood ($\mathbf{b}_{-i}$). Individual flood risk $r_i(b)$ is bounded such that $r_{in}(b) \in [0, 1]$. Note that the choice of barriers b is part of a broader choice of adaptation measures M. For simplification, I assume firms earn revenue $R(r_{in}(b), M)$ that depends on flooding and the choice of mitigation strategy.

Firms invest in flood mitigation technologies prior to the rainy season and then realize the results of rainy season flooding. Each firm chooses whether or not to use one, both or neither of two mitigation technologies M: wooden pallets (w) to raise merchandise above prospective flood waters, a concrete barrier (b) to keep flood waters out of the store, both (bw), or neither. Each mitigation technology has a direct cost but mitigates flood-related damages. Wooden pallets cost c_w and a concrete barrier costs c_b where $c_b > c_w$. The overall costs of the choice of mitigation technologies is $C(M_i)$.

In the case of a flood, firm i faces damage D_i which is a function of their mitigation choice M_i and their neighbor's mitigation choices of $\mathbf{M}_{-i}$ where $\mathbf{M}_{-i}$ combines the vector of investment in barriers of neighboring firms $\mathbf{b}_{-i}$ with their uphill or downhill elevation gain relative to firm i. Denote the flood damage of a firm with the function $D_i(M_i, \mathbf{M}_{-i})$.

Isolating the impact of the firm's choice of mitigation technology on flood damage, if a firm chooses to do nothing, they face damage $D_i(0, .)$. If a firm chooses wooden pallets as their only mitigation strategy, they face damage $D_i(w, .)$ and the firm faces damage $D_i(b, .)$ if they choose a barrier as their only mitigation strategy. If a firm chooses both wooden pallets and a barrier, they face damage $D_i(bw, .)$. Damage is greater if the firm does nothing and decreases with the cost of the technology:

$$D_i(0, .) > D_i(w, .) > D_i(b, .) > D_i(bw, .) \tag{1}$$

[5]Bold face represents a vector.

The choice of mitigation technology also impacts firm revenue in both the flooded and non-flooded state with

$$\frac{dR}{dM}|state = flood > \frac{dR}{dM}|state = notflood \tag{2}$$

With a slight abuse of notation, denote $\frac{dR}{dM}|state = flood$ as $\frac{dR_f}{dM}$ and $\frac{dR}{dM}|state = notflood$ as $\frac{dR_{nf}}{dM}$.

A firm's flood damage also depends on the choices made by their neighbors. Investing in a wooden pallet only decreases a firm's flood damage and does not impact the flood damage of its neighbors because it does not change floodwater flow. If a firm chooses a barrier, the risk of flood damage to their neighbors increases because the barrier diverts water away from the firm and towards neighboring firms. Let $\mathbf{b}_{-i}$ denote the number of neighboring firms that invest in a barrier. The flood damage of firm i, $D(., \mathbf{M}_{-i})$ increases as $\mathbf{b}_{-i}$ increases and is unchanged by neighboring firms using wooden pallets or doing nothing. Furthermore, since water flows downhill, $D(., \mathbf{M}_{-i})$ increases more with uphill investments in barriers. Firms can observe barriers outside of other firms and thus form expectations of other firms' behaviors.

When there is not a flood, the firm's profit function is:

$$\pi_{nf} = R_{nf}(M_i) - C(M_i) \tag{3}$$

since $D_i(M_i, \mathbf{M}_{-i})$ equals zero without a flood and $C(M_i)$ denotes the cost of mitigation M_i.

When there is a flood, the firm's profit function is:

$$\pi_f = R_f(M_i) - C(M_i) - D_i(M_i, \mathbf{M}_{-i}) \tag{4}$$

The firm maximizes expected profits:

$$\max_{M_i} E[r_{in}(M_i, \mathbf{M}_{-i})[R_f(M_i) - C(M_i) - D_i(M_i, \mathbf{M}_{-i})]] + E[(1 - r_{in}(M_i, \mathbf{M}_{-i})[R_{nf}(M_i) - C(M_i)]] \tag{5}$$

The first order condition to firm i's profit maximization problem that defines its best

response function can be written as:

$$E[r_{in}]\frac{dR_f}{dM_i} + E[(1-r_{in})]\frac{dR_{nf}}{dM_i} + \frac{\partial E[r_{in}]}{\partial M_i}R_f(M_i) + \frac{\partial E[(1-r_{in})]}{\partial M_i}R_{nf}(M_i) = \frac{\partial C}{\partial M_i} + E[r_{in}]\frac{\partial D_i}{\partial M_i} + \frac{\partial E[r_{in}]}{\partial M_i}(C(M_i) - D_i(M_i, E[\mathbf{M}_{-i}])) + \frac{\partial E[(1-r_{in})]}{\partial M_i}C(M_i) \quad (6)$$

Firms equate the expected marginal benefits of a mitigation strategy with the expected marginal costs where the marginal costs include the marginal costs of the strategy and the marginal damages from flooding. This equation governs the firm's decision in a non-cooperative one-shot game.

If, however, the firm is instead making a joint decision with the other firms in its neighborhood, their decision is one that maximizes all firms' joint profits. For a neighborhood of firms $i = 1, ..., I$, the firms collectively solve the maximization problem:

$$\max_{M_1,...,M_I} \sum_{i=1}^{I} E[r_{in}(M_i, \mathbf{M}_{-i})][R_f(M_i) - C(M_i) - D_i(M_i, \mathbf{M}_{-i})] + E[(1 - r_{in}(M_i, \mathbf{M}_{-i}))][R_{nf}(M_i) - C(M_i)] \quad (7)$$

The first order condition that governs firm j's mitigation strategy choice is:

$$E[r_{jn}]\frac{dR_f}{dM_j} + E[(1-r_{jn})]\frac{dR_{nf}}{dM_j} + \frac{\partial E[r_{jn}]}{\partial M_j}R_f(M_j) + \frac{\partial E[(1-r_{jn})]}{\partial M_j}R_{nf}(M_j) + \sum_{i\neq j}[\frac{\partial E[r_{in}]}{\partial M_j}R_f(M_i) + \frac{\partial E[(1-r_{in})]}{\partial M_j}R_{nf}(M_i)] = \frac{\partial C}{\partial M_j} + E[r_{jn}]\frac{\partial D_j}{\partial M_j} + \frac{\partial E[r_{jn}]}{\partial M_j}(C(M_j) - D_j(M_j, \mathbf{M}_{-j})]) + \frac{\partial E[(1-r_{jn})]}{\partial M_j}C(M_j) + \sum_{i\neq j}[\frac{\partial E[r_{in}]}{\partial M_j}(C(M_i) - D_i(M_i, \mathbf{M}_{-i})]) + \frac{\partial E[(1-r_{in})]}{\partial M_j}C(M_i) + E[r_{in}]\frac{\partial D_i}{\partial M_j}] \quad (8)$$

In the cooperative framework, each firm also considers how their choice of mitigation strategy potentially changes the flood risk of nearby firms and increases flood damages of neighboring firms. The last terms on both sides of equation (8) – the benefits and the costs of investment – represent the externality, the additional effect of barriers on other firms in the neighborhood. The predictable consequence is that firms acting individually will overinvest in technologies that hurt their neighbors by creating negative spillovers onto nearby firms. In the non-cooperative game, firms do not internalize the externality of additional flood risk from additional building of barriers. They do not fully consider how their investment impacts

the flood risk of their neighbors when simply maximizing their own profit. This prediction is similar to the Samuelson (1954) rule.

2.2.1 Additional Models of Cooperation

Assuming full cooperation in investment choices that maximizes joint profit is not the only mechanism that generates a prediction where firms consider the impact of their defensive investment choices on their neighbors and therefore invest less in technologies that generate spillovers. Since firms are not anonymous to other firms in their neighborhood and barriers are observable, firms could instead play a dynamic game with mutual insurance similar to the village economies in Townsend (1994). In this setting, firms maximize profits from an initial date $t = 0$ until a future end date T. Let β denote the discount rate on time. With a social planner's utility weights for firm's λ_i where $0 < \lambda_i < 1$ and $\sum_i \lambda_i = 1$, then the firm's maximization problem is:

$$\max_{M_{it}} \sum_{i=1}^{I} \lambda_i \sum_{t=0}^{T} \beta^t E[r_{int}(M_{it}, \mathbf{M}_{-it})[R_f(M_{it}) - C(M_{it}) - D_i(M_{it}, \mathbf{M}_{-it})]] + E[(1 - r_{int}(M_{it}, \mathbf{M}_{-it}))[R_{nf}(M_i) - C(M_{it})]] \quad (9)$$

The first order condition for firm j's mitigation strategy choice in time t is:

$$E[r_{jnt}]\frac{dR_f}{dM_{jt}} + E[(1 - r_{jnt})]\frac{dR_{nf}}{dM_{jt}} + \frac{\partial E[r_{jn}]}{\partial M_{jt}} R_f(M_{jt}) + \frac{\partial E[(1 - r_{jnt})]}{\partial M_{jt}} R_{nf}(M_{jt}) + \frac{\sum_{j \neq i} \lambda_i}{\lambda_j} \sum_{i \neq j} [\frac{\partial E[r_{int}]}{\partial M_{jt}} R_f(M_{it}) + \frac{\partial E[(1 - r_{int})]}{\partial M_{jt}} R_{nf}(M_{it})] =$$
$$\frac{\partial C}{\partial M_{jt}} + E[r_{jnt}]\frac{\partial D_j}{\partial M_{jt}} + \frac{\partial E[r_{jnt}]}{\partial M_{jt}}(C(M_{jt}) - D_j(M_{jt}, \mathbf{M}_{-it})]) + \frac{\partial E[(1 - r_{jnt})]}{\partial M_{jt}} C(M_{jt}) + \frac{\sum_{i \neq j} \lambda_i}{\lambda_j} \sum_{i \neq j} [\frac{\partial E[r_{int}]}{\partial M_{jt}}(C(M_{it}) - D_i(M_{it}, \mathbf{M}_{-it})]) + \frac{\partial E[(1 - r_{int})]}{\partial M_{jt}} C(M_{it}) \frac{\partial D_i}{\partial M_{jt}}] \quad (10)$$

after dividing by $\lambda_1 \beta^t$ for ease of presentation. Mutual insurance thus also results in less investment in spillover-generating technologies relative to the non-cooperative game. Like the cooperative framework, each firm also considers how its choice of mitigation strategy potentially increases flood damages for neighboring firms because damages get shared among firms. The difference in the first order conditions between mutual insurance and maximizing joint profits comes in the distribution of the weights that determine risk sharing throughout

the neighborhood over time.

Finally, firms could instead punish other firms for erecting barriers and causing harm to neighbors in a penal code framework similar to Abreu (1988) or as in social sanctions in microfinance (Banerjee et al., 1994; Besley and Coate, 1995; Feigenberg et al., 2013; Morduch, 1999). In this case, there would be additional expected costs to barriers raising the likelihood that firms elect to use wooden pallets or do nothing as opposed to building barriers. Increasing the expected costs of barriers would be an alternative way to (at least partly) internalize the externality without relying on cooperation or risk pooling among firm owners. Across all models, any mechanism that compels a firm to consider the possible consequences of its own defensive investment decisions on other firms should shift investment patterns and change firm outcomes. The experiment is designed to test this prediction.

3 Experimental Design

3.1 Intervention

The intervention lowers the cost of private investment in flood mitigation technologies. Firms reported that the most common flood mitigation technological investments are cleaning out existing drainage infrastructure, building concrete barriers, building shelves, and raising stock off the floor of the store using pallets or similar structures. I narrowed down the set of investment choices to two based on pricing and the availability of local suppliers. While cleaning out drainage infrastructure is an impure public good as it has both private and public benefits, this study focuses on individual firm investments and thus did not incentivize cleaning drainage infrastructure. The study includes one technology that directly changed the drainage environment in and around the firm and thus had the propensity to cause spillovers on nearby firms: bags of cement to create a barrier. The study also includes a technology that solely decreased flood losses within a firm and did not change the broader drainage environment around the firm: wooden pallets.

Cement can be used to raise an entire building up from the street or to build a small barrier that prohibits water from entering a store. However, building a cement structure potentially changes the flood risk of nearby buildings as it can divert water towards neighboring structures. Wooden pallets raise existing stock off the ground to reduce damage from water intrusions. Wooden pallets are placed inside a firm and do not change the flood risk of nearby structures. Firms got a choice between the two voucher types because each technology may not be appropriate for every firm. Additionally, each technology has different implications for neighboring firms and thus voucher choices allow for direct measurement of the degree of potential spillovers a firm's choice generates.

All firms in either treatment arm (described below) got a choice of a voucher for either two bags of cement or two wooden pallets. Vouchers were non-transferable between firms and had to be redeemed by September so firms did not have an incentive to hold onto the vouchers. Both vouchers had the same value, 7,000 FCFA (about $11.67 USD). All treatment firms also received an additional 1,000 FCFA (about $1.67 USD) to transport the cement or wooden pallets from the supplier to their firm. Prices were directly written on the voucher and were arranged with local suppliers beforehand, so firms could not manipulate the value of the voucher or engage in price arbitrage. Local hardware stores supplied cement. All wooden pallets came from one supplier, thus, firms had to travel farther to redeem the vouchers for wooden pallets.[6] Vouchers contained the name and contact information of the participant, the name and contact information for the cement or pallet supplier and contact information for the research team. Firms redeemed their voucher by taking it to their designated supplier.

At the supplier, firms received their bags of cement or wooden pallets. The supplier then sent the voucher information to the research team and was paid by the research team. Firms paid any additional costs of their desired defensive investment such as labor, cement bricks, or additional materials required to build a cement barrier.[7] Wooden pallets were pre-made and were ready for use as firms just had to incur minor labor costs to move inventory, install the pallets, and place the inventory on the elevated structures. Firms that chose cement vouchers had to incur additional costs relative to firms that selected wooden pallets.

3.1.1 Treatment Arms

The study included two treatment arms, the individual choice treatment group and the community choice treatment group, and one control group. Firms in the control group participated in the baseline and endline survey, but did not receive any vouchers. Nontransferable vouchers were only distributed to randomly treated participants.

Treated firms made their voucher choice individually or as part of a small group exercise. Enumerators visited all firms in the individual choice treatment arm and asked which voucher the firm would like. Firms then received the voucher of their choice.

Firms in the community choice treatment were invited to a meeting of a group of four to six neighboring firms. Local community meetings took place outside of firms in the group. All treated firms within a local community received a voucher; however, the voucher choice depended on the outcome of the community meeting. First, enumerators explained that each firm would receive a voucher and how the group would make the voucher choices.

[6] Wooden pallets are widely available during onion season. Since vouchers were distributed and redeemed outside of onion season, there is only one market in the study area with multiple pallet suppliers that sell pallets year-round.

[7] If, or how much, additional materials required depends on what the firm decides to construct.

Enumerators then asked each group which voucher they would like each firm in the group to receive. To start the group discussion, enumerators asked participants to consider how the voucher choices might impact flooding for them and their local community. After the group reached a consensus, enumerators recorded the local community voucher choice.[8] Then, enumerators privately asked each group member if they accepted the group decision[9] and which voucher they individually prefer. Other group members could not hear those responses. If at least 70% of firms privately accepted the group decision, all firms in the local community received the voucher the group initially agreed upon. If, however, there was not at least 70% agreement, firms received their individually preferred voucher. This 70% threshold is similar to a provision point mechanism in a public goods game Rondeau et al. (1999). Of the 54 group meetings, 13 (24%) did not reach the 70% threshold, so the majority of groups stuck with the consensus choice.

In both treatment arms, firms received the same choice of vouchers and all firms who wanted a voucher received a voucher of equal value.[10] The only thing that differed between the two treatment arms is the individual or collective setting in which firms made their voucher choices. Thus, firms in both treatment arms faced a similar reduction in the cost of investment and similar investment choices. However, firms in the community choice treatment arm may not have received their preferred voucher if their local community preferred a different voucher to them.

The overall setup of the local community meetings was designed to make the potential externalities associated with investments in flood control technologies more salient. By bringing people together as a group and asking them to make a group decision on a voucher choice, they perhaps had to consider the preferences and potential considerations of others when deciding which voucher was best suited for them. In this way, the local community meeting pushed people from a myopic model in which they might only consider the costs and benefits to their own firm to a model in which they likely consider the impact of their decision and the decisions of others in their local community. The start of the group discussion directly asked firms to think about what voucher type is best for them and others in their local community. Thus, the local community meeting, by gathering individuals together

[8]Each community could decide themselves how they would reach a consensus. If after 15 minutes of discussion the group could not agree, then each member received the voucher of their individual choice. This only occurred in one out of 54 local community meetings.

[9]The question was not if firms wanted the voucher the group decided upon. The question was whether the firm accepted the group decision. Thus, firms could individually want a different voucher but accept the group decision.

[10]12 firms refused to accept any voucher because they either refused to accept any outside payment or help or because they did not want to make additional investment and reported their current investments were sufficient.

to try and make a collective decision about their preferred voucher, pushes firms from the non-cooperative one-shot game towards one of the other frameworks discussed in section 2: a cooperative framework in which firms consider the impacts of their decisions on others when making their choices, a risk pooling framework, or one in which some behaviors elicit punishment from others.

The community meetings were not any well-organized or defined institution. Unlike those in Ostrom (1990) or Baland and Platteau (2003), these community meetings were one-off events. Study participants were free to meet and discuss by themselves after the research team left, but the research team only organized the one, short community meeting to discuss and hand out vouchers. Thus this experiment is best understood as priming participants to consider prospective externalities, not as a test of any particular collective choice institution.

3.2 Eligibility and Randomization

I sampled small retail firms selling everyday items like food and cleaning supplies located in and near flood prone areas of the Pikine and Guédiawaye departments of Dakar, Senegal. Eligible firms had to sell retail goods like food, clothes, and other small consumer items that individuals purchase every day or every other day, had to have no more than 10 employees, be in a fixed location where the goods stayed overnight and be open at least five days a week during the dry season. Enumerators were assigned flood prone locations to begin identifying eligible firms. Once an enumerator identified an eligible firm, they then sampled an additional three to five firms located within about a two minute walk the firm. The number of nearby neighbors sampled depends on the density of firms in that area.

I created local communities of three to six nearby firms to become the unit of randomization for the experiment. As the experiment is designed to understand the local spillover effects of firm adaptation strategies, the average distance between firms in local communities is less than 100 meters. I stratified these local communities based on the average remotely sensed flood risk (European Space Agency, 2019) and average elevation of each firm measured at baseline data collection within the local community and randomly assigned each local community to the control, individual choice, or community choice treatment arm.

3.3 Experimental Timeline and Data Collection

The final sample consisted of 747 firms. July 2024 baseline data collection covers inventory, customer traffic, worker attendance, flood risk and experience, and investment in flood mitigation technologies. Randomization of local communities and firms voucher choices took place in August 2024. Voucher redemptions continued through September 2024. The Decem-

ber 2024 endline survey successfully re-surveyed 714 firms. The survey data were matched with remotely sense flood risk data from European Space Agency (2019) to assign a measure of flood risk to each firm location based on land use, elevation, and general precipitation patterns of the location. I used rainfall data from CHIRPS (Funk et al., 2015) to measure precipitation during the course of the study. The first rain during the study period was July 7 and the final rain was on October 18. While the rains started prior to treatment, most rainfall occurred after firms were treated.[11]

On average, firms have been in operation for just over seven years (Table A.3). Most firms are single proprietors as 87% have only one paid worker with an average of 1.5 workers including the owner. In the dry season, firms report making just under 50 customer transactions per day and are open all days of the week, for on average 14 hours per day. Self-assessed flood risk for the streets around the firm is quite high. The average likelihood that the streets around the firm will flood in the next rainy season averaged 12 out of 20, where 20 is total certainty that the area will flood. Self-assessed flood risk for the respondent firm is much lower with an average probability of 7 out of 20 for the upcoming rainy season.

Baseline measures of all pre-specified outcome variables were balanced across treatment arms (Table A.3). I cannot reject the joint hypothesis that baseline firm characteristics are not related to treatment assignment. There are slight differences across the treatment arms as firms in the community choice treatment arm have been in operation for fewer years. Self-assessed flood risk for the streets around the firm is higher in the individual and community choice treatment arms while firm owners work fewer hours in the individual choice treatment arm. I control for these three variables that were unbalanced at baseline in the main regression specifications.

Attrition was not related to treatment assignment (Table A.4). Firms that attrit had larger locations and monthly revenue and profit, were less likely to have employees not show up to work in the last month, and were less likely to have an owner that did not attend a formal school (Table A.5). Of the 33 firms that attrit, 15 of them closed (45% of firms that attrit). For firms that closed between baseline and endline, I include zeros for firm outcomes where appropriate. I also calculate Lee (2009) bounds as a robustness check against non-random firm survival.

[11] On average, 71% of the rain fell after firms in the individual choice treatment arm received their vouchers and 69% of the rain fell after firms in the community choice treatment arm received their voucher.

4 Empirical Strategy

I estimate the impact of treatment on firm adaptation strategies and firm performance using the following estimating equation:

$$y_{ic} = \beta Individual_{ic} + \gamma Community_{ic} + X'_{ic}\delta + \theta_s + \varepsilon_{ic} \tag{11}$$

where y_{ic} is the outcome of interest for firm i in local community c, $Individual_{ic}$ is a binary indicator variable for a local community of firms assigned to the individual choice treatment arm, $Community_{ic}$ is a binary indicator variable for a local community of firms assigned to the community choice treatment arm, and X_{ic} is a vector of firm level controls that includes the distance to each treatment arm, the average distance between firms in a local community, an indicator variable that takes the value of one if a firm was interviewed by an enumerator new to the project for the endline survey, and the three firm characteristics that were unbalanced across treatment arms at baseline: the self-assessed probability that the streets around the firm would flood in the next rainy season, the years of operation of the firm, and the average number of hours the firm owner worked per day in the last month. I also include strata fixed effects, θ_s, that account for stratified randomization based on average local community flood risk and elevation. I cluster the standard errors at the level of treatment assignment, the local community level. As robustness checks, I report Conley (1999) standard errors that allow for spatial correlation up to 500 meters and area-wise error rate adjusted p-values following Westfall et al. (1993). These area-wise error rate adjustments are quite conservative, so I also report sharpened q-values following Anderson (2008) which preserve more power in the experiment.[12]

In this intent-to-treat (ITT) framework, β gives the causal impact of being in individual choice treatment arm relative to the control group on a firm's investment decisions, flood experience, and performance while γ identifies the causal impact of being in the community choice treatment arm relative to the control. I test the difference between β and γ to test whether the individual and community choice treatment groups differentially impact the outcomes of interest as hypothesized in the theory of section 2.

While the ITT estimation cleanly identifies the effect of being assigned to either the individual or community choice treatment arm on firm investment, flooding, and performance, the decision to use a voucher and actually invest in flood control technologies is endogenous.

[12] Area-wise error rates following Westfall et al. (1993) were pre-specified (Doruska, 2024). The main investment results are robust to area-wise error rate or sharpened q-values (Anderson, 2008) multiple hypothesis correction and were the main outcomes targeted in the power analysis. Both area-wise error rates and sharpened q-values of multiple hypothesis testing greatly reduce power for outcomes related to flooding and firm performance.

Furthermore, the ITT estimates do not actually measure the effects of investment in wooden pallets or barriers on firm flooding or performance. To measure the impact of investments on firm flooding and performance, I estimate the local average treatment effect (LATE) for firms that make investments using two-stage least squares. I estimate

$$I_{ic} = \alpha_1 Community_{ic} + \alpha_2 Individual_{ic} + X'_{ic}\delta + \phi y_{ic0} + \theta_s + \varepsilon_{ic} \tag{12}$$

$$y_i c = \beta_{LATE} \hat{I}_{ic} + X'_{ic}\delta + \phi y_{ic0} + \theta_s + \varepsilon_{ic} \tag{13}$$

where I_{ic} is an indicator variable that takes the value of one if a firm makes an investment in barriers, wooden pallets, or shelves between July and December 2024 and $\hat{I}_{ic}$ is the predicted value of investment from the first-stage estimation. As in the ITT estimation, I include controls for the distance to each treatment arm, the average distance between firms in a local community, an indicator variable that takes the value of one if a firm was interviewed by an enumerator new to the project for the endline survey, the three variables that were unbalanced across treatment arms at baseline, and strata fixed effects. I also include the baseline value of the outcome measure where available y_{ic0}.[13]

4.1 Estimating Spillovers

While the experimental design centers around local communities, spillovers are not limited to firms within the same local community. Especially in areas with a higher concentration of firms, nearby firms can be assigned to different treatment groups. If nearby firms build a barrier, that could potentially divert water into other firms in the sample, constituting a violation of the stable unit treatment value assumption (SUTVA). To better understand the role of spillovers, I estimate the equation:

$$y_{ic} = \beta_1 Individual_{ic} + \beta_2 IndividualNear_{ic} + \gamma_1 Community_{ic} + \gamma_2 CommunityNear_{ic} + \phi y_{ic0} + X'_{ic}\delta + \theta_s + \varepsilon_{ic} \tag{14}$$

[13]This ANCOVA specification is included as a robustness check in the main experimental analysis. While McKenzie (2012) notes that using an ANCOVA specification can increase power, the baseline survey references dry season outcomes for firms and the endline survey covers rainy season outcomes for firms. Thus, I measure two slightly different things between baseline and endline data. So, I consider the ANCOVA specification a robustness check for the main analysis. I include the control for the baseline measure of the outcome variable where available for the IV and spillover analysis to follow as it increases goodness of fit measures. Wooden pallets were not counted at baseline so it is not possible to estimate an ANCOVA specification. There is no ANCOVA specification for voucher preference or redemption.

where $IndividualNear_{ic}$ is the count of the number of firms within 200 meters of firm i assigned to the individual choice treatment group and $CommunityNear_{ic}$ is the count of the number of firms within 200 meters of firm i assigned to the community choice treatment group. This estimating equation measures both the direct effect of being assigned to either the individual choice or community choice treatment arm as well as the spillovers from nearby firms being assigned to each respective treatment arm. I then use elevation data from the Shuttle Radar Topography Mission (Farr et al., 2007) accessed through Google Earth Engine to identify uphill and downhill firms from firm i and consider heterogeneity by the slope of the land, estimating

$$\begin{aligned} y_{ic} = \beta_1 Individual_{ic} + \beta_2 IndividualNearUphill_{ic} + \beta_3 IndividualNearDownhill_{ic} \\ + \gamma_1 Community_{ic} + \gamma_2 CommunityNearUphill_{ic} + \gamma_3 CommunityNearDownhill_{ic} + \\ \phi y_{ic0} + X'_{ic}\delta + \theta_s + \varepsilon_{ic} \quad (15) \end{aligned}$$

where uphill and downhill denote the count of firms within 200 meters of firm i in the respective treatment group located uphill or downhill from firm i. This estimating equation, similar to strategies employed studying air pollution based on wind direction (Deryugina et al., 2019; Schlenker and Walker, 2016), leverages the fact that water generally flows downhill and thus spillover effects of investment should be concentrated in firms located downhill from firms making investments.

5 Experimental Results

First, I present the results around voucher preferences and redemptions. Then, I present the main experimental results, focusing first on investment decisions before moving on to outcomes related to firm flooding and performance.

5.1 Take-up and Voucher Preferences

Overall, 470 of the 500 firms assigned to receive a voucher got one in August 2024[14] and 65% of all firms that received a voucher redeemed that voucher. There are no differences in the rates of voucher redemption (Table 1). Firms preferred cement across both treatment

[14]In the individual choice treatment group, firms that did not get a voucher refused a voucher. Most often, firms stated they did not need cement or wooden pallets. In the community choice treatment group, firms had to show up to the community meeting to get a voucher, thus most firms did not receive a voucher because they did not show up to the meeting.

arms as almost 84% of firms received a voucher for two bags of cement.[15] However, in the individual choice treatment arm, 84% of firms wanted cement while in the community choice treatment group, when asked individually, only 77% of firms wanted cement as reported in Table 1. Firms in the community choice treatment group individually preferred wooden pallets at higher rates than in the individual choice treatment group, but this difference is not statistically significant (p-value = 0.201). However, the experimental design pushed some firms who preferred wooden pallets into receiving vouchers for cement as there is almost no difference between treatment groups in the number of firms that actually received a voucher for bags of cement.

5.2 Investment Decisions

ITT estimates in Table 1 show that across the control and two treatment arms, 31% of firms made some defensive investment during the study. Firms in the individual treatment arm were 26 percentage points more likely to make a defensive investment and firms in the community treatment arm were 22 percentage points more likely to make a defensive investment relative to the control, respectively. While the direction of the difference in investment likelihood is consistent with firms in the community choice treatment arm taking into consideration the negative prospective externalities of their choice, there is no statistical difference between the two treatment arms. Only 14 percent of firms in the control group made any defensive investment between baseline and endline, so the decreased costs of investment through vouchers resulted in a large, economically meaningful increases in defensive investments.

Of these defensive investments, firms built new or improved barriers or similar structures that might divert floodwater. Firms in the individual treatment arm were 22 percentage points more likely to make a change to the structure of their building relative to the control while firms in the community choice treatment arm were 15 percentage points more likely to make a similar change. In the control group, only 8 percent of firms made a change to the structure of their building, so these vouchers, primarily for cement, resulted in meaningful changes in the structures of firms. Firms in the individual treatment arm also report getting new wooden pallets at higher rates relative to the control. The point estimate for the community choice treatment arm is positive but not statistically different from the control and there is no statistical difference between the coefficient estimates of the two treatment arms. The majority of firms who got voucher for wooden pallets in the community choice

[15]The voucher preference of firms assigned to the community choice treatment arm is the voucher they said they would prefer when they were asked individually away from the group. The voucher these firms received was then determined by the community choice process.

Table 1. Voucher Choice and Investment Decisions Estimation Results

	(1) Individually Prefer Cement	(2) Redeemed Voucher	(3) Made Any Investment	(4) Built Something	(5) New Wooden Pallets	(6) New Shelves
Individual Choice			0.263***	0.216***	0.081***	-0.001
			(0.053)	(0.045)	(0.029)	(0.034)
			[0.046]	[0.049]	[0.027]	[0.033]
			{0.002}	{0.002}	{0.013}	{0.999}
			⟨0.001⟩	⟨0.001⟩	⟨0.020⟩	⟨0.733⟩
Community Choice	-0.084	0.095	0.213***	0.150***	0.035	-0.006
	(0.065)	(0.076)	(0.061)	(0.056)	(0.035)	(0.041)
	[0.070]	[0.070]	[0.054]	[0.054]	[0.035]	[0.036]
	{0.383}	{0.383}	{0.024}	{0.141}	{0.933}	{0.999}
	⟨0.270⟩	⟨0.270⟩	⟨0.004⟩	⟨0.024⟩	⟨0.322⟩	⟨0.718⟩
Control Group Mean			0.138	0.0792	0.0208	0.0792
Individual Group Mean	0.840	0.661				
Individual = Community			0.428	0.281	0.225	0.879
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	471	500	729	729	729	729
Adjusted R^2	0.00209	0.0380	0.0665	0.0520	0.0319	0.00648

Notes. Columns 1 and 2 only consider the individual choice and community choice treatment groups while columns 3 - 6 consider the entire sample. Individually Prefer Cement is an indicator variable that takes the value of one if a firm in the individual choice treatment arm selected cement or if a firm in the community choice treatment arm preferred a cement voucher when asked individually. Redeemed Voucher is an indicator variable that takes the value of one if a firm redeems their voucher. Made Any Investment is an indicator variable that takes the value of one if a firm built or improved part of their firm structure, got new wooden pallets, or got new shelves. Built Something is an indicator variable that takes the value of one if a firm built a new part of the structure or if they improved part of the structure. New Wooden Pallets and New Shelves are indicator variables that take the value of one if a firm got new wooden pallets or new shelves, respectively. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. Conley standard errors that allow for spatial correlation up to 500 meters are in square brackets. Area wise error-rate adjusted p-values following Westfall et al. (1993) are in curly brackets while the angle brackets report sharpened q-values following Anderson (2008). Stars reported based on clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

treatment group were from local communities who did not accept the group decision and thus each firm got their individually preferred voucher. These local communities report similar rates of investments in wooden pallets as the individual choice treatment group.

Shelving units that raise inventory off the ground, much like pallets, are another defensive investment, but they were not incentived or targeted by the experiment. The test for differences in investments in shelves is thus a placebo test. While it is not surprising that both voucher treatments had no effect on shelving, this test rules out the possibility that the vouchers spurred broader defensive investments or are somehow spuriously correlated with other unobserved factors that sparked defensive investments. The increase in investment is limited to technologies targeted directly by the vouchers. Furthermore, few firms got new

shelves in the control group, less than 8%. The lack of investment in shelves suggests that the survey team asking about flooding did not spur additional investment in firms' flood loss mitigation technologies simply by making flooding more salient right before the rainy season. So, the experiment seems to have worked as designed as a clean inducement to invest in flood loss mitigation through either an externality-prone concrete barrier or wooden pallets that create no externality.

Table B.1 explores how treatment impacted the level of investment in wooden pallets, shelves, or barriers, measuring the latter as whether the store entrance is at street level or not, and if so, how much higher the entrance to the firm is. Almost 80% of firms are higher than street level. At endline, firms in the community choice treatment group are less likely to be raised up from the street relative to the control while there is no difference between the individual choice treatment and the control groups. This effect is marginally statistically significant suggesting that the take-up of cement vouchers in the community choice treatment group was not used to raise firms up from the street. The p-value on test of the difference between the two treatment groups is 0.0932 so there is a weakly significant difference across treatment arms. Even so, firms can still use cement to build small-scale barriers at doors (like a lip that one has to step over to enter) or place cement bricks outside the store to limit the incursion of water into the firm without changing the general elevation of the structure. Thus, this result is consistent with the idea that firms who built in the community choice treatment arm did so on a smaller scale relative to the individual choice treatment arm. Firms in the individual treatment group are on average 6 centimeters higher off the street than firms in the control. The point estimate for the community choice treatment is positive but not statistically different than the control. There are no differences in the number of wooden pallets or shelving units across treatment arms. Given the low take-up of vouchers for wooden pallets across the study, the positive but statistically insignificant result is unsurprising.

Digging in to what firms built, there is suggestive evidence of different investment patterns between the two treatment groups. For firms that built, firms in the community choice treatment group were more likely to build something new as opposed to reinforcing or improving an existing part of the firm (Table B.2). Additionally, using pictures of what firms built, I classify what the firm built or improved upon into seven broad categories: a cement slab, a small lip, an external barrier, the floor, steps up to the firm, the roof, or cement bricks placed outside of the firm and not connected in a cohesive structure. Firms assigned to the community choice treatment group were more likely to use cement bricks outside of their firm (Table B.3). These results are consistent with the lack of changes in the overall structure or entrance to the firm in Table B.1 and suggest that firms in the community

choice treatment group built new, but smaller-scale, structures. Overall, the small vouchers of 7,000 FCFA, equivalent 8% of median monthly profit, result in large increases in defensive investments by firms.

5.3 Flooding and Firm Performance

There are no differences in the rate of street flooding around firms across treatment arms (Table B.4). Consistent with the baseline results, flooding in streets is widespread; over 75% of firms in the control group report flooding in the streets around their firm between July 2024 and December 2024. The vouchers targeted individual firm defensive investments that should not result in changes in flood risk of streets around firms. Thus the lack of changes in street flooding is not surprising and consistent with firms making individual investments instead of larger investments in broader drainage infrastructure that would affect street flooding.

Results for regressions considering firm flood occurrence and damage are in Tables 2 and 3. Only 13% of firms in the control group flooded between July 2024 and December 2024. At baseline, 36% of firms report that they normally flood during the rainy season, thus the flood reports were lower during the course of the study.[16] Being assigned to receive a voucher did not significantly affect the likelihood that a firm flooded.

Even so, being assigned to receive a voucher decreased the intensity of firm flooding for firms in the community choice treatment arm. Firms in the community choice treatment arm report that their firm flooded in the rainy season 0.358 fewer times relative to the control (Table 2). This result includes all firms that did not flood and thus experienced zero firm floods. Considering that control group firms flooded 0.415 times on average, this estimate represents a 86% decrease in the frequency of flooding. The point estimate for the individual choice treatment arm is negative but not statistically different from the control. The decrease in the frequency of firm floods is almost statistically different across treatment arms, with a p-value of 0.135.

Firms in the community choice treatment arm also report that they experienced fewer inventory losses from floods and were closed for fewer days due to a flood (Table 3). Firms in the community choice treatment group report a decrease in flood losses of 10,174 FCFA (around $17 USD) relative to the control. The control group reports almost 8,000 FCFA in flood losses. The decrease in inventory losses is roughly 10% of baseline median monthly firm profit and 3.4% of baseline median monthly firm revenue. So, this decrease represents

[16]Since 2013, 2024 rainfall between June and October was just under the overall average rainfall across the rainy season for these firm locations. The last year with similar rainfall was 2019. There was higher rainfall from 2020 to 2023.

Table 2. Firm Flooding Estimation Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	0.009	-0.071	-0.061
	(0.041)	(0.139)	(0.075)
	[0.035]	[0.124]	[0.057]
	{0.971}	{0.920}	{0.835}
	⟨0.553⟩	⟨0.440⟩	⟨0.390⟩
Community Choice	-0.057	-0.358*	-0.235
	(0.056)	(0.216)	(0.170)
	[0.058]	[0.219]	[0.159]
	{0.795}	{0.663}	{0.685}
	⟨0.331⟩	⟨0.304⟩	⟨0.304⟩
Control Group Mean	0.132	0.415	0.167
Individual = Community	0.211	0.135	0.198
Strata FE	Yes	Yes	Yes
ANCOVA	No	No	No
Observations	714	714	714
Adjusted R^2	0.0257	0.0241	0.0485

Notes. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. Conley standard errors that allow for spatial correlation up to 500 meters are in square brackets. Area wise error-rate adjusted p-values following Westfall et al. (1993) are in curly brackets while the angle brackets report sharpened q-values following Anderson (2008). Stars reported based on clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

a meaningful reduction in inventory losses, effectively eliminating all losses in expectation. The point estimate for the individual treatment arm is positive and noisy and there is a statistically significant difference between the two treatment arms. Firms in the community choice treatment group were 9 percentage points less likely to close due to a flood during the last rainy season relative to the control, a 44% decrease in the likelihood of firm closure. When firms had to close due to a flood, firms in the community choice treatment group closed for 0.386 fewer days relative to the control. The average firm closure in the control group

lasted 0.372 days suggesting that firms in the community choice treatment group were able to meaningfully decrease the damage from flooding throughout the rainy season. There is no detectable difference in the number of days a firm was closed due to a flood in the individual choice treatment arm relative to the control and the point estimates are statistically different between treatment arms (p-value = 0.0901). Thus, there is evidence that flood intensity decreased in the community choice treatment arm but not in the individual choice treatment arm.

There are mixed results on firm performance across treatment arms. Firms in the individual choice treatment arm had more customers enter the store and had more transactions in a typical operating day in the last month of the rainy season relative to the control (Table 4). The point estimate for customer entrances and transactions per day is also positive for the community choice treatment group, but it is not statistically different from the control. There is no statistical difference between the two point estimates for the two treatment arms. Firms in the individual choice treatment arm also had lower self-reported monthly revenue relative to the control. There is no statistically significant differences for firm revenue and profit in the community choice treatment group relative to the control as these point estimates are not precisely estimated. Even so, firms in the community choice treatment group had statistically higher monthly revenue compared to firms in the individual choice treatment group. This result may seem surprising as these firms also have higher customer transactions per day, but firms in the individual choice treatment have less valuable transactions as the point estimate for the value of weekly sales for their two most frequently sold items is negative (but not statistically significant). While firms in the community choice treatment group saw decreased flood damage, there were no increases in firm performance measures four months later during the endline survey. Even so, these firms did not experience the negative revenue effects that firms in the individual treatment group did, suggesting that the group meetings are able to mitigate negative spillovers associated with individual defensive investments against flood losses.

All main ITT results are robust to including baseline measures of the outcome variables (an ANCOVA specification, Tables B.5 – B.8). To account for a small number of firms (less than 5%) attriting during the survey, I estimate Lee (2009) bounds. The main results are robust and can be found in Tables B.9 – B.12.[17]

Results are also robust to including controls for spillovers following Borusyak and Hull (2023). I created 2,000 re-randomized draws and then calculated the expected number of neighbors within 200 meters assigned to either treatment group and then included these

[17]Some of the point estimates lie outside the estimated bounds. Lee (2009) bounds are asymptotic and thus this result is unsurprising given the small sample size of this study.

Table 3. Firm Flood Damage Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	6907.376	-0.073	0.052
	(4484.729)	(0.045)	(0.225)
	[4165.433]	[0.045]	[0.214]
	{0.663}	{0.663}	{0.971}
	⟨0.304⟩	⟨0.304⟩	⟨0.553⟩
Community Choice	-10174.602*	-0.090*	-0.386**
	(5402.219)	(0.047)	(0.185)
	[5013.583]	[0.044]	[0.183]
	{0.570}	{0.570}	{0.515}
	⟨0.304⟩	⟨0.304⟩	⟨0.304⟩
Control Group Mean	7908.1	0.205	0.372
Individual = Community	0.0141	0.714	0.0901
Strata FE	Yes	Yes	Yes
ANCOVA	No	No	No
Observations	714	714	714
Adjusted R^2	0.00661	0.0151	0.00559

Notes. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. Conley standard errors that allow for spatial correlation up to 500 meters are in square brackets. Area wise error-rate adjusted p-values following Westfall et al. (1993) are in curly brackets while the angle brackets report sharpened q-values following Anderson (2008). Stars reported based on clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

expected number of neighbors as controls in estimating equation. Results including Borusyak and Hull (2023) controls can be found in Tables B.13 – B.16.

5.4 Estimated Impacts of Defensive Investments

Even though there was good take-up in the experiment, over 60% of firms redeemed their vouchers and invested, there is still unobserved selection by firms into actually making a

Table 4. Firm Performance Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.016	9.033**	6.818**	-138546.929**	-25356.332	-4365.549
	(0.010)	(3.898)	(3.359)	(57644.973)	(15510.526)	(4862.439)
	[0.009]	[3.758]	[3.043]	[51362.872]	[14633.374]	[4843.317]
	{0.581}	{0.242}	{0.370}	{0.232}	{0.581}	{0.801}
	⟨0.234⟩	⟨0.140⟩	⟨0.165⟩	⟨0.140⟩	⟨0.234⟩	⟨0.395⟩
Community Choice	-0.018	4.989	4.331	-20816.651	-637.199	1179.373
	(0.013)	(4.695)	(3.832)	(62831.587)	(17145.471)	(7201.805)
	[0.010]	[4.909]	[3.916]	[57494.582]	[15930.066]	[6539.148]
	{0.623}	{0.801}	{0.765}	{0.979}	{0.991}	{0.991}
	⟨0.298⟩	⟨0.364⟩	⟨0.364⟩	⟨0.763⟩	⟨0.841⟩	⟨0.841⟩
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
Individual = Community	0.799	0.387	0.517	0.0392	0.133	0.325
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	729	729	729	727	718	729
Adjusted R^2	-0.00341	0.0411	0.0454	0.0250	0.0210	0.0447

Notes. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. Conley standard errors that allow for spatial correlation up to 500 meters are in square brackets. Area wise error-rate adjusted p-values following Westfall et al. (1993) are in curly brackets while the angle brackets report sharpened q-values following Anderson (2008). Stars reported based on clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

defensive investment of building or improving a barrier, getting a new pallet, or getting new shelves. I use random assignment into the community choice and the individual choice treatment groups as instruments for making any investment to estimate the LATE of how investments impact firm flooding and performance. Results of the first stage regressions are in Table B.17.

Results from the IV regressions for flooding in the firm itself (Table B.18) suggests that firms that invested flooded fewer times; however, the coefficients are imprecisely estimated and not statistically significant. Investment does decrease the likelihood that a firm had to close due to a flood (Table 5). The point estimate for the LATE is -0.322, which represents a decrease of more than the rate of firm closures due to flooding in the control group. Across both treatment groups, those who invested saw mitigated flood losses as they were able to remain open during times where they otherwise would have had to close due to a flood.

Table 5. Firm Flood Damage IV Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Any Investment	10568.982	-0.322*	-0.231
	(14611.755)	(0.169)	(0.727)
Control Group Mean	7908.1	0.205	0.372
ANCOVA	Yes	Yes	Yes
Observations	711	714	714

Notes. I instrument for firms making an investment using randomized treatment assignment. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Firms that made investments also saw increased customer traffic. Firms that invested in barriers, new wooden pallets, or new shelves were less likely to have employees not show up to work and had more customer entrances and transactions per day in the last month of the rainy season (Table 6). The LATE for increase in transactions is 29.9 transactions per day. Relative to the control group mean of 35.6 transactions per day, this represents an 84% increase in transactions. Firms that invested have lower monthly revenue (Table 6), but there are no statistically significant differences in firm self-reported monthly profit for firms that invested. Thus, firms are able to complete more transactions, but these are not high value transactions and thus do not lead to more revenue or profit in the four months following the vouchers to spur investments.

To better understand how the impact of investment may operate differently between the two treatment arms, I interact the predicted investment ($\hat{I}_{ic}$) with the community choice treatment indicator ($Community_{ic}$). These regressions necessarily violate the assumptions required for causal inference (Angrist and Pischke, 2009); however, they provide descriptive evidence as to how investment operates differently between the individual choice and the community choice treatment arms. Alternatively, I subset the analysis to only consider the control and either the individual choice or community choice treatment group. However, subsetting the data severely decreases first stage power (Table B.17) raising concerns about

Table 6. Firm Performance IV Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Any Investment	-0.065*	38.219**	29.874**	-457769.914**	-82673.234	-12192.478
	(0.038)	(16.424)	(13.553)	(195688.386)	(51380.977)	(19818.094)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	729	729	729	727	718	729

Notes. I instrument for firms making an investment using randomized treatment assignment. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

weak instruments (Staiger and Stock, 1997; Lee et al., 2022). Thus, both sets of analyses should be interpreted with caution but can provide descriptive evidence on how investment may operate differently in the two treatment arms. Consistent with the ITT results, investment in the community choice treatment arm is associated with larger decreases in firm flooding, flood damage, and better firm profits (Tables B.19 - B.25).

5.5 Heterogeneity

While much of the analysis reveals similar rates of investment between the two treatment arms, there are meaningful differences in firm flood damage outcomes. These results raise questions about what could drive these results. There exists, however, a difference in the concentration of people within a local community across the two treatment groups. A kernel density plot of the concentration of firms that build within a local community across both treatment arms and the control is in Figure C.1, where the concentration is defined as the number of firms that build in a local community divided by the number of firms in that local community. The concentration of builds is higher in both the treatment arms relative to the control, but the individual choice treatment arm has a larger mass of firms above 0.5, meaning more individual communities had more people build in them just as the simple theory model predicts. While a larger concentration of builds is partly mechanical due to randomized assignment of local communities, considering how more people building within a smaller area changes firm outcomes can potentially point to how many firms investing point to more (or less) spillovers from investment.

I formally test for heterogeneity in outcomes based on the concentration of firms that built within a local community by creating an indicator variable for communities in treatment arms whose concentration of builds within the local community was greater than the median. I then include this indicator variable and the interaction of this indicator variable with the community choice treatment indicator in the main estimating equation.

First, when separately considering communities with above and below median concentration of builds, communities with a lower concentration of builds in both treatment arms experienced fewer firm floods and these firm floods were shorter relative to the control group (Table C.1). Firms located in local communities with a higher concentration of builds were 12.7 percentage points more likely to flood. These firms also experienced 0.428 more floods, and their average flood was 0.288 days longer. The interaction effects between the above median concentration of builds and the community choice treatment arm are negative but imprecisely estimated. More firms building within a local community actually increases the instance of firm flooding suggesting that when individual firms make investments, they divert water away from their firm and towards others increasing the volume of water going towards other structures and increasing flooding. This corroborates the externality at the heart of this study.

Turning to flood losses and firm closures due to flooding, there are no significant differences based on the concentration of builds within a local community (Table C.2). There are, however, fewer flood losses and firm closures due to flooding in the community choice treatment group. Overall, when more firms build in a local community, flooding increases suggesting that there are negative spillover effects from individual investments but those effects are attenuated through coordinated firm choice.

Finally, firms in local communities with more firms building, particularly in the individual treatment arm, have lower performance outcomes (Table C.3). For firms within above median builds within their local community, the total effect on customer entrances and transactions is almost zero as the coefficient estimates for local communities with more builds are negative and very similar in magnitude. Importantly, the interaction effect between more builds and the community choice treatment arm is positive, suggesting that the negative effects from more builds on consumer demand is limited to firms in the individual choice treatment arm. When firms made their voucher choice with other firms located near them, they avoided the negative spillover effects experienced by many firms individually deciding to build barriers nearby. Above median community builds is also associated with an almost 37,000 FCFA ($60 USD or 37% of median monthly baseline profit) reduction in monthly profit and lower weekly sales. Taken together, these results suggest that the adaptation choices of others within a local community matter as there are negative spillover effects that can be mitigated

through coordination among community members. Furthermore, these results suggest that there may be a low-level equilibrium in which costly firm investment actually increases flood damage explaining the lack of investment without inter-firm coordination prior to the study.

I also pre-specified testing for heterogeneity based on baseline flood risk, rainfall during data collection, and baseline firm performance. There are no significant interactions between any of these groups and the treatment arms. Additionally, while not pre-specified, I consider heterogeneity by firms that report paying no rent and thus likely own their store. These firms are more likely to build in both treatment arms but there are no significant interaction effects on flooding, flood damage, or firm performance.[18]

6 Spillovers

The main investment results are robust to including measures of spillovers, although there is evidence that nearby firm randomization matters. Firms with an additional firm within 200 meters assigned the individual choice were more likely to invest, build, and have new shelves (Table D.1). Furthermore, I find clear evidence of spillovers on flooding outcomes (Table 7). Firms with an additional firm assigned to the individual choice treatment group within 200 meters are more likely to flood experience longer floods. Firms with an additional firm assigned to the community choice treatment group also have longer floods.

Additionally, there is evidence of spillovers for firms located near other firms assigned to the individual choice treatment group (Table 8). Firms located near other firms assigned to the individual choice treatment group were 5% more likely to close due to a flood. Furthermore, firm closures were 6% longer for firms with an additional firm assigned to the individual choice treatment group within 200 meters. Taken together, these results suggest that there were negative spillovers for firms located near other firms in the individual choice treatment group. Individual investments resulted in more flooding and greater flood damage for other firms located nearby.

Finally, the firm performance results are generally consistent with the main ITT estimates (Table D.2). When accounting for the treatment assignment of nearby firms, firms in the community choice treatment also group have more customer entrances and transactions per day relative to control. Estimates of spillover effects are imprecisely and inconsistently estimated with no discernible pattern.

While considering nearby firms broadly captures the nature of possible spillovers, in the case of flooding, the elevation between firms matters. Specifically, water flows from higher

[18] Full heterogeneity results available upon request.

Table 7. Firm Flooding Spillover Estimation Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	-0.044	-0.239	-0.183*
	(0.049)	(0.167)	(0.093)
Individual Firms Nearby	0.009*	0.022	0.020**
	(0.005)	(0.015)	(0.009)
Community Choice	-0.060	-0.383*	-0.280*
	(0.054)	(0.208)	(0.167)
Community Firms Nearby	0.004	0.022	0.017**
	(0.004)	(0.020)	(0.008)
Control Group Mean	0.132	0.415	0.167
Individual = Community	0.777	0.482	0.517
Individual = I. Nearby	0.318	0.141	0.043
Community = C. Nearby	0.244	0.060	0.080
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	714	714	714
Adjusted R^2	0.0580	0.0990	0.0805

Notes. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms nearby is the number of firms assigned to the community choice treatment group within 200 meters. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Individual = I. Nearby reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the count of individual choice treatment firms within 200 meters. Community = C. Nearby is the p-value of the same test for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

elevations to lower elevations.[19] Indeed, firms with more uphill neighbors, in either treatment group, were more likely to prefer cement vouchers (Table D.3). Furthermore, firms with an additional neighbor uphill from them assigned to the individual treatment group were 1.7

[19]Focusing on firm investments uphill is similar to focusing on downwind impacts of air pollution as in Schlenker and Walker (2016) and Deryugina et al. (2019).

Table 8. Firm Flood Damage Spillover Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	6233.577	-0.143***	-0.085
	(4341.371)	(0.053)	(0.230)
Individual Firms Nearby	148.035	0.011**	0.023**
	(415.392)	(0.005)	(0.011)
Community Choice	-10906.834*	-0.109**	-0.433**
	(6331.083)	(0.049)	(0.210)
Community Firms Nearby	451.990	0.004	0.014
	(493.696)	(0.005)	(0.017)
Control Group Mean	7908.1	0.205	0.372
Individual = Community	0.018	0.567	0.181
Individual = I. Nearby	0.175	0.007	0.641
Community = C. Nearby	0.092	0.028	0.045
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	711	714	714
Adjusted R^2	0.00947	0.0504	0.00431

Notes. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms nearby is the number of firms assigned to the community choice treatment group within 200 meters. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Individual = I. Nearby reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the count of individual choice treatment firms within 200 meters. Community = C. Nearby is the p-value of the same test for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

percentage points more likely to redeem their voucher while firms with an additional neighbor uphill from them assigned to the community choice treatment group were three percentage points more likely to redeem their voucher. The three percentage point increase represents almost a 5% increase in voucher redemptions. While firms in the individual treatment group

were not gathered together as part of the study, they could observe investments made by other firms and could talk to each other[20]. These results suggest that firms in the individual group may be responding to others' decisions.

More firms in the individual choice treatment group, either uphill or downhill, is associated with higher rates of investment and building in particular (Table D.3). However, there is no evidence that more neighboring firms within 200 meters in the community choice treatment group, either uphill or downhill from the firm, result in different patterns of investment.

There is some evidence of spillovers as an additional firm downhill in the individual choice treatment group resulted in firms that were more likely to flood and experienced longer floods while an additional uphill firm in the community choice treatment group resulted in longer floods as well (Table D.4). While a bit unintuitive for downhill firm decisions to lead to more flooding, these estimates could reflect a slightly higher volume of water. A barrier downhill could limit how water is able to flow leading to more water buildup at higher elevations as places where water used to flow get cutoff. These buildups are likely to be small and the small estimated downhill flooding impacts are consistent with diversions of water leading to small increases in uphill flooding. Furthermore, firms with an additional uphill firm assigned to the community choice treatment group experienced longer firm floods. The point estimate is small, 0.025 days (Table D.4), but suggests that while community meetings can help mitigate the negative spillover effects of individual investments, they still generate spillovers onto other firms nearby.

Consistent with the hypothesis that uphill firm investment matters more for spillovers, firms were 5% more likely to have to close if they had an additional uphill firm assigned to the individual choice treatment group nearby (Table 9). Firm closures were 11% longer when there was an additional uphill firm in the individual choice treatment group. Comparing these estimates to those in Table 8, all of the negative spillover effects for firms located near others in the individual treatment arm come from firms located uphill.

Firms with an additional uphill firm assigned to the individual choice treatment group had lower monthly revenue and the value of their weekly sales for their two most frequently sold items was lower (Table D.5). When neighbors uphill from a firm are prompted to make uncoordinated defensive investments, the downhill firm experiences negative spillover effects on their own revenue and sales. Additionally, an additional uphill firm assigned to the community choice treatment group is associated with fewer customer entrances and transactions per day. Coordinated investments by uphill firms result in less demand; however, there is no corresponding drop in revenue or profit suggesting that firms are not losing out on transactions that generate lots of revenue for the firm.

[20]These firms are all located nearby so likely some firm owners interact frequently.

Table 9. Firm Flood Damage Spillover Complete Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	6368.639	-0.144***	-0.090
	(4400.179)	(0.053)	(0.226)
Individual Firms Nearby Uphill	-437.526	0.015**	0.042**
	(462.676)	(0.007)	(0.020)
Individual Firms Nearby Downhill	761.100	0.007	0.003
	(948.300)	(0.006)	(0.018)
Community Choice	-10745.412*	-0.110**	-0.439**
	(6359.039)	(0.049)	(0.210)
Community Firms Nearby Uphill	616.362	0.005	0.014
	(838.733)	(0.007)	(0.027)
Community Firms Nearby Downhill	129.944	0.004	0.018
	(402.284)	(0.006)	(0.016)
Individual Group Mean	7908.1	0.205	0.372
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	711	714	714
Adjusted R^2	0.00886	0.0493	0.00382

Notes. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms nearby is the number of firms assigned to the community choice treatment group within 200 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

These analyses consider a 200 meter threshold for spillovers which allows for spillovers between local communities potentially assigned to different treatment groups without including large portions of the sample as nearby or neighboring firms.[21] I can instead consider a tighter 100 meter radius for spillovers. These results can be found in Tables D.6 - D.9. Given that most firms within the same local community are within 100 meters, considering only

[21] I considered expanding the threshold to 500 meters but this proved difficult as some firms were then "nearby" more than 100 firms. I also considered a 50 meter radius but this only captures a small number of nearby firms.

neighbors within 100 meters largely only considers nearby firms within the same treatment arm as I randomized at the local community level. Thus, a 100 meter radius will not fully capture any SUTVA violations and instead generally captures potential spillovers from firms within the same local community. Even so, the 100 meter spillover results are generally consistent with the 200 meter spillover results; however, the tighter bound decreases statistical power.

Overall, there are negative spillovers associated with individual firm investments that are largely driven by uphill firms. Water flows down to firms at lower elevations and increases flooding, flood damage, and decreases firm performance. While there is some evidence of negative spillovers from firms in the community choice treatment group, these community meetings largely mitigate the negative spillovers that accompany individual firms investments.

7 Conclusions

Urban flooding is a growing and expensive problem for individuals, households, and firms in the Global South. In the absence of investments from local government or community entities, firms and individuals may be incentivized to take up private defensive investments to protect themselves against flood-related losses. Thus, it is important to understand how individual, private investments in flood mitigation technologies impact the firms that make these investments and other firms around them.

This paper yields three important takeaways. First, urban flooding poses significant challenges for small retail firms in Dakar, Senegal. Despite being located in flood-prone areas, firms in the study that flooded in the prior year face significant reductions in profit and demand. Exploring how firms can mitigate flood damage and better adapt to urban flooding could greatly increase firm productivity and overall welfare for individuals in these areas.

Second, firms are willing to invest in flood mitigation technologies when provided the opportunity, but uncoordinated investments can produce negative spillover effects. Providing firms a small voucher more than doubled the rate of investment in the study. However, only firms that made their voucher choice in a group saw decreases in flood losses and were less likely to close due to a flood. Spillover effects are most pronounced for firms whose uphill neighbors got vouchers individually. These results highlight the potential risks firms face when making defensive investments.

Third, short community meetings that prompt firms to think about their neighbors when they make their investment decisions can mitigate the negative externalities associated with

uncoordinated investments. When firms were prompted to think about their neighbors and adopt a more cooperative framework, they still made defensive investments; however, these defensive investments did not generate the same spillover effects as firms that made uncoordinated investment decisions. If, instead, short community meetings were adopted at scale to encourage coordinated defensive investments of small retail firms across flood-prone areas in Dakar, the net present value of the next 10 years of inventory savings is 82,494 FCFA (about $137 USD) per firm or an estimated 67,785,217 FCFA ($112,975 USD) across all firms in flood-prone areas of Dakar.[22] This ten-year benefit is just below baseline median monthly profit for these retail firms. The one-year inventory saving benefit exceeds the cost of the vouchers and the transportation subsidy for each firm (10,000 FCFA in inventory savings relative to 8,000 FCFA in vouchers and transportation subsidies). Firms that built likely had to contribute up to an additional 30,000 FCFA depending on what they built[23] and thus it would take about four years of inventory savings for the investment to pay for itself. Even so, scaling up these community meetings could provide substantial inventory savings for small retail firms in flood-prone areas.

While this study focuses on decreasing the cost of investment to increase firm investments, the policy instrument to increase individual firm defensive investments is not important to the broader implications. Individuals may not fully account for the potential spillovers onto others, so other policies designed to increase individual investments also can generate negative spillover effects. But, as suggested by Ostrom (1990) and Baland and Platteau (2003), local communities may be able to manage their own flood risk, even without clear community institutions and structures. Small interactions that prompt people to think about the neighbors and consider the potential spillovers can results in investments that better benefit more members of the community. Policies designed to increase defensive investments should consider potential ways to prompt recipients to think about how their actions might impact their neighbors to help mitigate any potential spillovers.

This study also suggests areas for new research. Additional work is necessary to better understand what optimal investment patterns are when considering community interactions. Future work should also consider different types of investments. Furthermore, investments to mitigate flood losses are not the only form of adaptation measure that can generate externalities. Ideas developed in this work should be applied to other types of adaptation as firms and individuals make defensive investments in the face of a changing climate.

[22]This analysis assumes an annual discount rate of 5% (Haacker et al., 2020) and scales based on the sampling proportion of firms within flood-prone areas.

[23]Building an entire new concrete slab to raise up a firm is estimated to be 37,000 FCFA. Most firms built smaller structures and likely spent far less.

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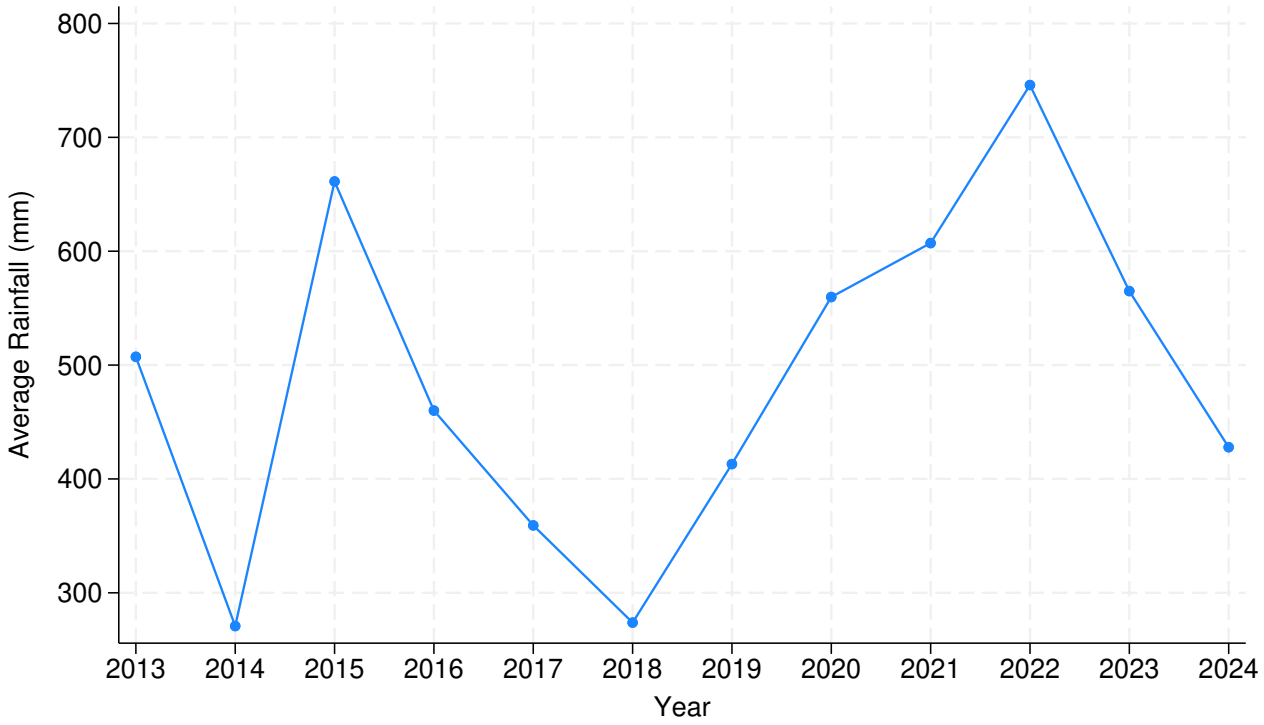
A Descriptive Analysis Figure and Tables

Figure A.1. Average Rainy Season Rainfall since 2013



Notes. This figure plots the average June to October rainfall in millimeters (mm) for firm locations from 2013 to 2024. Rainfall data from Funk et al. (2015).

Table A.1. Flooding at Baseline: Firm Flood Damage Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Flooded Last Year	37920.524***	0.492***	2.303***
	(3304.499)	(0.034)	(0.536)
Observations	744	747	747
R^2	0.257	0.287	0.0671

Notes. This table reports results of descriptive regressions on the association between flooding and firm flood damage outcomes at baseline. Flood Losses (FCFA) is the self-reported inventory losses due to flooding in FCFA in the previous rainy season. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm reports that they had to close due to a flood in the last rainy season. Length of Firm Closure is the number of days a firm closed due to a flood in the last rainy season. All regressions include controls for remotely sensed flood risk. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2. Flooding at Baseline: Firm Performance Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Firm Monthly Revenue (FCFA)	(5) Firm Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Flooded Last Year	-0.030*	-15.870***	-13.659***	-71808.533**	-42984.524***	-70948.739**
	(0.016)	(2.865)	(2.497)	(32159.957)	(8485.063)	(31245.290)
Observations	747	747	747	747	747	747
R^2	0.00982	0.0428	0.0370	0.00807	0.0387	0.00876

Notes. This table reports results of descriptive regressions on the association between flooding and firm performance outcomes at baseline. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work within the past month. Customer Entrances and Transactions (per-day) are the number of customers that enter and the number of transactions firms report per day on a typical day the firm was open in the last month. Firm Monthly Revenue and Firm Monthly Profit are the self-reported firm revenue and profit within the last month in FCFA. Value of Weekly Sales is the calculated value of weekly sales the firm has for their two most sold items in FCFA. All regressions include controls for remotely sensed flood risk. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3. Balance Table

Balance Variable	Control	Individual Choice	Community Choice	Control = Individual	Control = Community	Individual = Community
Number of Workers	1.567	1.560	1.452	0.932	0.131	0.123
	(0.777)	(0.665)	(0.657)			
Location Size (m^2)	11.178	11.669	11.619	0.639	0.662	0.960
	(7.361)	(7.658)	(7.182)			
Years in Operation	7.423	8.162	6.567	0.345	0.240	0.046**
	(7.914)	(8.483)	(7.219)			
Last Month Revenue	414,532.724	451,233.871	432,871.410	0.354	0.686	0.652
	(375,125.175)	(393,187.578)	(404,893.114)			
Last Month Profit	118,353.061	120,900.436	134,112.903	0.808	0.190	0.254
	(104,098.682)	(98,228.314)	(106,455.686)			
Rent (per m^2)	3,156.172	3,155.874	3,337.672	1.000	0.761	0.752
	(4,284.272)	(4,196.188)	(4,785.032)			
Customer Entrances per day	57.279	51.254	57.294	0.179	0.998	0.180
	(39.146)	(37.200)	(39.295)			
Transactions per day	48.818	44.589	49.321	0.276	0.902	0.216
	(35.510)	(32.989)	(35.545)			
Hours Open per day	14.283	14.218	13.944	0.874	0.419	0.507
	(3.507)	(3.536)	(3.558)			
Missing Products for Clients	5.340	5.169	4.290	0.855	0.198	0.300
	(6.912)	(6.608)	(5.406)			
Value of Inventory	66,157.085	68,877.581	58,500.992	0.752	0.338	0.178
	(78,600.598)	(81,171.088)	(68,575.882)			
Value of Weekly Sales	185,976.579	221,743.871	158,110.774	0.478	0.514	0.205
	(378,037.863)	(421,104.416)	(348,965.413)			
Employees Did Not Show	0.057	0.060	0.028	0.892	0.217	0.123
	(0.232)	(0.239)	(0.165)			
Neighborhood Flood Prob. (20)	10.817	13.097	12.558	0.008***	0.058*	0.505
	(6.860)	(5.925)	(6.404)			
Firm Flood Prob. (20)	6.581	7.452	6.143	0.304	0.601	0.125
	(6.750)	(7.000)	(6.694)			
Remotely Sensed Flood Risk (4)	1.235	1.512	1.317	0.204	0.689	0.342
	(1.313)	(1.371)	(1.276)			
Firm Raised up from Street	0.607	0.649	0.631	0.481	0.686	0.747
	(0.489)	(0.478)	(0.484)			
Number of Shelves	4.870	4.754	5.044	0.723	0.624	0.390
	(2.901)	(2.942)	(2.998)			
Stock on the Ground (4)	1.291	1.359	1.298	0.508	0.949	0.553
	(0.886)	(0.875)	(0.790)			
Firm Owner Female	0.413	0.423	0.452	0.860	0.518	0.611
	(0.493)	(0.495)	(0.499)			
Owner Did Not Go to School	0.615	0.601	0.627	0.764	0.820	0.573
	(0.487)	(0.491)	(0.485)			
Hours Firm Owner Works (per day)	10.899	9.984	10.052	0.074*	0.137	0.897
	(5.372)	(5.607)	(5.428)			
Observations	247	248	252			

Notes. This table reports summary statistics and balance tests for main outcome variables and firm characteristics at baseline. The value displayed for t-tests are p-values. Standard errors are clustered at the local community level. Last Month Revenue and Profit are reported in FCFA. Value of Inventory and Value of Sales are for the two most commonly sold items at the store and are reported in FCFA. Employees Did Not Show is an indicator variable that takes the value of one if an employee did not show up to work in the last month. Neighborhood Flood Probability and Firm Flood Probability are measured out a 20, with 20 representing the respondents belief that it will flood in the next rainy season. Remotely Sensed Flood Risk is measured out of four where four represented very high flood risk. Firm Raised up from Street is an indicator variable for the firm entrance being above street level. Stock on the Fround is measured out of four where four is all of the firms stock is on the ground. Firm Owner Female and Owner Did Not Go to School are indicator variables that are one if the firm owner is female or did not go to school, respectively. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The p-value on the joint test for orthogonality of all variables is 0.1113. The p-value on the joint test for orthogonality following Kerwin et al. (2024) is 0.4740.

Table A.4. Differential Attrition Across Treatment Arms

	(1) Firm Not in Endline Survey
Individual Choice	-0.012
	(0.019)
Community Choice	-0.013
	(0.019)
Observations	747
Adjusted R^2	-0.002

Notes. This table reports results of a regression that tests for differential attrition across treatment arms. Firm Not in Endline Survey is an indicator variable that takes the value of one if a firm attrited for any reason. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5. Characteristics of Attrition

	(1) Firm Not in Endline Survey
Number of Workers	0.007
	(0.016)
Location Size (m^2)	0.001
	(0.001)
Years in Operation	0.001
	(0.001)
Last Month Revenue	0.000
	(0.000)
Last Month Profit	0.000*
	(0.000)
Rent (per m^2)	0.000
	(0.000)
Customer Entrances per day	-0.001
	(0.001)
Transactions per day	0.000
	(0.001)
Hours Open per day	0.001
	(0.003)
Missing Products for Clients	0.004**
	(0.002)
Value of Inventory	0.000
	(0.000)
Value of Sales	0.000
	(0.000)
Employees Did Not Show	-0.077***
	(0.023)
Neighborhood Flood Prob. (20)	-0.001
	(0.001)
Firm Flood Prob. (20)	0.000
	(0.001)
Remotely Sensed Flood Risk (4)	-0.000
	(0.006)
Firm Raised up from Street	0.009
	(0.016)
Number of Shelves	-0.004*
	(0.002)
Stock on the Ground (4)	-0.003
	(0.012)
Firm Owner Female	0.001
	(0.020)
Owner Did Not Go to School	-0.024
	(0.015)
Hours Firm Owner Works (per day)	-0.001
	(0.002)
Observations	747
Adjusted R^2	0.004

Notes. This table reports results of a regression that tests for differential attrition by characteristics of the firm at baseline. Last Month Revenue and Profit are reported in FCFA. Value of Inventory and Value of Sales are for the two most commonly sold items at the store and are reported in FCFA. Employees Did Not Show is an indicator variable that takes the value of one if an employee did not show up to work in the last month. Neighborhood Flood Probability and Firm Flood Probability are measured out a 20, with 20 representing the respondents belief that it will flood in the next rainy season. Remotely sensed flood risk is measured out of four where four represented very high flood risk. Firm Raised up from Street is an indicator variable for the firm entrance being above street level. Stock on the Ground is measured out of four where four is all of the firms stock is on the ground. Firm Owner Female and Owner Did Not Go to School are indicator variables that are one if the firm owner is female or did not go to school, respectively. Firm Not in Endline Survey is an indicator variable that takes the value of one if a firm attrited for any reason. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B Additional Results and Robustness Tables

Table B.1. Observed Measures of Firm Adaptation Estimation Results

	(1) Raised Up From the Street	(2) Centimeters Above the Street	(3) Number of Wooden Pallets	(4) Number of Shelves
Individual Choice	0.005	6.944**	0.103	-0.552
	(0.054)	(2.887)	(0.136)	(0.338)
	[0.048]	[2.924]	[0.129]	[0.198]
	{0.999}	{0.227}	{0.971}	{0.660}
	⟨0.718⟩	⟨0.033⟩	⟨0.403⟩	⟨0.167⟩
Community Choice	-0.099*	2.391	0.035	-0.606
	(0.059)	(3.847)	(0.183)	(0.413)
	[0.056]	[3.512]	[0.190]	[0.354]
	{0.658}	{0.977}	{0.999}	{0.732}
	⟨0.148⟩	⟨0.457⟩	⟨0.718⟩	⟨0.180⟩
Control Group Mean	0.799	15.24	0.782	5.761
Individual = Community	0.0932	0.250	0.713	0.894
Strata FE	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No
Observations	714	714	714	714
Adjusted R^2	0.0313	0.0359	0.0302	0.0140

Notes. Raised Up From the Street is an indicator variable that takes the value of one if the entrance to a firm is above the level of the street while Centimeters Above the Street measures how far above the street the entrance to the firm is. Number of Wooden Pallets and Number of Shelves measure the observed number of wooden pallets and shelves in the firm. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. Conley standard errors that allow for spatial correlation up to 500 meters are in square brackets. Area wise error-rate adjusted p-values following Westfall et al. (1993) are in curly brackets while the angle brackets report sharpened q-values following Anderson (2008). Stars reported based on clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.2. New or Improve Existing Builds Results

	(1) New Build	(2) Improve Existing Build
Individual Choice	0.015	0.009
	(0.187)	(0.182)
Community Choice	0.343*	-0.257
	(0.177)	(0.171)
Control Group Mean	0.316	0.526
Individual = Community	0.0189	0.0514
Strata FE	Yes	Yes
ANCOVA	No	No
Observations	145	145
Adjusted R^2	0.00936	-0.00858

Notes. New Barrier is an indicator variable that takes the value of one if the firm built a new structure between July 2024 and December 2024. Improve Barrier is an indicator variable that takes the value of one if the firm reinforced or improved an exisiting structure between July 2024 and December 2024. Regressions consider only the sample of people who report building something between July 2024 and December 2024. All regressions include controls for years in operation, self assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.3. What Firms Built Results

	(1) Cement Slab	(2) Small Lip	(3) External Barrier	(4) Floor	(5) Steps	(6) Roof	(7) Bricks
Individual Choice	0.099	-0.099	-0.049	0.062	0.013	-0.057	0.030
	(0.150)	(0.120)	(0.060)	(0.077)	(0.115)	(0.058)	(0.038)
Community Choice	0.020	-0.114	-0.015	0.003	-0.014	-0.058	0.177**
	(0.140)	(0.119)	(0.079)	(0.080)	(0.130)	(0.064)	(0.070)
Control Group Mean	0.263	0.263	0.0526	0.105	0.211	0.105	0
Individual = Community	0.495	0.893	0.428	0.504	0.808	0.969	0.0302
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No	No
Observations	145	145	145	145	145	145	145
Adjusted R^2	0.00939	0.0186	-0.0101	-0.0116	-0.0180	-0.00699	0.0494

Notes. All outcome variables are indicator variables that take teh value of one if the firm built or improved that part of their firm's structure between July 2024 and December 2024. Small lip refers to a small cement lip in a doorway that people step over to enter the firm. External barrier is some cement barrier outside of the firm. Cement slap is the cement slab that the firm sits on or is a cement slab in front of the firm. Bricks are cement bricks placed outside the entrance to the firm but they are not fully connecting in a cohesive structure. Regressions consider only the sample of people who report building something between July 2024 and December 2024. All regressions include controls for years in operation, self assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.4. Flooding of the Streets Around the Firm Regression Results

	(1) Flood in Area Around the Firm	(2) Number of Area Floods	(3) Duration of Average Area Flood
Individual Choice	0.027	-0.467	-0.563
	(0.052)	(0.455)	(0.475)
	[0.043]	[0.429]	[0.498]
	{0.861}	{0.724}	{0.696}
	⟨0.065⟩	⟨0.068⟩	⟨0.076⟩
Community Choice	0.084	-0.418	-0.185
	(0.057)	(0.626)	(0.557)
	[0.054]	[0.633]	[0.606]
	{0.549}	{0.850}	{0.861}
	⟨0.065⟩	⟨0.068⟩	⟨0.076⟩
Control Group Mean	0.752	3.338	1.902
Individual = Community	0.244	0.937	0.514
Strata FE	Yes	Yes	Yes
ANCOVA	No	No	No
Observations	714	714	714
Adjusted R^2	0.0757	0.129	0.148

Notes. Flood in Area Around the Firm is an indicator variable that takes the value of one if the streets around the firm flooded between July 2024 and December 2024. Number of Area Floods is the number of times the streets around the firm flooded between July 2024 and December 2024 while Duration of Average Area Flood is the number of days the average flooding in the streets around the firm lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. Conley standard errors that allow for spatial correlation up to 500 meters are in square brackets. Area wise error-rate adjusted p-values following Westfall et al. (1993) are in curly brackets while the angle brackets report sharpened q-values following Anderson (2008). Stars reported based on clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.5. Observed Measures of Firm Adaptation ANCOVA Estimation Results

	(1) Raised Up From the Street	(2) Centimeters Above the Street	(3) Number of Wooden Pallets	(4) Number of Shelves
Individual Choice	0.003	6.756**	0.103	-0.445
	(0.055)	(2.804)	(0.136)	(0.307)
Community Choice	-0.103*	2.878	0.035	-0.606*
	(0.059)	(3.858)	(0.183)	(0.362)
Control Group Mean	0.799	15.24	0.782	5.761
Individual = Community	0.0848	0.314	0.713	0.628
Strata FE	Yes	Yes	Yes	Yes
ANCOVA	Yes	Yes	No	Yes
Observations	714	714	714	714
Adjusted R^2	0.0306	0.0487	0.0302	0.197

Notes. Raised Up From the Street is an indicator variable that takes the value of one if the entrance to a firm is above the level of the street while Centimeters Above the Street measures how far above the street the entrance to the firm is. Number of Wooden Pallets and Number of Shelves measure the observed number of wooden pallets and shelves in the firm. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.6. Firm Flooding ANCOVA Regression Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	0.008	-0.087	-0.074
	(0.038)	(0.135)	(0.071)
Community Choice	-0.047	-0.334	-0.217
	(0.054)	(0.215)	(0.166)
Control Group Mean	0.132	0.415	0.167
Individual = Community	0.275	0.196	0.272
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	714	714	714
Adjusted R^2	0.0541	0.0414	0.0917

Notes. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.7. Firm Flood Damage ANCOVA Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	7088.552	-0.079*	0.049
	(4380.876)	(0.042)	(0.227)
Community Choice	-9354.831*	-0.095**	-0.386**
	(5213.762)	(0.047)	(0.185)
Control Group Mean	7908.1	0.205	0.372
Individual = Community	0.0143	0.728	0.0934
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	711	714	714
Adjusted R^2	0.0118	0.0445	0.00454

Notes. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.8. Firm Performance ANCOVA Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.015	10.840***	8.254**	-146278.116***	-26481.236*	-4637.136
	(0.010)	(3.884)	(3.300)	(50598.846)	(15215.653)	(4803.317)
Community Choice	-0.019	6.013	5.199	-25184.061	-5029.324	1446.942
	(0.013)	(4.203)	(3.398)	(60769.910)	(16627.714)	(7228.371)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
Individual = Community	0.768	0.296	0.418	0.0264	0.177	0.283
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	729	729	729	727	718	729
Adjusted R^2	-0.00450	0.166	0.159	0.166	0.0813	0.0478

Notes. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.9. Firm Investment Decisions Lee Bounds Estimation Results

	(1) Made Any Investment	(2) Built Something	(3) New Wooden Pallets	(4) New Shelves
Individual Upper	0.271***	0.219***	0.083***	-0.001
	(0.054)	(0.045)	(0.030)	(0.034)
Individual Choice	0.263***	0.216***	0.081***	-0.001
	(0.053)	(0.045)	(0.029)	(0.034)
Individual Lower	0.253***	0.206***	0.071**	-0.008
	(0.052)	(0.045)	(0.028)	(0.033)
Community Upper	0.218***	0.154**	0.037	-0.005
	(0.060)	(0.056)	(0.035)	(0.041)
Community Choice	0.213***	0.150***	0.035	-0.006
	(0.061)	(0.056)	(0.035)	(0.041)
Community Lower	0.202***	0.141***	0.025	-0.023
	(0.060)	(0.055)	(0.030)	(0.041)
Strata FE	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No

Notes. This table reports Lee Bounds measuring the impact of treatment on firm investment decisions at endline. Upper and Lower designate the upper and lower Lee bound estimates following Lee (2009). Made Any Investment is an indicator variable that takes the value of one if a firm built or improved part of their firm structure, got new wooden pallets, or got new shelves. Built Something is an indicator variable that takes the value of one if a firm built a new part of the structure or if they improved part of the structure. New Wooden Pallets and New Shelves are indicator variables that take the value of one if a firm got new wooden pallets or new shelves, respectively. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.10. Firm Flooding Lee Bounds Estimation Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Upper	0.011	-0.067	-0.059
	(0.041)	(0.139)	(0.076)
Individual Choice	0.009	-0.071	-0.061
	(0.041)	(0.139)	(0.075)
Individual Lower	0.004	-0.057	-0.013
	(0.039)	(0.127)	(0.049)
Community Upper	-0.055	-0.350	-0.236
	(0.057)	(0.217)	(0.164)
Community Choice	-0.057	-0.358*	-0.235
	(0.056)	(0.216)	(0.170)
Community Lower	-0.070	-0.477**	-0.297*
	(0.056)	(0.208)	(0.164)
Strata FE	Yes	Yes	Yes
ANCOVA	No	No	No

Notes. This table reports of results of Lee bounds estimations measuring the impact of treatment on firm flooding at endline. Upper and Lower designate the upper and lower Lee bound estimates following Lee (2009). Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.11. Firm Flood Damage Lee Bounds Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Upper	7158.819	-0.070	0.063
	(4429.456)	(0.044)	(0.228)
Individual Choice	6907.376	-0.073	0.052
	(4484.729)	(0.045)	(0.225)
Individual Lower	257.530	-0.087**	-0.134
	(2640.538)	(0.044)	(0.083)
Community Upper	-12604.924**	-0.089*	-0.379**
	(5322.178)	(0.047)	(0.189)
Community Choice	-10174.602*	-0.090*	-0.386**
	(5402.219)	(0.047)	(0.185)
Community Lower	-10182.533*	-0.095*	-0.469***
	(5582.426)	(0.048)	(0.177)
Strata FE	Yes	Yes	Yes
ANCOVA	No	No	No

Notes. This table reports results of Lee bounds estimations measuring the impact of treatment on firm flood damage at endline. Upper and Lower designate the upper and lower Lee bound estimates following Lee (2009). Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.12. Firm Performance Lee Bounds Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Upper	-0.016	6.941**	6.256**	-132002.686*	-21704.130	-3958.337
	(0.010)	(3.291)	(3.031)	(57363.888)	(15272.457)	(4787.600)
Individual Choice	-0.016	9.033**	6.818**	-138546.929**	-25356.332	-4365.549
	(0.010)	(3.898)	(3.359)	(57644.973)	(15510.526)	(4862.439)
Individual Lower	-0.018*	5.662*	4.757	-157934.290**	-33745.820*	-5478.549
	(0.009)	(3.152)	(3.042)	(58076.164)	(14815.209)	(4421.510)
Community Upper	-0.018	4.975	4.431	-9312.363	7166.474	1592.033
	(0.013)	(4.048)	(3.526)	(62161.357)	(16919.186)	(7089.861)
Community Choice	-0.018	4.989	4.331	-20816.651	-637.199	1179.373
	(0.013)	(4.695)	(3.832)	(62831.587)	(17145.471)	(7201.805)
Community Lower	-0.024**	2.907	3.071	-29185.440	-10972.826	-3767.072
	(0.011)	(3.894)	(3.471)	(61828.696)	(16265.867)	(6049.866)
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No

Notes. This table reports results of Lee bounds estimations measuring the impact of treatment on firm performance measures at endline. Upper and Lower designate the upper and lower Lee bound estimates following Lee (2009). Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.13. Firm Investment Decisions Borusyak and Hull Estimation Results

	(1) Made Any Investment	(2) Built Something	(3) New Wooden Pallets	(4) New Shelves
Individual Choice	0.234***	0.193***	0.075**	-0.012
	(0.050)	(0.043)	(0.030)	(0.034)
Community Choice	0.225***	0.159***	0.039	-0.001
	(0.061)	(0.055)	(0.036)	(0.042)
Control Group Mean	0.138	0.0792	0.0208	0.0792
Individual = Community	0.884	0.558	0.363	0.758
Strata FE	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No
Observations	729	729	729	729
Adjusted R^2	0.0832	0.0654	0.0323	0.0115

Notes. This table reports results of regressions measuring the impact of treatment on firm investment decisions at endline including controls for the average number of firms assigned to each treatment group across 2,000 bootstrap replications following Borusyak and Hull (2023). Made Any Investment is an indicator variable that takes the value of one if a firm built or improved part of their firm structure, got new wooden pallets, or got new shelves. Built Something is an indicator variable that takes the value of one if a firm built a new part of the structure or if they improved part of the structure. New Wooden Pallets and New Shelves are indicator variables that take the value of one if a firm got new wooden pallets or new shelves, respectively. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.14. Firm Flooding Borusyak and Hull Regression Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	-0.002	-0.158	-0.095
	(0.039)	(0.129)	(0.076)
Community Choice	-0.041	-0.284	-0.201
	(0.054)	(0.205)	(0.164)
Control Group Mean	0.132	0.415	0.167
Individual = Community	0.447	0.477	0.424
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	714	714	714
Adjusted R^2	0.0560	0.101	0.0794

Notes. This table reports results of regressions measuring the impact of treatment on firm flooding at endline including controls for the average number of firms assigned to each treatment group across 2,000 bootstrap replications following Borusyak and Hull (2023). Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.15. Firm Flood Damage Borusyak and Hull Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	6473.728	-0.085*	0.024
	(4353.415)	(0.043)	(0.235)
Community Choice	-8703.931*	-0.090*	-0.367**
	(4891.887)	(0.047)	(0.181)
Control Group Mean	7908.1	0.205	0.372
Individual = Community	0.0104	0.927	0.134
Strata FE	Yes	Yes	Yes
ANCOVA	No	No	No
Observations	711	714	714
Adjusted R^2	0.0106	0.0441	0.00349

Notes. This table reports results of regressions measuring the impact of treatment on firm flood damage at endline including controls for the average number of firms assigned to each treatment group across 2,000 bootstrap replications following Borusyak and Hull (2023). Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.16. Firm Performance Borusyak and Hull Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.014	11.538***	8.850***	-141349.784***	-23742.469	-3585.552
	(0.009)	(3.943)	(3.354)	(51147.727)	(15459.125)	(4873.657)
Community Choice	-0.018	5.521	4.831	-23561.943	-5653.229	1139.579
	(0.012)	(4.136)	(3.362)	(61548.240)	(16709.643)	(7403.258)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
Individual = Community	0.700	0.210	0.307	0.0319	0.268	0.428
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	729	729	729	727	718	729
Adjusted R^2	-0.00594	0.167	0.159	0.165	0.0822	0.0485

Notes. This table reports results of regressions measuring the impact of treatment on firm performance measures at endline including controls for the average number of firms assigned to each treatment group across 2,000 bootstrap replications following Borusyak and Hull (2023). Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.17. First Stage IV Results

	(1) Any Investment	(2) Any Investment	(3) Any Investment
Individual Choice	0.264***	0.258***	
	(0.053)	(0.055)	
Community Choice	0.211***		0.232***
	(0.061)		(0.079)
Effective F Statistic	12.58	21.16	8.79
10% Critical Value	5.58	23.11	23.11
Strata FE	Yes	Yes	Yes
Sample	Yes	Yes	Yes
ANCOVA	All	Control and Individual	Control and Community
Observations	729	483	486

Notes. Column one presents results for any investment made by the firm on the whole sample. Columns two and three present results for the subest of the control group and either the individual choice or community chioce treatment group, respecitively. Effective F Statistic and 10% Critical Value reports the effective F statistic and the 10 percent critical values from Olea and Pflueger (2013) to test for weak instruments. All regressions include controls for years in operation, self assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.18. Firm Flooding IV Regression Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Any Investment	-0.021	-0.617	-0.413
	(0.143)	(0.540)	(0.369)
Control Group Mean	0.132	0.415	0.167
ANCOVA	Yes	Yes	Yes
Observations	714	714	714

Notes. I instrument for firms making an investment using randomized treatment assignment. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.19. Firm Flooding IV Regression Results - Interaction with Local Community

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Any Investment	0.028	-0.421	-0.263
	(0.146)	(0.488)	(0.281)
Any Investment x Community	-0.137	-0.562	-0.439
	(0.124)	(0.433)	(0.344)
Control Group Mean	0.132	0.415	0.167
ANCOVA	Yes	Yes	Yes
Observations	714	714	714

Notes. I instrument for firms making an investment using randomized treatment assignment. Any Invesment x Community interacts the predicted investment from the first stage with assigment to the community choice treatment group. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.20. Firm Flooding IV Regression Results - Subsets

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood	(4) Firm Flooded	(5) Number of Times the Firm Flooded	(6) Duration of Average Firm Flood
Any Investment	-0.110	-1.179*	-0.785*	0.177	0.661	0.294
	(0.176)	(0.650)	(0.460)	(0.216)	(0.839)	(0.362)
Control Group Mean	0.132	0.415	0.167	0.132	0.415	0.167
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Individual	Individual	Individual	Community	Community	Community
Observations	472	472	472	476	476	476

Notes. Columns one to three present results for the subset of the control group and the individual choice treatment group while columns four to six present results for the subset of the control group and the community choice treatment group. I instrument for firms making an investment using randomized treatment assignment. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.21. Firm Flood Damage IV Estimation Results - Interaction with Local Community

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Any Investment	26296.067	-0.290*	0.195
	(16506.589)	(0.160)	(0.844)
Any Investment x Community	-38419.824**	-0.111	-1.151**
	(15866.040)	(0.104)	(0.556)
Control Group Mean	7908.1	0.205	0.372
ANCOVA	Yes	Yes	Yes
Observations	711	714	714

Notes. I instrument for firms making an investment using randomized treatment assignment. Any Invesment x Community interacts the predicted investment from the first stage with assigment to the community choice treatment group. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.22. Firm Flood Damage IV Estimation Results - Subsets

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure	(4) Flood Losses (FCFA)	(5) Firm Closed Due to Flood	(6) Length of Firm Closure
Any Investment	33642.188	-0.302	-0.034	-32237.701	-0.073	-0.437
	(26167.630)	(0.195)	(1.004)	(32941.481)	(0.295)	(0.713)
Control Group Mean	7908.1	0.205	0.372	7908.1	0.205	0.372
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Sample	Individual	Individual	Individual	Community	Community	Community
Observations	469	472	472	476	476	476

Notes. Columns one to three present results for the subset of the control group and the individual choice treatment group while columns four to six present results for the subset of the control group and the community choice treatment group. I instrument for firms making an investment using randomized treatment assignment. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.23. Firm Performance IV Estimation Results - Interaction with Local Community

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Any Investment	-0.058	40.758***	31.082**	-565297.834***	-105480.580*	-18600.116
	(0.036)	(14.677)	(12.460)	(191361.886)	(57874.316)	(18293.878)
Any Investment x Community	-0.018	-6.199	-3.198	270953.445**	55774.868	16280.483
	(0.023)	(10.388)	(8.496)	(132309.167)	(37401.999)	(14048.003)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	729	729	729	727	718	729

Notes. I instrument for firms making an investment using randomized treatment assignment. Any Invesment x Community interacts the predicted investment from the first stage with assigment to the community choice treatment group. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.24. Firm Performance IV Estimation Results - Individual Subset

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Any Investment	-0.063	47.076**	37.487**	-528227.760**	-105753.874*	-33812.976
	(0.042)	(21.314)	(17.692)	(208741.222)	(55267.686)	(20907.738)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	483	483	483	481	473	483

Notes. This table reports results of IV regressions measuring the impact of investment on firm performance measures at endline for the subset of firms assigned to the control or the individual choice treatment group. I instrument for firms making an investment using randomized treatment assignment. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

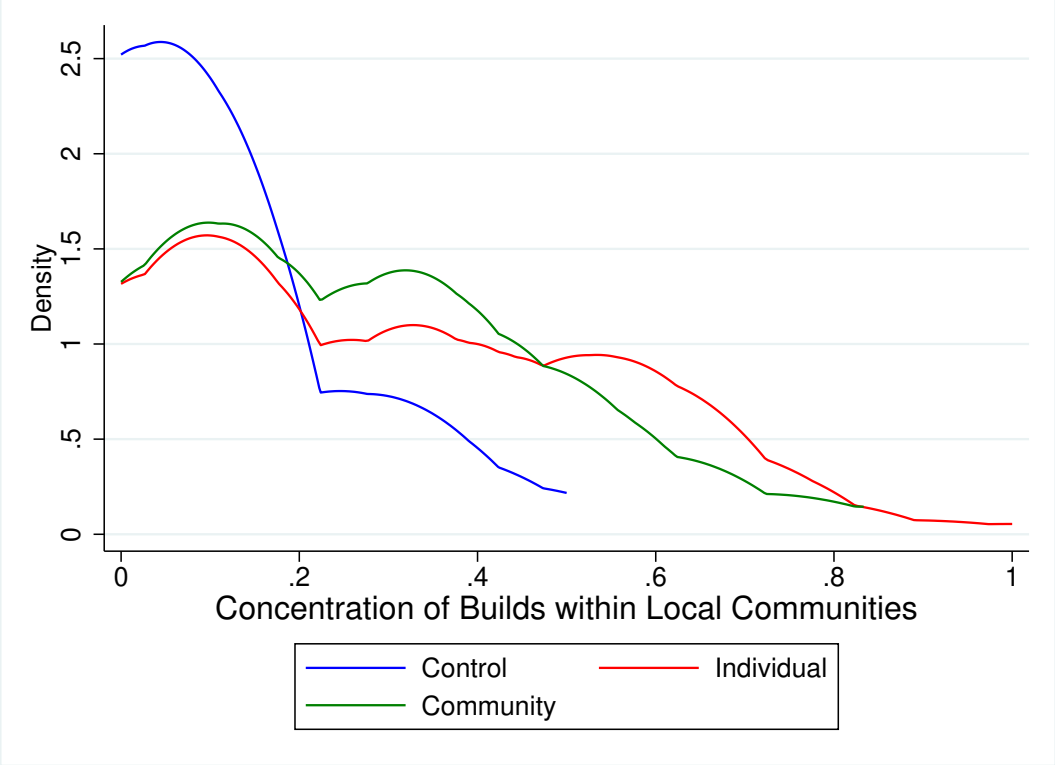
Table B.25. Firm Performance IV Estimation Results - Community Subset

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Any Investment	-0.104	-10.670	-1.971	-46835.318	-83088.089	-1307.667
	(0.105)	(23.567)	(18.617)	(341444.391)	(85101.072)	(34218.376)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	486	486	486	485	477	486

Notes. This table reports results of IV regressions measuring the impact of investment on firm performance measures at endline for the subset of firms assigned to the control or the community choice treatment group. I instrument for firms making an investment using randomized treatment assignment. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, the average distance between firms in their local community, and if the firm was surveyed by an enumerator new to the study at endline. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C Heterogeneity Analysis Figure and Tables

Figure C.1. Concentration of Firms Building within Local Communities by Treatment Arm



Notes: This figure plots the kernel density plot of the concentration of the number of firms within a local community that built a new barrier or improved an existing barrier at endline. The concentration is defined as the number of firms that build in a local community divided by the number of firms in that local community.

Table C.1. Firm Flooding Heterogeneity by Local Community Builds Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	-0.048	-0.301**	-0.194*
	(0.048)	(0.150)	(0.109)
Community Choice	-0.085	-0.467**	-0.290*
	(0.056)	(0.213)	(0.167)
Above Median Builds	0.127**	0.428**	0.288**
	(0.062)	(0.201)	(0.136)
Community x Above Median Builds	-0.029	-0.023	-0.106
	(0.075)	(0.259)	(0.145)
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	714	714	714
Adjusted R^2	0.0668	0.109	0.0902

Notes. Above Median Builds is an indicator that take the value of one if that treated local community had above the median concentration of firms who built something between baseline and endline. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.2. Firm Flood Damage Heterogeneity by Local Community Builds Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	4139.327	-0.118**	-0.015
	(4764.511)	(0.047)	(0.313)
Community Choice	-11380.953**	-0.144***	-0.531***
	(5680.120)	(0.048)	(0.190)
Above Median Builds	6831.819	0.082	0.116
	(7176.984)	(0.050)	(0.268)
Community x Above Median Builds	-1705.925	0.035	0.222
	(8342.661)	(0.073)	(0.252)
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	711	714	714
Adjusted R^2	0.0111	0.0523	0.00586

Notes. Above Median Builds is an indicator that take the value of one if that treated local community had above the median concentration of firms who built something between baseline and endline. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.3. Firm Performance Heterogeneity by Local Community Builds Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.014	17.429***	13.829***	-110179.741**	-9983.375	-189.454
	(0.011)	(4.373)	(3.764)	(53372.239)	(16337.612)	(5507.833)
Community Choice	-0.025**	5.819	4.831	23314.969	5617.620	-1199.389
	(0.012)	(4.642)	(3.643)	(72905.835)	(19240.683)	(6503.080)
Above Median Builds	-0.005	-16.032***	-13.635***	-74165.154	-36800.204***	-11404.300**
	(0.007)	(4.343)	(3.858)	(46321.974)	(13727.037)	(5487.964)
Community x Above Median Builds	0.018	14.799**	13.030**	-41456.206	9538.275	16043.248
	(0.013)	(6.516)	(5.583)	(76280.388)	(22273.206)	(9715.960)
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	729	729	729	727	718	729
Adjusted R^2	-0.00575	0.187	0.179	0.171	0.0923	0.0519

Notes. Above Median Builds is an indicator that take the value of one if that treated local community had above the median concentration of firms who built something between baseline and endline. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

D Additional Spillover Tables

Table D.1. Voucher Choices and Investment Decisions Spillover Estimation Results

	(1) Individually Prefer Cement	(2) Redeemed Voucher	(3) Made Any Investment	(4) Built Something	(5) New Wooden Pallets	(6) New Shelves
Individual Choice			0.160***	0.128**	0.064*	-0.057
			(0.060)	(0.052)	(0.038)	(0.037)
Individual Firms Nearby	0.013**	0.018**	0.018***	0.015***	0.003	0.010***
	(0.006)	(0.009)	(0.005)	(0.005)	(0.003)	(0.003)
Community Choice	-0.079	0.117	0.190***	0.142**	0.026	-0.021
	(0.078)	(0.102)	(0.063)	(0.060)	(0.032)	(0.043)
Community Firms Nearby	0.016	0.019**	0.006	0.002	0.003	0.004
	(0.010)	(0.009)	(0.008)	(0.006)	(0.005)	(0.005)
Control Group Mean			0.138	0.0792	0.0208	0.0792
Individual Group Mean	0.840	0.661				
Individual = Community			0.682	0.827	0.378	0.440
Individual = I. Nearby			0.025	0.041	0.133	0.091
Community = C. Nearby	0.250	0.363	0.006	0.025	0.481	0.569
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	471	500	729	729	729	729
Adjusted R^2	0.0166	0.0574	0.0787	0.0633	0.0308	0.0156

Notes. Columns 1 and 2 only consider the individual choice and community choice treatment groups while columns 3 - 6 consider the entire sample. Individually Prefer Cement is an indicator variable that takes the value of one if a firm in the individual choice treatment arm selected cement or if a firm in the community choice treatment arm preferred a cement voucher when asked individually. Redeemed Voucher is an indicator variable that takes the value of one if a firm redeems their voucher. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms Nearby is the number of firms assigned to the community choice treatment group within 200 meters. Made Any Investment is an indicator variable that takes the value of one if a firm built or improved part of their firm structure, got new wooden pallets, or got new shelves. Built Something is an indicator variable that takes the value of one if a firm built a new part of the structure or if they improved part of the structure. New Wooden Pallets and New Shelves are indicator variables that take the value of one if a firm got new wooden pallets or new shelves, respectively. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Individual = I. Nearby reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the count of individual choice treatment firms within 200 meters. Community = C. Nearby is the p-value of the same test for the community choice treatment group. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.2. Firm Performance Spillover Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.005	9.174**	6.352	-125931.413**	-17527.705	-450.461
	(0.010)	(4.564)	(3.934)	(57189.428)	(17184.131)	(5554.818)
Individual Firms Nearby	-0.002*	0.289	0.331	-3505.745	-1529.660	-721.283
	(0.001)	(0.360)	(0.323)	(5015.047)	(1418.368)	(471.014)
Community Choice	-0.023	7.789*	7.019*	-39198.619	-2215.388	129.078
	(0.019)	(4.445)	(3.623)	(63296.119)	(18120.719)	(7823.747)
Community Firms Nearby	0.001	-0.531	-0.544	4241.168	-784.812	412.884
	(0.003)	(0.420)	(0.343)	(6114.537)	(2063.398)	(895.750)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
Individual = Community	0.288	0.795	0.880	0.174	0.437	0.934
Individual = I. Nearby	0.719	0.064	0.146	0.042	0.373	0.963
Community = C. Nearby	0.273	0.073	0.046	0.507	0.940	0.972
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	729	729	729	727	718	729
Adjusted R^2	-0.00264	0.167	0.162	0.165	0.0809	0.0494

Notes. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms Nearby is the number of firms assigned to the community choice treatment group within 200 meters. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Individual = Community reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the community choice treatment group. Individual = I. Nearby reports the p-value of the test that the coefficient for the individual choice treatment group is equal to the coefficient for the count of individual choice treatment firms within 200 meters. Community = C. Nearby is the p-value of the same test for the community choice treatment group. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.3. Voucher Choices and Investment Decisions Spillover Complete Estimation Results

	(1) Individually Prefer Cement	(2) Redeemed Voucher	(3) Made Any Investment	(4) Built Something	(5) New Wooden Pallets	(6) New Shelves
Individual Choice			0.160***	0.128**	0.064*	-0.057
			(0.060)	(0.052)	(0.038)	(0.038)
Individual Firms Nearby Uphill	0.011*	0.017*	0.020***	0.015**	0.002	0.011**
	(0.007)	(0.010)	(0.007)	(0.007)	(0.005)	(0.005)
Individual Firms Nearby Downhill	0.014**	0.018	0.015**	0.015**	0.004	0.008*
	(0.006)	(0.011)	(0.007)	(0.006)	(0.005)	(0.004)
Community Choice	-0.077	0.123	0.189***	0.142**	0.026	-0.022
	(0.078)	(0.103)	(0.063)	(0.060)	(0.032)	(0.043)
Community Firms Nearby Uphill	0.020**	0.030 ***	0.003	0.001	0.003	0.002
	(0.009)	(0.010)	(0.009)	(0.008)	(0.005)	(0.006)
Community Firms Nearby Downhill	0.012	0.008	0.011	0.003	0.002	0.007
	(0.013)	(0.012)	(0.011)	(0.008)	(0.008)	(0.006)
Control Group Mean			0.138	0.0792	0.0208	0.0792
Individual Group Mean	0.840	0.661				
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	471	500	729	729	729	729
Adjusted R^2	0.0139	0.0607	0.0772	0.0608	0.0282	0.0141

Notes. Columns 1 and 2 only consider the individual choice and community choice treatment groups while columns 3 - 6 consider the entire sample. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms Nearby is the number of firms assigned to the community choice treatment group within 200 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Individually Prefer Cement is an indicator variable that takes the value of one if a firm in the individual choice treatment arm selected cement or if a firm in the community choice treatment arm preferred a cement voucher when asked individually. Redeemed Voucher is an indicator variable that takes the value of one if a firm redeems their voucher. Made Any Investment is an indicator variable that takes the value of one if a firm built or improved part of their firm structure, got new wooden pallets, or got new shelves. Built Something is an indicator variable that takes the value of one if a firm built a new part of the structure or if they improved part of the structure. New Wooden Pallets and New Shelves are indicator variables that take the value of one if a firm got new wooden pallets or new shelves, respectively. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.4. Firm Flooding Spillover Complete Estimation Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	-0.043	-0.237	-0.180*
	(0.049)	(0.166)	(0.093)
Individual Firms Nearby Uphill	0.005	0.013	0.011
	(0.007)	(0.018)	(0.010)
Individual Firms Nearby Downhill	0.013**	0.032	0.029**
	(0.006)	(0.021)	(0.013)
Community Choice	-0.059	-0.380*	-0.277*
	(0.054)	(0.209)	(0.166)
Community Firms Nearby Uphill	0.007	0.014	0.025**
	(0.005)	(0.024)	(0.011)
Community Firms Nearby Downhill	-0.000	0.029	0.005
	(0.006)	(0.027)	(0.012)
Control Group Mean	0.132	0.415	0.167
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	714	714	714
Adjusted R^2	0.0578	0.0974	0.0830

Notes. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms Nearby is the number of firms assigned to the community choice treatment group within 200 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.5. Firm Performance Spillover Complete Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.005	9.282**	6.461	-124451.763**	-17437.595	-307.805
	(0.010)	(4.532)	(3.915)	(57342.292)	(17277.287)	(5507.628)
Individual Firms Nearby Uphill	-0.001	-0.255	-0.198	-10014.327*	-2042.290	-1274.867**
	(0.001)	(0.406)	(0.381)	(5993.313)	(1901.524)	(512.271)
Individual Firms Nearby Downhill	-0.002*	0.876	0.895*	3239.641	-1026.771	-126.437
	(0.001)	(0.547)	(0.482)	(6485.886)	(1689.047)	(595.438)
Community Choice	-0.023	7.846*	7.081*	-37425.040	-1964.942	237.082
	(0.019)	(4.407)	(3.608)	(63484.328)	(18065.155)	(7818.453)
Community Firms Nearby Uphill	0.000	-1.197**	-1.069**	5831.781	236.147	-50.673
	(0.003)	(0.554)	(0.446)	(8248.913)	(2432.626)	(938.820)
Community Firms Nearby Downhill	0.002	0.064	-0.096	1045.726	-1990.221	770.010
	(0.003)	(0.562)	(0.454)	(7169.735)	(2527.070)	(1002.564)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	729	729	729	727	718	729
Adjusted R^2	-0.00398	0.176	0.171	0.166	0.0796	0.0507

Notes. Individual Firms Nearby is the number of firms assigned to the individual choice treatment group within 200 meters while Community Firms Nearby is the number of firms assigned to the community choice treatment group within 200 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.6. Firm Investment Decisions (100m) Spillover Complete Estimation Results

	(1) Individually Prefer Cement	(2) Redeemed Voucher	(3) Made Any Investment	(4) Built Something	(5) New Wooden Pallets	(6) New Shelves
Individual Choice			0.201***	0.141**	0.116**	-0.032
			(0.067)	(0.058)	(0.045)	(0.039)
Indiv. Firms Nearby (100m) Uphill	0.026**	0.032**	0.020	0.025*	-0.014*	0.007
	(0.011)	(0.015)	(0.015)	(0.015)	(0.008)	(0.011)
Indiv. Firms Nearby (100m) Downhill	0.045***	0.055***	0.013	0.015	-0.004	0.010
	(0.012)	(0.018)	(0.015)	(0.016)	(0.010)	(0.009)
Community Choice	-0.125	0.130	0.166**	0.092	0.061	-0.041
	(0.087)	(0.107)	(0.073)	(0.066)	(0.043)	(0.046)
Com. Firms Nearby (100m) Uphill	0.066***	0.052**	0.010	0.013	-0.008	0.007
	(0.020)	(0.023)	(0.024)	(0.022)	(0.011)	(0.015)
Com. Firms Nearby (100m) Downhill	0.038*	0.017	0.019	0.022	-0.007	0.016
	(0.020)	(0.023)	(0.019)	(0.020)	(0.011)	(0.013)
Control Group Mean			0.138	0.0792	0.0208	0.0792
Individual Group Mean	0.840	0.661				
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	No	No	No	No	No	No
Observations	471	500	729	729	729	729
Adjusted R^2	0.0315	0.0604	0.0653	0.0546	0.0305	0.00496

Notes. Columns 1 and 2 only consider the individual choice and community choice treatment groups while columns 3 - 6 consider the entire sample. Indiv. Firms Nearby is the number of firms assigned to the individual choice treatment group within 100 meters while Com. Firms Nearby is the number of firms assigned to the community choice treatment group within 100 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Individually Prefer Cement is an indicator variable that takes the value of one if a firm in the individual choice treatment arm selected cement or if a firm in the community choice treatment arm preferred a cement voucher when asked individually. Redeemed Voucher is an indicator variable that takes the value of one if a firm redeems their voucher. Made Any Investment is an indicator variable that takes the value of one if a firm built or improved part of their firm structure, got new wooden pallets, or got new shelves. Built Something is an indicator variable that takes the value of one if a firm built a new part of the structure or if they improved part of the structure. New Wooden Pallets and New Shelves are indicator variables that take the value of one if a firm got new wooden pallets or new shelves, respectively. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.7. Firm Flooding Spillover (100m) Complete Estimation Results

	(1) Firm Flooded	(2) Number of Times the Firm Flooded	(3) Duration of Average Firm Flood
Individual Choice	-0.025	-0.200	-0.115
	(0.053)	(0.173)	(0.088)
Indiv. Firms Nearby (100m) Uphill	-0.004	-0.005	0.001
	(0.012)	(0.030)	(0.020)
Indiv. Firms Nearby (100m) Downhill	0.021	0.052	0.024
	(0.013)	(0.046)	(0.018)
Community Choice	-0.056	-0.386	-0.233
	(0.064)	(0.261)	(0.183)
Com. Firms Nearby (100m) Uphill	0.017	0.034	0.021
	(0.015)	(0.062)	(0.020)
Com. Firms Nearby (100m) Downhill	-0.015	0.015	-0.020
	(0.012)	(0.056)	(0.016)
Control Group Mean	0.132	0.415	0.167
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	714.0	714.0	714.0
Adjusted R^2	0.06	0.09	0.07

Notes. Indiv. Firms Nearby is the number of firms assigned to the individual choice treatment group within 100 meters while Com. Firms Nearby is the number of firms assigned to the community choice treatment group within 100 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Firm Flooded is an indicator variable that takes the value of one if the firm flooded between July 2024 and December 2024. Number of Times the Firm Flooded is the number of times the firm flooded between July 2024 and December 2024 while Duration of Average Firm Flood is the number of days the average firm flood lasted. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.8. Firm Flood Damage Spillover (100m) Complete Estimation Results

	(1) Flood Losses (FCFA)	(2) Firm Closed Due to Flood	(3) Length of Firm Closure
Individual Choice	7246.934	-0.104*	0.076
	(4267.837)	(0.049)	(0.279)
Indiv. Firms Nearby (100m) Uphill	-794.434	0.015	0.022
	(1545.736)	(0.013)	(0.043)
Indiv. Firms Nearby (100m) Downhill	783.992	-0.001	-0.032
	(2159.504)	(0.011)	(0.023)
Community Choice	-7322.247	-0.082	-0.213
	(4178.975)	(0.059)	(0.246)
Com. Firms Nearby (100m) Uphill	-741.981	-0.005	-0.062
	(1224.749)	(0.018)	(0.061)
Com. Firms Nearby (100m) Downhill	-682.607	-0.008	-0.062
	(1330.589)	(0.013)	(0.049)
Control Group Mean	7908.1	0.205	0.372
Strata FE	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes
Observations	711.0	714.0	714.0
Adjusted R^2	0.007	0.04	0.002

Notes. Indiv. Firms Nearby is the number of firms assigned to the individual choice treatment group within 100 meters while Com. Firms nearby is the number of firms assigned to the community choice treatment group within 100 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Flood Losses (FCFA) is the value of firm inventory losses due to flooding from July 2024 to December 2024. Firm Closed Due to Flood is an indicator variable that takes the value of one if a firm closed due to a flood between July and December 2024. Length of Firm Closure reports the number of days a firm closed due to a flood. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.9. Firm Performance Spillover (100m) Complete Estimation Results

	(1) Employees Don't Show	(2) Customer Entrances (per day)	(3) Customer Transactions (per day)	(4) Monthly Revenue (FCFA)	(5) Monthly Profit (FCFA)	(6) Value of Weekly Sales (FCFA)
Individual Choice	-0.010	9.280**	6.368	-140146.184**	-30293.146	-3892.728
	(0.011)	(4.588)	(4.080)	(58136.774)	(18385.190)	(6527.602)
Indiv. Firms Nearby (100m) Uphill	-0.001	-1.109	-0.711	-15560.719	-424.969	-590.841
	(0.001)	(0.853)	(0.765)	(11799.688)	(3951.030)	(1258.102)
Indiv. Firms Nearby (100m) Downhill	-0.002	2.064	1.826*	14077.652	2445.336	126.805
	(0.002)	(1.269)	(1.084)	(12822.895)	(3570.589)	(1265.096)
Community Choice	-0.035	7.140	5.691	23427.802	-5446.231	-1382.393
	(0.024)	(4.950)	(4.053)	(75225.731)	(22007.650)	(9427.271)
Com. Firms Nearby (100m) Uphill	0.000	-1.181	-0.940	-18275.174	2360.354	497.376
	(0.003)	(1.322)	(1.073)	(19529.885)	(6847.962)	(2700.002)
Com. Firms Nearby (100m) Downhill	0.013	0.318	0.497	-16176.736	-2689.773	1747.333
	(0.009)	(1.109)	(0.924)	(15482.939)	(5026.469)	(1901.982)
Control Group Mean	0.0208	43.92	35.62	548523.0	133693.1	35741.9
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes
ANCOVA	Yes	Yes	Yes	Yes	Yes	Yes
Observations	729.0	729.0	729.0	727.0	718.0	729.0
Adjusted R^2	0.008	0.2	0.2	0.2	0.08	0.04

Notes. Indiv. Firms Nearby is the number of firms assigned to the individual choice treatment group within 100 meters while Com. Firms Nearby is the number of firms assigned to the community choice treatment group within 100 meters. Uphill designates firms located uphill or higher in elevation relative to the firm of interest while downhill designates firms downhill or lower in elevation relative to the index firm. Employees Don't Show is an indicator variable that takes the value of one if an employee did not show up to work during the last month of the rainy season. Customer Entrances and Transactions (per day) are self-reported measures of the number of customer entrances and transactions per day during the last month of the rainy season. Monthly Revenue (FCFA) and Monthly Profit (FCFA) are self-reported monthly revenue and profit for the firm in the last month of the rainy season in FCFA. Value of Weekly Sales (FCFA) is the value of weekly sales for the two most frequently sold items in FCFA. All regressions include controls for years in operation, self-assessed neighborhood flood risk, owner work hours at baseline, distance to the nearest control, individual choice, and local community choice treatment firm, and the average distance between firms in their local community. Regressions marked Yes for ANCOVA include the baseline value of the outcome variable. Standard errors clustered at the local community level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.