Customer Training Externalities and Technology Adoption: A Field Experiment on Formal Savings in Mozambique

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Abstract

Lack of information has been found to be a important constraint to technology adoption. There is also evidence that interventions that alleviate this constraint, such as training, can increase take up of the technology and improve the well-being of the beneficiaries. It has been argued that the providers of new technology should play an important role in training because their incentives are aligned. and yet there is relatively little evidence of the private sector undertaking training or other initiative to tackle this information constraint. To explain this, we present a theoretical model that combines learning about a technology with competition among firms that provide it. The firms choose the location and intensity of training, which increase the expected benefits of the technology. However the additional demand generated by the training is shared with the competitors, creating a free-riding issue and an under-provision of training that is more accentuated when the competition increases. We test the predictions of the model using data from an experiment in rural Mozambique, where we partnered with a bank and randomly assigned treatments that include financial education and monetary encouragements to save. As predicted by the model, we find that, during the two years following the beginning of the programs, the savings interventions 1) increased consumption and wealth of the beneficiaries 2) increased the number of accounts and savings, not only at our partner bank but also at competitor banks 3) this spillover to competitors is stronger for clients who are closer to the competitor and farther from the partner bank 4) the partner bank benefited from the presence of competitors, which increased prior knowledge about savings accounts. This spillover to the competition provides a novel explanation for the slow diffusion of profitable technologies, and a rationale for public subsidy or collaboration in information provision among providers of a technology.

Keywords: technology adoption, information constraint, spillover, savings, Mozambique

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1 Introduction

Differences in technology are widely believed to explain cross-country differences in per capita GDP (Caselli and Coleman, 2001). Because an increase in the productivity of the poor through technology adoption is one of the drivers of poverty reduction, understanding the low adoption of such technologies has been the focus of attention for a number of researchers in development economics. Past work highlighted a number of constraints to technology adoption, including credit constraints (Gine and Klonner, 2005; Miyata and Sawada, 2007), risk (Moser and Barrett, 2006; Dercon and Christiaensen, 2007; Foster and Rosenzweig, 2009), or information imperfections which lead to a need for learning about new technologies.[1] The latter may take the form of poor knowledge about how to use it Foster and Rosenzweig (1995); Bandiera and Rasul (2006); Conley and Udry (2010), or about the magnitude of the gains from successfully implementing it Munshi (2006). Information constraints might be alleviated by, among other things, trainings that teach how to use the technology, and emphasize its benefits, or a targeted subsidy that allows the beneficiary to experiment the technology and learn about it. This paper's findings focus on trainings but could be applied to any intervention addressing the information constraints to the adoption of the technology.

Researchers and practitioners still have a long way to go in finding out how to address these constraints, and why some solutions that are found to be successful have rarely been implemented by the stakeholders. In agriculture, public extension workers have been given an important role in addressing these constraints. However, Anderson and Feder (2007) find that public agricultural extension workers are not very effective because they lack the incentives to deliver information. Since then the idea of giving this role to the private providers of the technologies gained prominence, because their incentives are better aligned. It seems that, at least in a number of cases, the cost of showing the benefits of the technology should be outweighed by the benefits of the use of the technology, and yet such training is not provided. In this paper, we provide a possible explanation for this phenomena. We show that when a private agent bears the cost of providing training to address the information constraint, his ability to internalize the benefits is reduced because the increase in the demand for the technology is shared with competitors. Hence in the absence of subsidy or coordination between the providers of the technology, this spillover results in free-riding and under-provision of trainings. We provide a theoretical model followed by a test of its implications, using the data of a field experiment in rural Mozambique, where the technology in question is the use of savings account.

[1] Foster and Rosenzweig (2010) review the technology adoption literature in economics.

The important role of savings in the financial management strategies of poor households has long been recognized. It is used as a buffer stocks for smoothing consumption in the face of shocks, and facilitates lump sum investments, such as in small enterprises, agriculture, education, or migration. Demirguc-Kunt and Klapper (2013) document that formal savings is strongly positively associated with income, in cross-country comparisons as well as across households within countries. There is an emerging body of evidence that formal savings does have positive causal impacts on development outcomes. Bruhn and Love (2009) find that bank branch openings by consumer durable stores in Mexico leads to increases in business ownership, employment, and income. Burgess and Pande (2005) show that the expansion of rural banking in India reduced rural poverty, and provide suggestive evidence that savings mobilization was an intermediate channel. Recent randomized controlled trials in developing countries also find positive impacts of treatments facilitating formal savings on productive investments, consumption, and ability to cope with shocks (for example Dupas and Robinson (2013a) and Dupas and Robinson (2013b) in Kenya, Prina (2013) in Nepal, and Brune et al. (2014) in Malawi). Our results show similar improvements resulting from our interventions that encourage the use of savings account by addressing information constraints. The purpose of this paper is to go beyond this positive effect of the training and understand why, despite its high economic benefits, its use by private actors remains limited.

The theoretical model combines a Hotelling's competition model with an endogenous willingness to pay, because consumers who initially underestimate the benefits of the technology. Hence the firms can provide training that will stimulate the learning and increase the willingness to pay of the consumers. Based on their beliefs, distances, and preferences, the potential consumers chose whether they consume the technology, and if they do so, from which firm. We first show that even in a situation of monopoly, the provision of training by the firm is below the social optimum because the clients' Willingness to Pay remains below the true benefit of the technology. Most importantly, the additional demand is spread with other firms that provide the same technology, which causes a free-riding issue and an under-provision of training that is accentuated by the presence and proximity of the competition. Being able to choose the location and intensity of trainings allows the provider to target clients most likely to obtain the technology from the provider, but as long as location is not the only determinant of which firm a client buys from, the spillover and free-riding still occur. Besides the endogenous willingness to pay, the inclusion of preferences as the non-observable determinants of the clients' choices is part of the innovation of our theoretical model.

The model leads to a number of testable predictions. First, because at equilibrium the amount of training is below its social optimum, the total benefits of the training must exceed its cost. Second, the trainings given by one provider of the technology should generate an increase in demand not only for the provider of the technology, but also for its competitors. Third the spillover to the competitor should be greater for clients who are located closer to the competitor and farther away from the provider of the training. Fourth, the model is consistent with a marginal effect of the training on the demand to its provider that increases with the proximity of competitors, benefiting from the fact that competitors increased prior willingness to pay. Finally, learning should be faster among clients with higher cognitive skills or education, hence this ability should have a positive effect on the impact of the training on the use of the technology.

We conducted a randomized controlled trial on formal savings and its impacts, and use it to test the predictions of the model. We partnered with a micro-finance bank (Banco Oportunidade de Mozambique, BOM) to randomly assign two different savings-promotion programs across 94 localities in rural Manica province, Mozambique. Localities were randomly assigned with equal probabilities to either a control group (that experienced no savings treatment), to an "information" treatment, or a "match" treatment. The information treatment involved a financial education program on how to use formal savings for asset accumulation, agricultural investment, and buffer stock purposes. The match treatment was identical to the information treatment, but additionally provided generous but temporary "savings matches" (essentially, very high interest rates.)[2] The matched savings treatment could be thought of as facilitating learning-by-doing about the benefits of formal savings, and, if effective, could be interpreted as alleviating information constraints. Studies on IDAs include Boshara (2005), Schreiner and Sherraden (2007), Sherraden and McBride (2010), Sherraden (1988), Sherraden (1991), Grinstein-Weiss et al. (2013b), Grinstein-Weiss et al. (2013a). See also Ambler et al. (forthcoming) and Karlan and List (2007) on matching in different contexts. Research on matching programs and tax credits for saving is also related; Duflo et al. (2006) find positive effects of savings matching programs on savings.

In a separate randomization, conducted in collaboration with the Manica provincial government some months earlier, individual study participants within each of the 94 localities were randomized (with 50% probability) into receiving a subsidy voucher for 72% of the value of a package of modern agricultural inputs. These randomizations yield a 2x3 experimental design, as depicted in Table 1. A

[2]Specifically, this treatment involved offering matching funds of 50% of the minimum balance held between August 1 and October 31. The matches were provided during this period in 2011 and 2012.

"pure control" group consists of individuals in the control localities (vis-a-vis the savings treatments) who did not receive the input subsidy voucher. Other treatment conditions are defined by one's locality's savings treatment status, and one's individual voucher receipt status. We measure impacts on account ownerships, formal savings and other outcomes, in two annual surveys occurring one and two years after the savings treatments were implemented, and can also examine impacts on savings from administrative data of our partner bank (BOM). Two companion papers (Carter et al., 2014, 2017) discuss the broader results of the field experiment. It shows that the voucher intervention led to a sustainable increase in the use of fertilizer and to the well-being of the beneficiaries. The savings interventions led to an increase in savings and in indicators of well-being. However, when the two interventions are combined, the benefits of the two programs do not add up and the savings tend to be used for investments other than fertilizer.

In the technology adoption literature, a number of papers investigate spillovers from beneficiaries to non-beneficiaries and its implications for technologica diffusion (BenYishay and Mobarak, 2014; Beaman et al., 2018), however to the best of our knowledge, this paper is the first one to consider the spillover of customer trainings as a possible explanation for underprovision of such trainings and thus of technology adoption. We test the prediction of the theoretical model in order to better understand why, despite its cost effectiveness, trainings such as the ones that we tested are rarely provided by the banks. While the information treatments were delivered by, and specifically encouraged savings at our partner bank, BOM, we find that the formal savings stimulated by each of the savings treatments occurred mostly at institutions aside from our partner BOM. The evidence is also consistent with the other testable predictions of the model. Hence providing information leads to an increase in the demand which is also satisfied by other providers of the technology. Private providers of the technology may still have incentives that are better aligned than, for example, public extension, however the fact that the provider of the training cannot capture the full benefit of its training encourages free-riding by other firms, so laissez-faire will not deliver the optimal amount of information. This provides a rationale for public subsidy of information provision, or some other means of mandating cross-bank collaboration to alleviate information constraints.

2 Model combining learning about a technology and competition among providers of the technology

Our model that provides a combination of two features, commonly found in different settings: 1) Learning about a new technology and 2) Hotelling's competition model (Hotelling, 1990) among the firms which provide this technology. It highlights why competition results in the under-provision of trainings promoting a new technology. Training generates an increase in demand for the technology that benefits the firm that provided the training, but also benefits other firms that provide the same technology, acting as a positive spillover for competitors. This generates incentives for firms to free-ride on other firms' training and generate an under-provision of the training for the profitable technology.

The model allows the firms to choose exactly where to provide training, however, as long as the location of a consumer is not the only determinant of her willingness to pay (WTP), this does not eliminate the spillover issue and under-provision of the training. The model leads to a number of predictions related to under-provision, spillover and spacial patterns (effects of the savings interventions on beneficiaries conditional on their distance to the banks). We test them in the empirical section. For a better assimilation, we first present the case of a single firm with exogenous WTP before making the WTP at each location a function of training provided by the firm, and finally introduce a competitor to show the effects of competition on training provision.

2.1 One Firm and exogenous willingness to pay

We start with a representation of Hotelling's model where a consumer is defined by i, its location on a line, which will affect its distance from the firm(s), but also by j, which allows heterogeneity in preferences for the technology for reason other than the location (non-observed by the firm).

The consumer ij purchases the technology from firm f if:

$$p_f + d_{fi} + \tau_{fj} < w(tr_i) \tag{1}$$

where p_f is the price of the technology sold by firm f, d_{fi} is the distance from firm f to consumer i, $w(tr_i)$ is the willingness to pay of consumer i, further below, it will be a function of the amount of training provided at point i, however for pedagogic purpose, we first calculate the demand when the willingness to pay is exogenous: $w(tr_i) = w$.

τ_{1ij} is defined as an additional cost due to the variation in the preferences of the consumer j at

location i. We assume that, at any point i, τ_{1ij} is uniformly distributed between 0 and η. This is an extension to Hotelling's model, which allows the demand to not be determined only by distance. As a consequence demand decreases progressively as consumers are farther away from the firm, which is a more realistic hypothesis.

Figure 1.1 represents the case with one firm and an exogenous willingness to pay of the consumer $w(tr_i) = w$.

Applying the condition of equation (1) the demand for firm 1 at location i is defined by:

$$dd_{1i} = \begin{cases} 0 & if \quad w < p + d_{1i} \\ \frac{1}{\eta}(w - p - d_{1i}) & if \quad p + d_{1i} < w < p + d_{1i} + \eta \\ 1 & if \quad p + d_{1i} + \eta < w \end{cases} \tag{2}$$

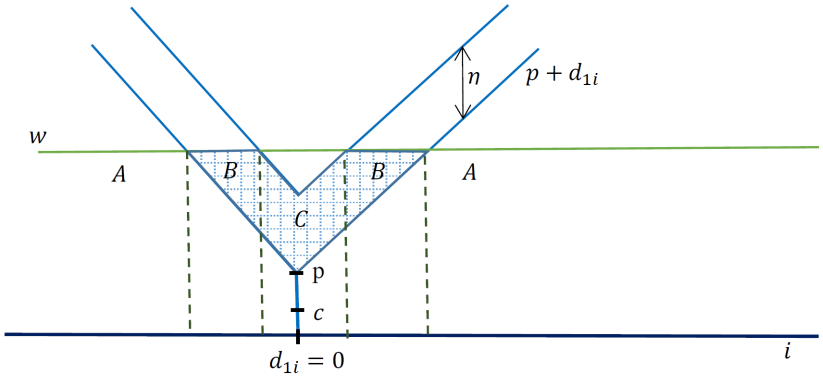
$$\begin{array}{ccc} -tr_i.c_{tr} & if & w(tr_i) < p + d_{1i} \\ (p-c)\frac{1}{\eta}(w(tr_i) - p - d_{1i}) - tr_i.c_{tr} & if & p + t_i < w(tr_i) < p + d_{1i} + \eta \\ p - c - tr_i.c_{tr} & if & p + d_{1i}(tr_i) + \eta < w(tr_i) \end{array}$$

There are thus three possible case scenarios depending on the distance from the firm. If $w < p + d_{1i}$ (area A in figure 1.1) then the consumers are so far that none of them wants to consume the technology. If $p + d_{1i} + \eta < w$ (area C), then the consumers are so close that all of them want to consume the technology. Finally in the intermediate case (area B), then consumers will split between buyers and non buyers of the technology, depending on their preference τ_{fj}. In this case, the resulting demand will be decreasing in the distance to the firm d_{1i}.

Figure 1.1: One firm and Exogenous WTP:

$$\text{Demand for firm 1 at location } i \text{ :}$$

$$dd_{1i} = \begin{cases} 0 & if\ w_i < p + d_{1i} & A \\ \frac{1}{\eta}(w_i - p - d_{1i}) & if\ p + d_{1i} < w_i < p + d_{1i} + \eta & B \\ 1 & if\ p + d_{1i} + \eta < w_i & C \end{cases}$$



2.2 One Firm and endogenous willingness to pay

We will now make the WTP at location i a function of the amount of training provided at point i: $w(tr_i)$. The WTP of the customer is equal to the benefits that she expects to derive from the use of the technology. There are two possible reasons why training would increase WTP. First, it can generate learning about how to better use the technology in order to derive more benefits from it and second, if the consumer initially underestimates the benefits of the technology, then then training provides information about the actual benefit of the technology, allowing an update of beliefs in that direction. We assume an update of $w(tr_i)$ that follows the expected value of a Bayesian update[3]. The consumer's prior has a variance $\frac{1}{\rho_0}$ (hence precision ρ_0) and expected value w_0. The training provides a signal with variance $\frac{1}{tr_i}$ (precision tr_i) and expected value $\bar{w}$ (which can be interpreted as true benefit for the consumer of the technology). Given this, the potential consumer's WTP after an amount of training $w(tr_i)$ is given by:

$$w(tr_i) = \frac{\rho_0 w_0 + tr_i.\bar{w}}{\rho_0 + tr_i} \tag{3}$$

Because the consumer initially underestimates the benefits of the technology, $w_0 < \bar{w}$. It is relatively

[3]For simplicity, we assume a non stochastic learning function, that follows the expected value of a Bayesian update. It can be interpreted as the effect on a consumer after average learning generated by the training. Adding stochasticity in learning would substantially complicate the analysis and is unlikely to affect the main conclusions. This can also represent a deterministic increase in the actual payoff that will be derived from the technology because the training generated learning about how to use the technology.

straightforward to show that $w(tr)$ satisfies the following properties:

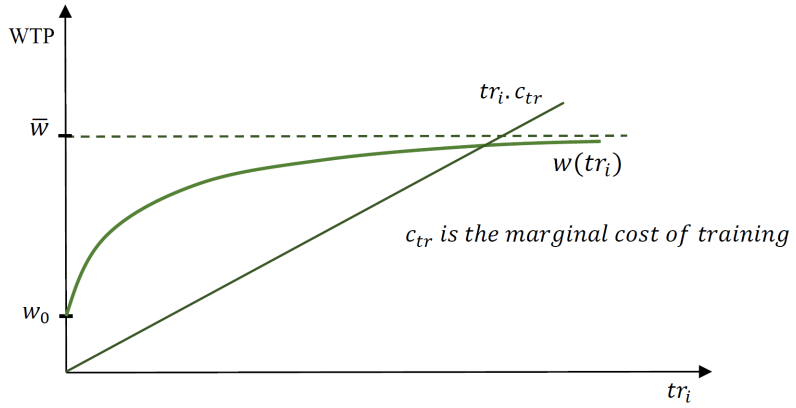
- $w'(tr_i) > 0 \quad w''(tr_i) < 0$, the marginal effect of training on willingness to pay is positive and decreasing in the amount of training provided.

- $w(0) = w_0$, in the absence of training, the WTP is equal to the consumer's prior.

- $w(tr_i) \underset{tr_i \mapsto \infty}{\rightarrow} \bar{w}$ & $w'(tr_i) \underset{tr_i \mapsto \infty}{\rightarrow} 0$, as the amount of training goes to infinity, the WTP converges to the true value of the benefit of the technology, and the marginal effect of training goes to 0.

This set of basic properties can be derived from Bayesian learning, but also from a much wider set of representations of the learning process (including learning how to use the technology, rather than learning about the returns). All the results derived subsequently do not require Bayesian learning, but only this much more general set of properties. Figure 1.2 shows the resulting WTP as a function of the amount of training provided at point i.

Figure 1.2: WTP as a function of training at a given location:



We now turn our attention to the firm's decision of training provision. The firm determines the amount of training it provides at each location i in order to maximize its profit:

$$\pi = \int_{-\infty}^{+\infty} \pi_i\,(tr_i)\;\, d\; d_i = \int_{-\infty}^{+\infty} (p-c)\; dd_i\,(tr_i) - tr_i.c_{tr}\; d\; d_i \tag{4}$$

where p and c are the unit price and cost of the technology (respectively) and c_{tr} is the fixed marginal cost of the training.

The total profit π of a firm is the integral of its profit at every point i , equal to the unit price minus

unit production cost multiplied by the demand at that localization i, to which the costs of trainings must be deduced. The trade off comes from the fact that an increase in training tr_i comes at a cost c_{tr}, but increases the demand $dd_i(tr_i)$.

Because each π_i is independent from decisions at other locations, then the maximization of π implies the maximization of each π_i separately. Combining equations 2 and 4 we obtain:

$$\pi_{1i}(tr_i) = \begin{cases} -tr_i.c_{tr} & if\ w(tr_i) < p + d_{1i} \\ (p-c)\frac{1}{\eta}(w(tr_i) - p - d_{1i}) - tr_i.c_{tr} & if\ p + t_i < w(tr_i) < p + d_{1i} + \eta \\ p - c - tr_i.c_{tr} & if\ p + d_{1i}(tr_i) + \eta < w(tr_i) \end{cases} \tag{5}$$

We will focus our attention on the second line of equation 5 , which is the interior solution, before specifying the conditions required to be in this case scenario.

Under this scenario, the maximization of $\pi_{1i}(tr_i) = (p-c)\frac{1}{\eta}(w(tr_i) - p - d_{1i}) - tr_i.c_{tr}$ is obtained by taking its derivative with respect to tr_i.

$$\frac{d\pi_i}{dtr_i} = (p-c).\frac{1}{\eta}w_i'(tr_i) - c_{tr} = 0 \tag{6}$$

$$tr_i^{\pi} = w_i'^{-1}\left(c.\frac{\eta}{p-c}\right) \tag{7}$$

Notice that the optimal level of training at location i is independent of the distance from the firm, hence whenever provided, the intensity of the training is the same everywhere. The provision of this training is conditional on $\pi_{1i} > 0$:

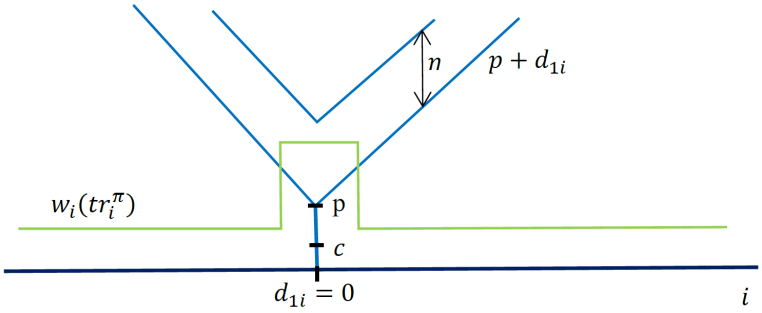
$$(p-c).\frac{1}{\eta}(w_i(tr_i^{\pi}) - p - d1_i) > tr_i^{\pi}.c_{tr} \tag{8}$$

otherwise the firm prefers providing $tr_i = 0$ leading to 0 profit at location i. This condition will be respected for $d1_i$ small enough. Figure 1.3 provides a graphical representation of the profit maximizing level of training provided by a firm in monopolistic situation[4]. As found by the calculations, the

[4]In this solution, tr_i =0 in line 1 of equation 5, corresponding to cases so far that it would be too costly to raise their WTP enough to reach a positive demand. The solution excludes line 3 of equation 5, because it would occur either in the case where the firm provided too much training so that the WTP exceeds the one for which the demand at point i is 100%; or in the a case where w_0 was so high that it led to 100% consumption without any training, which we consider

optimal amount of training is positive and independent of the location for any location where the demand generated is sufficient to make the training worth its cost, and training is 0 in other locations.

Figure 1.3: One firm and Endogenous WTP:



2.3 Comparison of monopolistic provision of training with social optimum

We calculate the amount of training that would maximize social surplus. The social surplus at location i is given by the following equation:

$$SS_i = (\bar{w} - d_i - c).dd_i\,(tr_i) - tr_i.c_{tr} \tag{9}$$

From which we replace $dd_i\,(tr_i)$ to obtain:

$$SS_i = (\bar{w} - d_i - c).\frac{1}{\eta}\,(w_i(tr_i) - p - d_i) - tr_i.c_{tr} \tag{10}$$

The net benefit per unit consumed is given by $\bar{w}$ (true return of the technology) minus costs related to production and distance. The cost of training at location i is also deduced from social surplus.[5]

We take its derivative to calculate the socially optimal level of training:

$$\frac{dSS_i}{dtr_i} = (\bar{w} - d_i - c).\frac{1}{\eta}w_i'(tr_i) - c_{tr} = 0 \tag{11}$$

$$tr_i^{SS} = w_i'^{-1}\left(c.\frac{\eta}{\bar{w} - d_i - c}\right) \tag{12}$$

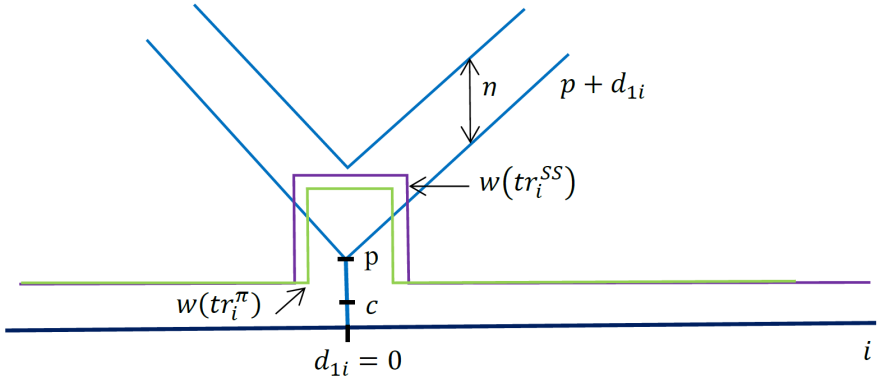
The consumer only buys if $p_f + d_{fi} + \tau_{fj} < w(tr_i)$. Because $\bar{w} > w(tr_i)\ \forall tr_i\ \&\ \tau_{fj} \geq 0\ \forall j$ we can infer that $\bar{w} - d_i - c > p - c$. Hence from equations 7 and 12, we find that $tr_i^{SS} > tr_i^{\pi}$and the

unlikely in this context since we assume a low initial prior to be the initial constraint.

[5]We have chosen not to represent τ_{ij} as a real cost. If it was the case it would not change the conclusions of under-provision of training

condition for the social surplus to be positive is weaker than the condition for the profit to be positive. The comparison between training that maximizes the social surplus and the one that maximizes profit appears in figure 1.4. It represents the 2 properties that we showed: in the social optimum, the level of training exceeds the one that is provided by a firm in monopoly, and it is positive over a greater range of locations. We have shown that even under monopoly, the provision of training by the firm is below the one that maximizes social surplus. The reason for this result is that since for any level of training, the consumer would still underestimate the true value of the technology, the firm would never be able to charge the technology at a price that reaches the true benefits for the consumer. Because the firm cannot fully internalize the benefits of the training, the provision of training remains below optimum.

Figure 1.4: One firm and Endogenous WTP, comparison with Social Optimum:



2.4 Two firms

We now assume that there are two firms. For simplicity, we assume that both firms have the same exogenous price: $p_1 = p_2 = p$[6].

Consumer ij buys from firm 1 if 1) $p + d_{1i} + \tau_{1i} < w_i(tr_i)$ & 2) $p + d_{1i} + \tau_{1ij} < p + d_{2i} + \tau_{2ij}$. The first condition is the one we had previously, i.e. that the WTP exceeds the full cost. The second condition adds that consumer ij buys from firm 1 only if he prefers it to buying from firm 2, meaning that the cost related to distance d_{1i} and subjective preference for firm 1 τ_{1ij} are lower than the cost of d_{2i} and τ_{2ij}.

We still assume that τ_{1i} and τ_{2i} are uniformly distributed and also that they are orthogonal: $\tau_{1ij}|i \sim U[0,\eta]$ & $\tau_{2ij}|i \sim U[0,\eta]$ and the two distributions are independent. This allows us to

[6] Also for simplicity, the price is exogenous, as it is often the case for a given branch of a bank or firm which decides prices at a national or regional level. It also allows us to focus on training as the only decision variable of each firm.

calculate how the demand will split between firm 1 and firm 2 in the area where the 2 firms are competing for the same demand (meaning the area where both demands are strictly positive).

Let us define:

$$k_i = d_{1i} - d_{2i} \tag{13}$$

Hence k_i is exactly equal to 0 for the consumer that is equidistant to the 2 firms, and increases when i becomes closer to firm 2.

Given that τ_{1i} and τ_{2i} are uniformly distributed and orthogonal, we show in the appendix that the share of consumption that goes to firm 1 is given by:

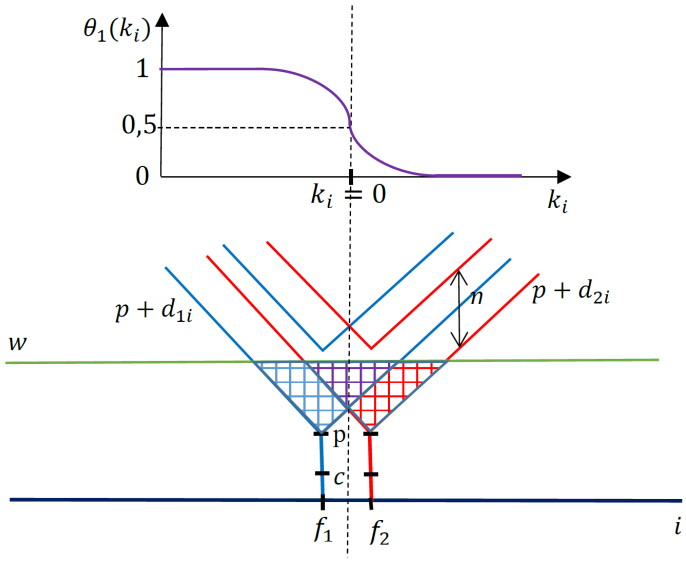
$$\theta_1(k_i) = \begin{cases} 1 & if\ k_i < -\eta \\ \frac{(\eta - k)^2}{2\eta^2} & if\ -\eta < k_i < 0 \\ 1 - \frac{(\eta + k)^2}{2\eta^2} & if\ 0 < k_i < \eta \\ 0 & if\ k_i > \eta \end{cases} \tag{14}$$

Hence we can rewrite the interior solution of equation 2, which describes the demand for firm 1:

$$dd_{1i} = \theta_1(k_i)\frac{1}{\eta}\left(w_i(tr_i) - p - d_{1i}\right) \tag{15}$$

Figure 1.5 shows the case with two firms, and an area where the monopolistic demands overlap. In this area the share of the demand that goes to firm 1 is given by $\theta_1(k_i)$, where $\theta_1(k_i)$ is given by equation 14. When $k_i = 0$ (equidistance between the two firms), then the demand splits equally between the two firms, and as k_i increases (getting closer to firm 2), then the share of the demand that goes to firm 1 decreases as represented in figure 1.5.

Figure 1.5: Two firms and Exogenous WTP:



We can now rewrite the profit of firm 1 under the interior solution:

$$\pi_{1i} = (p - c).\theta_1(k_i).\frac{1}{\eta}\left(w_i(tr_i) - p - d_{1i}\right) - tr_{1i}.c_{tr}$$

A new distinction becomes important tr_i is the total amount of training provided at location i, which is equal to the sum of trainings provided at this location. In the case of two firms, $tr_i = tr_{1i} + tr_{2i}$.

At equilibrium both firms must play their best response to the other firm's decision. Hence firm 1 selects tr_{1i} in order to maximize its profit π_{1i}, taking tr_{2i} as given.

We take the derivative of π_{1i} with respect to tr_{1i} :

$$\frac{d\pi_i}{dtr_i} = (p - c).\theta(k_i).\frac{1}{\eta}w_i'(tr_i) - c_{tr} = 0 \tag{16}$$

This can be interpreted as follows:

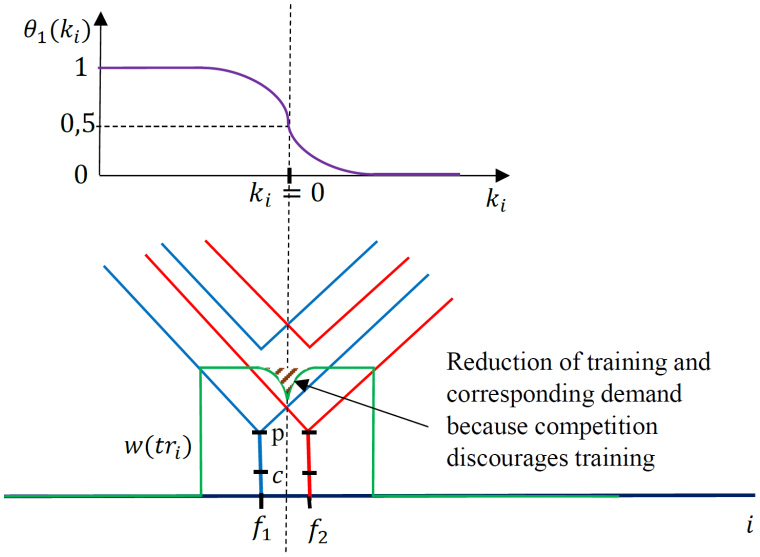
$$\theta_1(k_i)\ Marginal\ Benefits\ of\ total\ training = Marginal\ cost\ of\ training \tag{17}$$

At equilibrium, for any location i, only 1 firm provides training, the one that is closest to location i. The farthest firm free rides on the training of the closest one. The amount of training provided corresponds to the one that is optimal for this closest firm and is given by the following equation when $k_i < 0$ (when firm one is the closest one).

$$tr_{1i} = w_i'^{-1}\left(c.\frac{\eta}{\theta(k_i).(p-c)}\right)$$

Because $\theta(k_i) \leq 1$ then in areas with effective competition (where monopolistic demands of firms 1 and 2 overlap), the amount of training tr_i is below the training provided by firm 1 in monopoly. Also, because $\theta(k_i)$ is decreasing in k_i, then tr_{1i} is decreasing in k_i until $k_i = 0$, where firm 1 starts free riding on the training of firm 2 (because firm 2 becomes the closest one at $k_i = 0$). As represented in figure 1.6. locations that are prone to a higher level of competition (because they are closer to the middle) receive a lower level of training. Hence greater (and closer) competition reduces training and takes us further away from the optimal amount of training than in monopoly.

Figure 1.6: Two firms and Endogenous WTP:



2.5 Testable Implications

The proposed model leads to five testable implications that we explore in the empirical section, using an experiment that exogenously provided additional training.

1) A training generates an increase in the welfare of the beneficiaries that exceeds its cost. This results from the fact that, at equilibrium the amount of training provided by the firms is below the optimal level of training.

2) A training from one provider generates an increase in demand not only for the firm that provides the training, but also for competing firms. This is the smoking gun evidence of the spillover, and is

sufficient to be concerned that it should generate under-provision of training by the suppliers of the technology when facing competition.

3) The spillover effect of the training on the demand for a competing firm should be higher for clients that are located father away from the providing firm and closer to the competing firm. To show this, from equation 15, we can write the demand of firm 2 (which is the share of the demand that does not go to firm 1):

$$dd_{2i} = (1 - \theta_1(k_i))\frac{1}{\eta}\left(w_i(tr_i) - p - d_{2i}\right)$$

We then derive with respect to tr_i to obtain:

$$\frac{d\ dd_{2i}}{d\ tr_i} = (1 - \theta_1(k_i))\frac{1}{\eta}.w_i'(tr_i)$$

The marginal effect of an increase in tr_i on dd_{2i} is decreasing in $\theta_1(k_i)$ hence it is increasing in the distance to firm 1 (because $\theta(k_i)$ is decreasing in the distance to firm 1,which provides the training).

4) Under some parameters, it is possible that the proximity to a competitor increases the marginal effect of a training. Consider, for instance, the case of client localized in area A in Figure 1.1. In this case, the marginal effect of a training is 0 (because their willingness to pay is initially too low for any of the clients at location i to use the technology). But if a competitor is close enough to this location, at equilibrium, it would provide some level of training which would raise the initial WTP of consumers at location i and allow the marginal effect of an additional training to be strictly positive, thus higher than the marginal effect of a training in the absence of competition. This statement is relatively weaker than previous testable hypotheses, in the sense that we can only show that it is true in some circumstances. However the model provides a possible explanation for a feature that is uncommon in competition models. It can be interpreted as the other side of the spillover: the presence of the competitor can benefit the demand of the provider of the training (which can increase the level of the demand and the marginal effect of training) because at equilibrium the competitor also provides training.

5) If learning is faster among clients with a higher education, then the effect of the training on the use of the technology should be greater among clients with a higher level of education. For a simple formalization of this, we can assume that in equation 3 the precision of the signal would be a function of $educ_{ij}$, the level of education of individual ij:

$$w(tr_i) = \frac{\rho_0 w_0 + tr_i(educ_{ij}).\bar{w}}{\rho_0 + tr_i(educ_{ij})}$$

with $tr_i'(educ_{ij}) > 0$

This implies that individuals that have a higher level of education can better extract the signal from the training provided. As a consequence the learning from the training and its effects on the use of the technology are increasing in the level of education of the recipient of the training.

3 Project Description

We test the predictions of the model, using data from a field experiment in rural Mozambique. The study included a control group and five treatment arms presented in table 1 and described below. Two companion papers (Carter et al., 2014, 2017) discuss the broader results of the field experiment, showing positive and sustainable effects of the programs providing savings information, savings matches additional to the savings information, and agro-input subsidies, but the effects do not add up when the two types of program are combined. This paper uses the entire sample but we focus our attention on the effects of the savings interventions and the extent to which the findings are consistent with the theory that is proposed in the previous section. The objective is to go beyond the positive effects of the programs and understand the market failures behind the persistence of low technology adoption.

Table 1: Treatment conditions

Savings treatments	Voucher treatment: *No*	Voucher treatment: *Yes*
Control	**C**: Pure Control (N=267)	**T1**: Voucher (N=247)
Information	**T2**: Information (N=278)	**T3**: Voucher & Info (N=303)
Match	**T4**: Match (N=248)	**T5**: Voucher & Match (N=246)

Notes: Savings treatment conditions randomized across 94 study localities, each with 1/3 probability (32 control, 30 information, 32 info & match localities). Voucher treatment randomized at individual level (with 50% probability) within each study locality. Number of individual observations in parentheses. Total N=1,589. Match localities received the information treatment and a 50% match of their savings in the first two years.

3.1 Project Overview and Research Design

Localities in Manica province were selected to be part of the study on the basis of inclusion in the provincial input voucher program as well as access to Banco Oportunidade de Mocambique (BOM), our implementation partner for the savings component of the project. To be accessible to the BOM savings program, a village had to be within a certain distance of a paved road and within reasonable driving distance to one of BOM's branches or location that was visited weekly by a truck-mounted mobile bank branch. These restrictions led to inclusion of 94 localities[7] in the larger study, across the districts of Barue, Manica, and Sussundenga.

Within each locality, lists of eligible farmers were created jointly by government agricultural extension officers, local leaders, and agro-input retailers. Individuals were deemed eligible for participation in the study if they met the following criteria: 1) farming between 0.5 hectare and 5 hectares of maize; 2) being a "progressive farmer," defined as a producer interested in modernization of their production methods and commercial farming; 3) having access to agricultural extension and to input and output markets; and 4) stated interest in the input subsidy voucher (which included paying for the remaining portion of the value of the input package that was not covered by the voucher)[8]. Potential study participants were informed that the subsidy voucher would be awarded by lottery to 50% of study participants within each village. Only one person per household was allowed to register as a study participant.

Our study design involves randomization of an agricultural input subsidy voucher at the individual study participant level (within localities), crossed with randomization of savings programs across the 94 localities. Randomization of both the vouchers and the savings programs were conducted by the research team on the computer of one of the PIs. Appendix table A1 provides a timing of intervention and data collection.

3.2 Input subsidy voucher treatment

The voucher randomization and distribution was conducted first. In September through December 2010 (at the beginning of the 2010-2011 agricultural season),[9] vouchers were randomly assigned to

[7] The localities we use were defined by us for the purpose of this project, and do not completely coincide with official administrative areas. We sought to create "natural" groupings of households that had some connection to one another. In most cases our localities are equivalent to villages, but in some cases we grouped adjacent villages together into one locality, or divided large villages into multiple localities.

[8] This list of criteria was provided by the extension agents, but in practice they were subjective in assessing farmers that broadly correspond to this set of criteria

[9] The agricultural season in Manica province starts with planting in November and December, with the heaviest rain occurring in December through April, and harvest occurring in May and June. There is a dry period from July through

50% of study participants in each locality. The subsidy voucher randomization was done in the context of a larger nationwide input subsidy pilot conducted by the Mozambique government. The Manica provincial government agreed to collaborate with our project and allow the randomization of the voucher assignment within the study villages. The voucher qualified beneficiary farmers for a subsidy for the purchase of a technology package designed for a half hectare of improved maize production: 12.5 kg of improved seeds (either open-pollinated variety or hybrid) and 100 kg of fertilizer (50 kg of urea and 50 kg of NPK 12-24-12). The market value of this package was MZN 3,163 (about USD 117), of which MZN 2,800 was for the fertilizer component, and MZN 363 was for the improved seed. Farmers were required to co-pay MZN 863 (USD 32), or 27.2% of the total value of the package.[10]

3.3 Savings treatments

Later, in April 2011, each of the selected 94 localities was then randomly assigned to either a "no savings" condition or to one of two savings treatment conditions ("basic savings" and "matched savings"), each with 1/3 probability. A baseline survey was implemented prior to harvest, in April 2011. The week following the survey, study participants in localities assigned to either the information or match treatments were invited to a first meeting to introduce the savings program.

3.3.1 Information treatment

The first meeting with study participants in the information treatment localities was a financial education session. The half-day training sessions, implemented jointly by BOM and the study team, covered the benefits of using fertilizer and improved seeds and the importance of saving in order to be able to afford agro-inputs and other investments. Participants were introduced to BOM and were told how to open and use a savings account.

In the first session, participants were asked to form groups of five beneficiaries and select one representative per group. Representatives were offered a t-shirt with the BOM logo and were given the responsibility of maintaining the connection between the bank and the members of their group. Two follow-up sessions, organized between May and July 2011, allowed BOM personnel to check with representatives about the progress of their groups towards opening savings accounts and to address participants' questions and concerns. Representatives were also given more financial education, including materials to hand out or use with their group members at home, such as a comic strip and

October where less agricultural activity occurs.

[10] At the time of the study, one US dollar (USD) was worth roughly 27 Mozambican meticals (MZN).

a board game about savings. At the end of each follow-up session, participants were are asked to communicate what they had learned to the rest of their group members. The representatives were usually offered a meal or a snack during the training. The initial information sessions, to which all participants were invited, and the two follow-ups, which the representatives attended, define the information intervention.

3.3.2 Match treatment

In the match treatment localities, we also implemented all elements of the information treatment described above. In addition, participants were also offered a savings match for savings held at BOM during a particular three-month period in 2011 and 2012. The match program offered a 50% match on the minimum amount that was saved between August 1st and October 31st of 2011 and 2012, with a maximum match of MZN 1500 per individual (approximately USD 56). A flyer was given to savings group representatives, summarizing the rules of the savings match. The researchers provided a list of the study participants assigned to the match program, as well as the other members of the household, (listed during the first survey) who were also eligible to benefit from the match program (but no more than one member per household). Registration was made in person at a fixed BOM branch, (it was not possible at a truck-mounted mobile bank branch). An official ID was asked, if not available, a document from the local leaders that confirms the identity of the participant was required. A regular cooperation between the team investigators and BOM ensured that participants of the match program were labeled as such so that they would receive the match.

The aim of the match treatment was to familiarize the farmers with the banking system and encourage them to develop a habit of saving between harvest and planting time, when fertilizer and other inputs are typically purchased. The amount was deposited in beneficiaries' accounts at BOM during the first week of November. These dates were chosen in acknowledgment of the agricultural calendar. A majority of farmers sell most of their maize production before August and purchase their agro-inputs in November. Although the information sessions emphasized savings to purchase the agro-inputs needed for maize production, once the amount was deposited in the accounts, the beneficiaries could use the funds for any purpose.

4 Sample and data

4.1 Sample

Our sample for analysis in this paper consists of 1,589 study participants and their households in the 94 study localities. Randomization of vouchers was at the individual level, with 50% probability for each individual within a locality. The 94 study localities were also randomly assigned to the information treatment (30 localities), the match treatment (32 localities), or the control group (32 localities) after being grouped into stratification cells of three nearby localities.

4.2 Data

The data used in our analyses come from three sources: household survey data we collected over the course of the study, administrative data on savings from our partner bank (BOM), and transportation time and cost from villages to branches, measured by our team of enumerators.

We implemented a series of in-person surveys of study participants on savings and other outcomes in their households. Due to uncertainties in the timing of voucher distribution and delays in the creation of the list of study participants at the start of the 2010-2011 agricultural season, it was not feasible to conduct a baseline survey prior to the voucher lottery at the end of the 2010 calendar year. Our first survey was in April 2011, which before the savings treatments but after the voucher treatment (see timeline in appendix table A1). While this is therefore not a true baseline survey with respect to the voucher subsidy treatment, it does include questions on time-invariant variables (e.g., gender) as well as retrospective questions on respondents' pre-voucher-lottery agricultural outcomes and behaviors (relating to the the 2009-2010 season). Only time-invariant variables or outcomes reported retrospectively about the previous agricultural season will be used as control variables and in the balance tests (Table 2, to be discussed below). Follow-up surveys were implemented in September 2011, September 2012, and July-August 2013. These follow-up surveys were timed to occur after the May-July annual harvest period, so as to capture fertilizer use, production, and other outcomes related to that harvest. The surveys included modules on savings, consumption, assets, fertilizer use, and agricultural production.

Administrative data on savings at BOM are monthly balances, in total across all accounts of individuals in the households of study participants. BOM implemented a search process that identified study participants and their household members among their population of customers on the basis of

name and village. Even with the absence of well-defined addresses, this was a manageable search process, because BOM was for the most part offering bank accounts in the study villages for the first time, limiting the population of accounts within which the search was conducted. These searches were re-done regularly to capture information on new account openings over the course of the study. The search was cross-referenced with questions from the household survey on BOM bank account ownership in the households of study participants.

Finally, in order to test the predictions of this model, we collected data on transportation costs. For each one of the 94 localities, we listed the closest BOM branch and the closest bank branch from any competitor. We then sent enumerators to make all the trips listed by public transportation, as it is usually done by the farmers. They recorded their trip by GPS, the total amount spent and time of departure and arrival. Using the average daily salary in the region, we converted time spent into its value. We then added this cost of time to the money spent to create a distance index.

4.3 Summary statistics and balance tests

Table 2 presents means (standard deviations in parentheses) of baseline variables for the study households, and tests for balance on these variables across study participants in the control group and treatment groups T1 through T5. Sample household heads are roughly 85% male, and about three-quarters are literate. Given that the sample is composed of farmers considered "progressive" by provincial extension agents, these figures are somewhat higher than Manica province households overall, among which 66% of household heads are male and 45% are literate.[11]

Table 2 tests balance between treatment and control groups for variables that are not expected to vary in the short run (for example education of the household head), or agricultural variables related to the 2009-10 agricultural season (the season prior to our study.) Columns for each of treatment groups T1 through T5 report in brackets the p-values of the F-tests of pairwise equality of the mean in that treatment group and the mean in the control group. Out of 80 such pairwise comparisons, five differences vis-a-vis the control group are statistically significantly different from zero at the 10% level, and two are statistically significantly different from zero at the 5% level. This number of statistically significant differences is no larger than what would be expected to arise by chance.

Because most of our outcome variables of interest are obtained from our follow-up surveys, it is

[11] The Manica data used for comparison is from the 2007 "Terceiro Recenseamento Geral da População e Habitação", provided by Mozambique's National Institute of Statistics, accessible online at http://www.ine.gov.mz/home_page/censo2007.

important to examine whether attrition is correlated with treatment as any such correlation could potentially lead to biased treatment effect estimates. We examine the relationship between treatment and attrition by regressing an indicator for attrition on treatment indicators and stratification cell fixed effects, and present the results in Appendix Table 2. Surveys of all households of study participants were attempted in each subsequent survey round (in other words, attrition was not cumulative), so all attrition rates reported are vis-à-vis that initial sample. Attrition is 10% in the first (2011) follow-up survey, 11% in the second (2012) round, and 6.9% in the final (2013) round. There is no evidence of economically or statistically significant differentials in attrition related to treatment. We find that only one out of 20 coefficients is significant at the 10% level and none of the joint tests of significance of the five treatment dummies is significant. Because all our outcomes are obtained from their average between the second and third follow-up surveys, data are only missing when there are missing from both rounds. Only 3.5% of respondents attrited from both the second and third follow-up surveys, with none of the coefficients on treatment indicators being large or statistically significantly different from zero. Attrition bias is therefore not likely to be a concern in our context.

Table 2: Summary Statistics and Balance Tests

	C: Pure Control	**T1:** Voucher	**T2:** Information	**T3:** Voucher & Info	**T4:** Match	**T5:** Voucher & Match
HH head education (yrs.)	4.77	4.70	4.75	4.83	4.67	4.42
	(3.32)	(3.01)	(3.41)	(3.42)	(3.14)	(3.24)
		[0.853]	[0.744]	[1.000]	[0.773]	[0.117]
HH head is male (indic.)	0.85	0.85	0.87	0.82	0.85	0.82*
	(0.36)	(0.36)	(0.34)	(0.38)	(0.35)	(0.38)
		[0.877]	[0.596]	[0.297]	[0.497]	[0.0958]
HH head age (yrs.)	45.82	46.43	46.60	46.18	46.43	45.97
	(14.09)	(13.76)	(14.19)	(13.90)	(13.68)	(13.94)
		[0.711]	[0.634]	[0.636]	[0.416]	[0.515]
HH head is literate (indic.)	0.79	0.76*	0.74	0.77	0.76	0.73**
	(0.41)	(0.43)	(0.44)	(0.42)	(0.43)	(0.45)
		[0.324]	[0.0505]	[0.312]	[0.266]	[0.0278]
N	269	278	248	249	303	246

Note: Means presented in top row for each variable, with standard deviations in parentheses. Treatments are as described in Table 1. Data are from April 2011 survey, prior to info and match treatments but after voucher treatment. In brackets: p-values of test of equality of mean in a given treatment group with mean in pure control group, after partialling-out fixed effects for 32 stratification cells (groups of three nearby localities, within which information and match treatments were randomly assigned). Standard errors clustered at level of 94 localities.

5 Empirical results

As mentioned previously, two companion papers (Carter et al., 2014, 2017) discuss the broad results of the interventions. In this empirical section, we focus on the test of the predictions of the model in

order to learn about the constraints that impede private agents from addressing their potential clients' information constraints. The random assignment to the various treatments allows us to estimate the causal impacts of the treatments, greatly contributing to a direct test of the predictions.

In table 3 and 4, we estimate intention to treat (ITT) effects on post-treatment outcome Y_{ijk} for study participant i in locality j and stratification cell k as follows.

$$Y_{ijk} = \alpha + \beta_1 T1_{ijk} + \beta_2 T2_{ijk} + \beta_3 T3_{ijk} + \beta_4 T4_{ijk} + \beta_5 T5_{ijk} + \theta_k + \epsilon_{ijk} \tag{18}$$

Some outcome variables of interest have substantial noise and relatively low autocorrelation, such as savings, consumption, farm inputs, and agricultural production. In order to increase statistical power, we follow McKenzie (2012) and estimate treatment effects on the average of post-treatment outcomes across multiple periods, specifically across the 2012 and 2013 follow-up surveys.[12] Hence no regression variable has time subscripts. To moderate the undue influence of extreme values for continuous outcome variables with potentially large outliers (such as savings in Mozambican meticais), we winsorize the variable at the 99th percentile (replacing values above the 99th percentile with the 99th percentile). For some variables of interest, we also show results using the logarithm of one plus the variable to check the robustness of the findings.[13] θ_k are stratification cell fixed effects representing the groupings of nearby localities within which treatments were randomized (as mentioned previously, treatment was randomly assigned within these locality groups, so each locality group contains each type of savings treatment condition). Randomization of the savings treatment is at the locality level, so we report standard errors clustered at the level of the 94 localities (Moulton, 1986). Equation 18 estimates the ITT for households who are in a locality without any savings intervention and receive the voucher (β_1), for household in the information treatment localities without voucher (β_2) and with voucher (β_3), and for households in the match treatment localities without voucher (β_4) and with voucher (β_5). Any of the four savings treatments T2, T3, T4 and T5 includes a training that aimed at promoting the use of savings, hence we would expect their corresponding coefficients to go in the directions of the predictions of the model. In all tables, we also include a test of joint significance of β_2, β_3, β_4, andβ_5 to see whether they are jointly consistent with the predictions of the model. Also one may want to pay more attention to treatments β_2 and β_4, which only have a savings component

[12]To maximize sample size and limit issues related to attrition, in cases where the value from one year is missing, we simply use the value from the other year.

[13]We also used inverse hyperbolic sine transformation (IHST) instead of logarithmic transformation and obtained very similar results.

and thus are more tightly related to the test of our model.Though we generally find a high degree of consistency between how each one of the four treatments fit the predictions.

5.1 Effects on the well-being of beneficiaries

The model leads to the conclusions that there is under-provision of trainings for a technology. Training being below its social optimum means that it has positive effects on its beneficiaries, and that the benefits of the intervention exceed its costs. We first assess whether the savings treatments had positive effects on its beneficiaries, running regression 18 on indicators of well-being. In the first four columns of table 3, we show the effects of the interventions on the households' daily consumption, assets, a dummy for whether they improved their housing and a nutrition index. To obtain the latter, we calculated the intake per adult equivalent of 11 key micro and macro-nutrients.[14] We then divide the intake by the needs to obtain a measure of deficiency by nutrient; this ratio is made equal to 1 when the intake exceeds the need and is below one in case of nutrient deficiency. Finally, we averaged the deficiency across nutrients, reverse it and standardize the measure to ease its interpretation.[15] The table shows ITT effects of the five treatments but we will focus our attention on the four treatments that include a savings training and on the test of their joint significance. All the coefficients of interest are positive, with varying degree of significance. The variations could be due to different effects between treatments on different well-being indicators or simply to random variation and measurement errors. Hence we combine the four measures into one economic well-being composite index, using a principal component analysis (the factor loadings appear in table A3). We can see In column 5 that each one of the four treatment of interest had a positive and significant effect on the well-being index, and they are also jointly significant at 5 percent. The magnitude is large but plausible, with an effect of the interventions that ranges between 0.2 and 0.33 standard deviations. Thus we find strong positive effects of the savings interventions on well-being, which is in line with numerous prior studies on the positive effects of savings accounts (Dupas and Robinson, 2013a,b; Prina, 2013; Brune et al., 2014).

[14] The nutrients are calories, protein, calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, vitamin C and thiamin (vitamine B1). Their deficiency has been identified as a source of malnutrition in developing countries with potentially severe consequences on health and cognitive development (Singh, 2004; Müller and Krawinkel, 2005; Harper, 2006; Deaton and Drèze, 2009; Kumssa et al., 2015).

[15] We found an average deficiency of 14.4% across all nutrients, but 96.8% of households are defficient in at least one nutrient.

Table 3: ITT effects on well-being indicators

VARIABLES	(1) Per capita daily consumption (MZN)	(2) Total assets (MZN)	(3) Made housing improvement (dummy)	(4) Nutrition index	(5) Principal component of the 4 measures
Voucher (T1)	10.2**	10,410	0.046*	0.18**	0.34***
	(4.05)	(7,950)	(0.023)	(0.075)	(0.10)
Information (T2)	7.84*	11,067*	0.030	0.17**	0.29**
	(3.97)	(6,000)	(0.023)	(0.078)	(0.11)
Voucher & Info (T3)	3.42	12,430**	0.024	0.13	0.20*
	(3.57)	(5,792)	(0.027)	(0.079)	(0.11)
Match (T4)	8.39*	8,315	0.083***	0.21**	0.33***
	(4.35)	(6,989)	(0.030)	(0.090)	(0.12)
Voucher & Match (T5)	3.85	822	0.066**	0.18**	0.21**
	(3.40)	(6,052)	(0.030)	(0.074)	(0.093)
Observations	1,533	1,543	1,543	1,543	1,533
p-val joint significance of 4 savings treatments	0.22	0.19	0.053	0.079	0.031
mean in control group	77.3	68947	0.25	-0.021	-0.023

Note: *** p<0.01, ** p<0.05, * p<0.1. Each regression includes fixed effects for stratification cell (groups of three localities) and no other control. Standard errors (clustered at level of 94 localities) in parentheses. Vouchers for agricultural inputs distributed one time, at start of 2010-2011 agricultural season (Sep-Dec 2010). Information treatment administered in Mar-Jul 2011. Match treatment provides temporary high interest rates in Aug-Oct 2011 and Aug-Oct 2012. All outcome variables are averages from surveys administered in Sep 2012, and August 2013 (the two years following the beginning of the interventions. During study period Approximately 1 USD = 27 Mozambican meticais (MZN). The outcome variable in column 3 is a dummy for whether any improvement was made by the household in its housing. The nutrition index goes down when the household intake in micro and macro nutrients is below its needs. The variables of the last two columns are standardized.

[Forthcoming: Benefit-Cost analysis of the intervention]

5.2 Effects of trainings on accounts and savings at BOM and at other banks

The second prediction of the model states that trainings will increase the use of the promoted technology from the provider of the trainings, but also from its competitors. This is a direct test of the key mechanism of the model. If the increase in the demand for the technology is shared with competitors, it discourages any provider to fund a technology on its own and share the benefits. To test this, we run regression 18 on account ownerships and savings, at BOM and in other banks. Column 1 to 3 of table 4 show that any of the four treatments increased significantly the probably of owning an account by between 15 and 23 percentage points in BOM. This roughly corresponds to doubling the proportion of account owners compared to the control group. Moreover, account ownerships in other banks also

increased significantly, by 6 to 9 percentage points.

In columns 4 to 7, we examine the effects of the interventions on savings at BOM and in other banks. We measure savings at BOM either from administrative data shared by BOM (column 4), or from self-declared savings from our survey data. It appears that farmers tend to over-declare the amounts that they save, since the averaged self-declared amounts are more than double the savings recorded by our administrative data. Although, the coefficients of the treatments can vary substantially, any of the two measure leads to the same conclusion about which intervention had a significant impact on savings. Hence we feel relatively confident that we can use self-declarations to learn about the savings behaviour of the study participants, including savings in banks other than BOM. In column 5 and 6, we see that the four savings treatments significantly increased savings both at BOM but also at its competitors. Strikingly, most additional formal savings mobilized by the savings treatments, in terms of money amounts, are occurring at institutions other than the partner bank (BOM), as can be seen by comparing coefficients in columns 3 (BOM savings) and 4 (other bank savings). Depending on the treatment, the increase in other banks is about two to four times greater than the increase in savings at BOM. Hence not only the externality is happening, but it is very sizable, and the majority of the increase in savings did not benefit the provider of the training. For robustness, in columns 8 to 10, we present similar regressions using the log of savings amounts and also find that the savings treatments generated a significant increase in savings at BOM as well as at other banks. Here the coefficients appear greater for the savings at BOM, but it is essentially driven by the fact that savings at BOM in the control group are almost three times lower than savings in other banks, making the changes of savings at BOM appear larger in relative terms.

Table 4: ITT effects of treatments on accounts and savings balances at BOM and other banks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Dummy for having formal bank account .			Total value of savings balance (MZN) …				Log (1+x) of savings balance (MZN) …			
VARIABLES	at BOM	at other bank	at any bank	at BOM (admin data)	at BOM	at other banks	at any bank	at BOM (admin data)	at BOM	at other banks	at any bank
Voucher (T1)	0.022	0.048	0.062*	7.04	8.98	783*	771	0.10	0.083	0.36*	0.42*
	[0.022]	[0.029]	[0.031]	[33.7]	[86.3]	[464]	[498]	[0.13]	[0.11]	[0.20]	[0.23]
Information (T2)	0.15***	0.085***	0.20***	81.1	231	958*	1,175*	0.81***	0.80***	0.45**	1.06***
	[0.039]	[0.029]	[0.041]	[49.1]	[141]	[522]	[605]	[0.22]	[0.21]	[0.21]	[0.29]
Voucher & Info (T3)	0.15***	0.066**	0.18***	75.6*	404***	1,602***	2,249***	0.81***	0.87***	0.50**	1.14***
	[0.042]	[0.032]	[0.042]	[44.2]	[129]	[566]	[645]	[0.22]	[0.19]	[0.22]	[0.28]
Match (T4)	0.21***	0.089***	0.22***	243***	465***	1,008*	1,719***	1.35***	0.96***	0.54**	1.24***
	[0.046]	[0.031]	[0.049]	[73.6]	[155]	[543]	[602]	[0.28]	[0.24]	[0.22]	[0.32]
Voucher & Match (T5)	0.23***	0.058*	0.20***	378***	446***	1,173**	1,644**	1.49***	0.99***	0.60***	1.32***
	[0.050]	[0.030]	[0.046]	[74.3]	[129]	[583]	[638]	[0.29]	[0.22]	[0.22]	[0.30]
Observations	1,543	1,543	1,532	1,543	1,543	1,543	1,543	1,543	1,543	1,543	1,543
p-val joint significance of 4 savings treatments	0.0001	0.0450	0.0000	0.0001	0.0035	0.0580	0.0035	0.0000	0.0000	0.0600	0.0001
mean in control group	0.17	0.20	0.33	145	375	1629	2152	1	0.91	1.24	1.96

Note: *** p<0.01, ** p<0.05, * p<0.1. Each regression includes fixed effects for stratification cell (groups of three localities) and no other control. Standard errors (clustered at level of 94 localities) in parentheses. Vouchers for agricultural inputs distributed one time, at start of 2010-2011 agricultural season (Sep-Dec 2010). Information treatment administered in Mar-Jul 2011. Match treatment provides temporary high interest rates in Aug-Oct 2011 and Aug-Oct 2012. The outcome variables of col 4 and 8 are from administrative data provided by BOM (our partner organization implementing the trainings) on balances in sept 2012 and aug 2013. All other outcome variables are averages from surveys administered in Sep 2012, and August 2013 (the two years following the beginning of the interventions). During study period Approximately 1 USD = 27 Mozambican meticais (MZN).

For comparison, we analyze the increase in savings generated by the agro-input subsidy (T1). It appears that the increase in wealth generated by the voucher lead to an increase in savings, which indicates a positive income elasticity. But strikingly, most of this increase occurred in banks other than BOM. This tells us that, to some extent, the trainings provided by BOM succeeded in generated an increase in demand that is more oriented towards BOM than what results from an intervention that was neutral to all banks. However this orientation is far from being sufficient to fully eliminate the positive spillover towards the competitors. In the conclusion, we discuss the potential role of branding and gaining market shares in the trainings.

In this subsection, we find that the trainings increased the use of savings, both in the extensive margin (use of accounts) and in the intensive margin (amounts saved), but a large part of this increase is concentrated in other banks. This indicates that the beneficiaries learned from the financial education trainings and became more willing to own and use a savings account. However, many participants did not feel obliged to use the services of the training providers and turned to other suppliers. This is the most direct smoking gun evidence of the existence of the spillover to the competition which should discourage private firms from providing the training on their own.

5.3 Effects of trainings conditional on the distance to BOM and to its competitors

The theoretical model includes predictions about how the spillover varies depending on the distance of the clients to the providing bank and its closest competitor. The marginal effect of the training on the demand for a competing firm is predicted to be higher for clients located farther away from the firm that provides the training and closer to the competing firm. How the proximity of a competitor changes the marginal effect of the training on the demand of its provider is more ambiguous. On one side the proximity of the competitor takes away from the provider some of the demand that its training had raised. But on the other side, at equilibrium, the competitor already provided some training, or at least learning by doing and diffusion of knowledge from observation of other consumers. This exposure thanks to the activity of the competitors raised the willingness to pay of some clients, bringing them closer to being convinced to purchase the technology, thus increasing the marginal effect of the training on the demand for the technology. In order to test these predictions, as described in section 4.2, we sent our enumerators to travel using public transportation (as typically used by farmers) along all the paths, from each village to its closest BOM branch and to the branch of the closest competitor. We measured the costs in time and money and aggregated it into a distance index. In this section we analyze how these indexes of distance to BOM and to its closes competitor affect the impact of the training on the demand of savings services towards BOM and its competitors.

We do this using the following regression:

$$Y_{ijk} = \alpha + \beta_1 anysav_{jk} + \beta_2 ldistBOM_{jk} + \beta_3 anysav * ldistBOM_{jk} + \beta_4 ldistother + \beta_5 Anysav * ldistother_{jk} + \theta_k + \epsilon_{ijk} \quad (19)$$

where $anysav_{jk}$ is a dummy equal to one if the locality j in stratification cell k received any of the savings treatment (T2, T3, T4 or T5), $ldistBOM_{jk}$ is the log of distance indicator (cost in time and money) to reach the closest BOM branch from locality j, and $ldistother_{jk}$ is the log of the distance indicator to reach the closest branch other than BOM.[16] The use of the log of the distances mimics the gravity model, which has been shown to perform well in predicting how distance affects transactions. To test the predictions of the model, we focus on β_3 and β_5, which tell us about heterogeneity of the

[16] Given that the interactions are more demanding in power, we now pool the four treatments of interest into one, in order to test for heterogeneity with respect to distances. This appears to make sense in this situation given that the impact of the four treatment arms on savings outcomes followed similar patterns.

savings treatments with respect to the distance indexes. We present the results of this specification in table 5. We find that the effect of the spillover on accounts and savings (in level or logs) in other banks increase with the cost to reach BOM and decreases with the cost to reach another bank. This is intuitive and closely maps the predictions of the model. We also find that the benefits of the training for its provider is greater when provide to clients who are closer the competitors. This is at first sight counter-intuitive and in contradiction with standard competition models, but we showed in our theory section that it is a possible outcome, if the competition helped raise the willingness to pay of the clients prior to the start of the training. Hence the heterogeneity in treatment effects with respect to the distance to the banks is consistent with the patterns predicted by the theory model.

Table 5: ITT effects of savings interventions conditional on distance to the banks

	(1)	(2)	(3)	(4)	(5)	(6)
	Accounts (avg 2012-3) …		Savings (avg 2012-3)		Log (1+x) of savings balance …	
VARIABLES	at BOM	at other banks	at BOM	at other banks	at BOM	at other banks
Any savings * cost to reach BOM	0.073	0.091**	-40.0	1,659**	0.28	0.78***
	[0.048]	[0.040]	[159]	[641]	[0.27]	[0.27]
Any savings * cost to reach other bank	-0.12***	-0.13***	-115	-1,067**	-0.67***	-0.88***
	[0.037]	[0.048]	[130]	[500]	[0.21]	[0.33]
Any savings intervention (T2-T5)	0.29	0.15	935	-2,561	2.13	0.36
	[0.27]	[0.20]	[1,011]	[3,352]	[1.56]	[1.31]
cost to reach BOM	0.28***	0.038	1,242***	463	1.75***	0.49
	[0.066]	[0.069]	[308]	[1,408]	[0.45]	[0.55]
cost to reach other bank	-0.12**	-0.021	-797**	-75.9	-0.79**	-0.23
	[0.054]	[0.070]	[323]	[1,131]	[0.35]	[0.53]
Observations	1,539	1,539	1,539	1,539	1,539	1,539
mean in control group	0.16	0.20	375	1629	0.91	1.24

Note: *** p<0.01, ** p<0.05, * p<0.1. Each regression includes fixed effects for stratification cell (groups of three localities) and no other control. Standard errors (clustered at level of 94 localities) in parentheses. "Any savings intervention" includes treatment 2 to 5, i.e the information treatments and matched savings treatments (both with and without voucher). The outcome variables are averages from surveys administered in Sep 2012, and August 2013 (the two years following the beginning of the interventions). During study period Approximately 1 USD = 27 Mozambican meticais (MZN).

5.4 Adding controls to test the robustness of the effect of distance and additional heterogeneity of impact

The results of the previous subsection show patterns of heterogeneity of treatment with respect to distances that are consistent with the predictions of the theoretical model. However the distance to the different types of banks can be correlated with many characteristics of the households, which may be the actual cause of the observed heterogeneity with respect to the distances. A perfect identification

of the how the distance to the banks modifies the treatment effects would require an exogenous variation in the distance to the banks, which is clearly out of reach in this study. Hence this set of results must be interpreted with caution. Still, we can at least control for the most obvious correlates that may drive this heterogeneity. For example, one may be concerned that the other banks located themselves close to wealthier or more educated populations, because they expected a greater demand from this type of population.[17] This would provide an alternative explanation for why the effect of the savings training on savings at BOM is greater when clients are closer to a competitor.

We introduce a set of controls in order to test the robustness of the effects of distance, but also in order to learn more about other drivers of the heterogeneity of treatment effects and examine whether they are consistent with the story of the model. In table 6 we replicate regression 19, and control for measures of wealth, education, cognitive ability and knowledge about banks, each one alone and interacted with the savings treatments dummy. The measures, which are further described below, all come from the baseline survey, before the assignment of farmers to any of the savings interventions. For conciseness, we only present the results on the log of savings in BOM and in other banks.[18] Looking at the first two coefficients of each column, we find that the size and significance of β_3 and β_5 remain very similar to the results that we show in table 5 and discuss in the previous section. They are robust to the introduction of each one of the controls (alone and interacted with savings treatments dummy) as well the introduction of all controls together (column 9 and 10). Hence these most obvious possible confounds are not driving the heterogeneity of impact described in the previous section.

We now turn our attention to the coefficients of these controls and in particular, of the interacted ones. The first two columns introduce the value of assets at baseline, which is the same measure as the one analyzed in table 3 and is a proxy for the wealth of the beneficiaries. The effect of the treatments on formal savings is greater for wealthier farmers. In the context of the model, one can consider that $\bar{w}$, the true benefit from owning a savings account, should be increasing in the wealth of beneficiaries because farmers with more money to save can benefit more from having a banking account. Hence once a wealthy farmer can learn about about savings through the training, her willingness to pay and demand should increase more than the one of a poor farmer.

In column 3 to 6, we introduce the level of education of the household head and a measure of the

[17] For this to be an issue, it requires not only that the characteristics are correlated with distance to the closest bank, but that BOM differs from other banks in the characteristics of its closest clients, which occur if BOM tends to target a different population.

[18] The regressions on accounts and on savings in levels lead to similar robustness and conclusions on the effects of the four controls (results available from the authors upon request).

respondent's cognitive skills. To measure the latter, we included a digit span forwards and backwards test in our baseline survey. The digit span presents the advantages of being a more direct proxy of cognitive ability than education, which may be affected by other factors. [19] The fifth prediction of the model states that the treatment effect of the savings interventions should be greater for individuals who learn faster because of higher education or cognitive skills. We find that the effect on savings at BOM increase by 7% with each additional year of education, and the treatment increases savings by about 20% more when the cognitive ability score increases by one standard deviation. This is consistent with the fifth prediction of the model, where the effects of the intervention is due to learning and hence should be enhanced by cognitive abilities.

The last control variable is added with the intention to better understand the finding that the proximity to a competitor increases the marginal effect of the training (prediction 4). We argue in the theory section that this can be due to the fact that the activity of the other banks may have raised the WTP of its neighboring households, making them more inclined to be convinced by the training to start using the technology or to increase their use. We do not have a measure of the WTP for savings accounts, but we have a proxy for the attitude towards formal savings. In our baseline questionnaire, we asked what are the main obstacles for the respondent to have and use a savings account. The respondents could chose up to three answers among a set of possible answers. We categorize as lacking basic knowledge about formal savings respondents who mentioned that they don't know where the banks is, how to use a savings account, feel intimidated by the bank or are driven away by the bureaucracy to open an account.[20] The dummy is negatively correlated with owning a savings account at baseline (p=0.000), and slightly less than 20% of the respondents are classified as lacking basic information about savings. We use it as a proxy to identify the most financially illiterate clients. The training included only one session per year with all farmers, and two sessions per year with its representatives during two years. Hence the training is unlikely to be sufficient to convince a complete novice to start using formal savings. Indeed, in column 7 and 8, we find that the effect of the

[19] The digit span test measures short-term memory and executive functioning. The enumerator is asked (without visual aid) to repeat a series of numbers that the enumerator reads to them. It starts with a 3 number series with the series, becoming progressively longer as long as the respondent manages to repeat the series correctly. The score obtained corresponds to the longest series of digits that was repeated correctly. Afterwards, the respondent is asked to repeat different series backwards (starting from a 2 number series and again gradually increasing the length of the series). We use the average of the two scores and normalize it to facilitate the interpretation of its coefficients. Laajaj and Macours (2017) show the reliability and validity of this measure of cognitive skills when used in field surveys in developing countries.

[20] The full question was "For you, what are the main obstacles to have and use a savings account? 0 = none; 1 = does not have money to deposit; 2 = doesn't know where the bank is; 3 = distance to the branch office; 4 = doesn't know how to use a savings account; 5 = feel intimidated by the bank; 6 = high bureaucracy required by the bank to open a savings account; 7 = other"

training on savings is significantly lower for the farmers who lacked basic information about savings, which is consistent with the fourth prediction of the model.

Table 6: ITT effects of the savings interventions conditional on distance and other controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log (1+x) of savings balance at …									
VARIABLES	BOM	other banks	BOM	other banks	BOM	other banks	BOM	other banks	BOM	other banks
Any savings * cost to reach BOM	0.28	0.60**	0.40	0.81***	0.26	0.73***	0.31	0.82***	0.41	0.68***
	[0.26]	[0.25]	[0.27]	[0.26]	[0.27]	[0.26]	[0.27]	[0.27]	[0.26]	[0.24]
Any savings * cost to reach other bank	-0.69***	-0.87***	-0.75***	-0.77**	-0.67***	-0.83**	-0.68***	-0.90***	-0.82***	-0.81***
	[0.19]	[0.28]	[0.25]	[0.33]	[0.21]	[0.32]	[0.21]	[0.33]	[0.22]	[0.28]
Any savings intervention (T2-T5)	0.77	0.72	1.64	-0.32	2.26	0.40	2.18	0.34	0.27	0.12
	[1.59]	[1.64]	[1.50]	[1.32]	[1.58]	[1.27]	[1.58]	[1.32]	[1.55]	[1.67]
cost to reach BOM	1.78***	0.69	1.51***	0.72	1.74***	0.56	1.77***	0.52	1.52***	0.87**
	[0.45]	[0.44]	[0.47]	[0.52]	[0.44]	[0.53]	[0.44]	[0.55]	[0.46]	[0.43]
cost to reach other bank	-0.82**	-0.32	-0.65	-0.48	-0.79**	-0.29	-0.78**	-0.23	-0.63	-0.49
	[0.34]	[0.44]	[0.41]	[0.52]	[0.35]	[0.51]	[0.34]	[0.53]	[0.38]	[0.43]
Any savings * assets	0.15***	0.039							0.18***	0.054
	[0.054]	[0.080]							[0.058]	[0.086]
Total assets (MZN)	0.063**	0.36***							0.055	0.31***
	[0.029]	[0.068]							[0.034]	[0.071]
Any savings * educ			0.070**	0.016					0.039	-0.0065
			[0.033]	[0.037]					[0.034]	[0.039]
Educ of hh head (yrs)			-0.012	0.15***					-0.0080	0.12***
			[0.023]	[0.028]					[0.023]	[0.031]
Any savings * cog					0.22**	0.20			0.14	0.13
					[0.091]	[0.12]			[0.097]	[0.14]
cognitive ability (digit span)					-0.071	0.22**			-0.082	0.030
					[0.064]	[0.094]			[0.064]	[0.12]
Any savings * Lacks knowl.							-0.45*	-0.61*	-0.40	-0.62*
							[0.26]	[0.31]	[0.28]	[0.31]
Lacks basic knowledge on banks							0.11	-0.037	0.10	0.037
							[0.17]	[0.25]	[0.17]	[0.27]
Observations	1,539	1,539	1,455	1,455	1,535	1,535	1,539	1,539	1,452	1,452

Note: *** p<0.01, ** p<0.05, * p<0.1. Each regression includes fixed effects for stratification cell (groups of three localities) and no other control. Standard errors (clustered at level of 94 localities) in parentheses. "Any savings intervention" includes treatment 2 to 5, i.e the information treatments and matched savings treatments (both with and without voucher). The outcome variable the average from surveys administered in Sep 2012, and August 2013 (the two years following the beginning of the interventions). Cognitive ability is measured using digit span forward and backward. Lack of basic knowledge is equal to 1 for the 20% farmers who answered as key obstacles to using a banking account that they don't know where the banks is, how to use a savings account, feel intimidated or are driven away by the bureaucracy to open an account.

6 Discussion and Conclusion

In this paper we provide a theoretical model where the provision of a training for a new technology will lead to an increase in demand for this technology, which will be shared with other providers. We find clear evidence of this phenomena occurring in the case of savings account in Mozambique, and show a number of patterns consistent with the theoretical model. The theoretical argument is relatively straightforward, but we believe that the model still contributes to a better understanding. First it provides clear testable implications that guides the regressions and their interpretation. Second, one may argue that an easy fix to the externality issue is to provide trainings only to the potential clients

located closer to the provider than to its competitors. This argument holds when distance is the only determinant of which provider a client would go to.[21] The free-riding issue emerges under the presence of other determinants of the choice of provider, which are not observable, limiting the possibility for the training provider to target only clients that would purchase the technology from him. This extension to the hotelling model explains why being fully able to chose the location and intensity of trainings is only a partial fix to the free-riding issue.

We believe that our way of modeling training and its positive externality to the competition is particularly adapted to the developing context. In developed countries, most communication exercises promote the brand and specificity of the product of the company compared to the one of its competitors. Such training aims at signaling that one's technology is better than the one of its competitors. In practice, most forms of training or publicity include a mix of branding and information about the technology. The former aims at increasing market share of the provider and has a negative externality for its competitors; and the latter increases the total demand and has a positive externality. In many rural developing contexts, given the scarcity of sources of information and low education, it makes little sense to invest in convincing potential clients that one's brand is better than the other before raising awareness about the general usefulness of the technology and explaining how to use it. Whether the positive spillover of information should dominate the negative effect of branding in this context is an empirical question. In this context, our results indicate that there is some branding effect of the training because it generates a demand more oriented towards BOM than the increase in savings generated by the agro-input vouchers. However we find that the positive spillover on competitors clearly dominates the negative one. Interestingly, even the match savings, which included a payment for savings at BOM was not sufficient for BOM to capture all the increase in the demand.

This paper provides a new explanation for the low diffusion of technologies: in the presence of competition, this spillover results in free riding and under-provision of trainings, and of any type of intervention that may address the information constraint and raise demand for all providers of the technology. This corresponds to a concern that we heard in the field from providers of financial services as well as agro-inputs. It has been argued by AGRA and other organizations that the providers of the technology need to be involved in interventions that inform their potential clients about the technologies because their incentives are well aligned. Indeed their incentives may be better aligned

[21] It is quite straightforward to see from the model that in the absence of τ , agents who want to purchase a technology would always go the closest provider, and trainings would be implemented exactly until the client who is equidistant to the provider, without any free-riding issue.

than, for example a public extension service, but not sufficiently for them to provide the optimal amount of training on their own. Our results provide an explanation for why, in spite of the numerous evidence that information is a key constraint to technology adoption and that training is an effective way to address this constraint, we find limited evidence of training provision initiated by the private sector. Our findings provide a justification for learning subsidies and interventions that can increase the coordination between the providers of the technology (or a combination of the two).

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Online Appendix

Appendix 1: Demonstration of the calculation of $\theta_1(k_i)$

In areas where the demand for firm 1 and firm 2 overlap, $\theta_1(k_i)$ tells us the share of the demand that goes to firm 1. Here we demonstrate how $\theta_1(k_i)$ is calculated.

The condition that tells us how the demand split is the following, $p + d_{1i} + \tau_{1ij} < p + d_{2i} + \tau_{2ij}$ and we know that preferences $\tau_{1ij}|i \sim U[0,\eta]$ & $\tau_{2ij}|i \sim U[0,\eta]$ and they are orthogonal.

Using $k_i = d_{1i} - d_{2i}$, for any location i, the condition can be simplified to:

$$k_i < \tau_{2ij} - \tau_{1ij} \tag{20}$$

In other terms, if firm 1 is farther from firm 2, the preference for buying from firm one must at least compensate for the difference in distance, and if firm 1 is closer, the difference in the preferences should not compensate for this distance advantage.

Because for a given location, τ_{1ij} and τ_{2ij} are uniform over $[0,\eta]$ and orthogonal, graphically the probability of obtaining any combination (τ_{1ij}, τ_{2ij}) can be represented by a square with a side of size $[0,\eta]$ with density $\frac{1}{\eta^2}$. First of all, because $\tau_{2ij} - \tau_{1ij}$ is bounded between $-\eta$ and η, it is straightforward to see that the condition is always satisfied for clients located in $k_i < -\eta$ (hence $\theta_1(k_i) = 1$) and never satisfied when $k_i > \eta$ (hence $\theta_1(k_i) = 0$).

When $k_i \in [-\eta, \eta]$, $\theta_1(k_i)$is given by the share of the square that satisfies the condition in equation 20 (see figure A1). This share is represented by the following equation:

$$\theta_1(k_i) = \int_{\tau_{1ij}=0}^{\eta} \int_{\tau_{2ij}=0}^{\eta} 1\left(k_i < \tau_{2ij} - \tau_{1ij}\right) \frac{1}{\eta^2} d\tau_{2ij} d\tau_{1ij} \tag{21}$$

Where $1\left(k_i = d_{1i} - d_{2i}\right)$ is a dummy equal to 1 if the condition is satisfied. We can simplify it as follows:

$$\theta_1(k_i) = \frac{1}{\eta^2} \int_{\tau_{1ij}=0}^{\eta} \int_{\tau_{2ij}=0}^{\eta} 1\left(\tau_{2ij} > k_i + \tau_{1ij}\right) d\tau_{2ij} d\tau_{1ij} \tag{22}$$

We must distinguish the cases where k_i is positive and negative.

We start with the case where $k_i \in [0,\eta]$.

Because $\tau_{2ij} \leq \eta$, the condition $1\left(\tau_{2ij} > k_i + \tau_{1ij}\right)$will never be satisfied when $\tau_{1ij} > \eta - k_i$, hence

we can restrict equation 22 to:

$$\theta_1(k_i) = \frac{1}{\eta^2} \int_{\tau_{1ij}=0}^{\eta-k_i} \int_{\tau_{2ij}=0}^{\eta} 1\left(\tau_{2ij} > k_i + \tau_{1ij}\right) d\tau_{2ij} d\tau_{1ij} \tag{23}$$

We apply the condition the condition $1\left(\tau_{2ij} > k_i + \tau_{1ij}\right)$by restricting the integral to the area that satisfies it:

$$\theta_1(k_i) = \frac{1}{\eta^2} \int_{\tau_{1ij}=0}^{\eta-k_i} \int_{\tau_{2ij}=k_i+\tau_{1ij}}^{\eta} 1 \; d\tau_{2ij} d\tau_{1ij}$$

And simplify it as follows:

$$= \frac{1}{\eta^2} \int_{\tau_{1ij}=0}^{\eta-k_i} \eta - k_i - \tau_{1ij} \; d\tau_{1ij}$$

$$= \frac{1}{\eta^2} \left[\tau_{1ij}\left(\eta - k_i\right) - \frac{\tau_{1ij}^2}{2} \right]_0^{\eta-k_i}$$

$$\theta_1(k_i) = \frac{\left(\eta - k_i\right)^2}{2\eta^2} \tag{24}$$

Writing it as $\frac{1}{\eta^2} \frac{(\eta-k_i)^2}{2}$we can see that it is the density multiplied by half the square of side $\eta - k_i$, as it can be seen in figure A1.

In the case where $k_i \in [0, \eta]$ graphically, the corresponding area is represented in figure A2.

Because the condition is always satisfied when $\tau_{1ij} < -k_i$, we can divide the area into two integrals and simplify it to obtain:

$$\theta_1(k_i) = \frac{1}{\eta^2} \int_{\tau_{1ij}=0}^{-k_i} 1 d\tau_{1ij} + \int_{\tau_{2ij}=-k}^{\eta} \eta - k_i - \tau_{1ij} d\tau_{2ij} d\tau_{1ij}$$

Following calculations similar to the previous demonstration, we obtain:

$$\theta_1(k_i) = \frac{1}{2} - \frac{k_i^2}{2\eta^2} - \frac{k_i}{\eta}$$

We can also re-write the last equality as:

$$\theta_1(k_i) = 1 - \frac{\left(\eta + k_i\right)^2}{2\eta^2} \tag{25}$$

which is consistent with what we should obtain by symmetry between firm 1 and firm 2, where k_i of one firm is equal to $-k_i$ of its competitor, and the sum of the 2 demands is equal to 1.

Hence we obtain:

$$\theta_1(k_i) = \begin{cases} 1 & if\ k_i < -\eta \\ \frac{(\eta-k)^2}{2\eta^2} & if\ -\eta < k_i < 0 \\ 1 - \frac{(\eta+k)^2}{2\eta^2} & if\ 0 < k_i < \eta \\ 0 & if\ k_i > \eta \end{cases} \tag{26}$$

Table A1: Timeline

Period	Activities
Aug-Sept 2010	Selection of beneficiaries
Nov 2010	Vouchers Distribution
April 2011	"Baseline" survey
May 2011	Beginning of Savings Information training sessions (also applied to MS
May-July 2011	Harvest 2011
Aug 2011	First Follow-up Survey
Aug-Oct 2011	MS 3 month period
May-July 2012	Harvest 2012
Aug 2012	2nd Follow-up Survey
Aug-Oct 2012	2nd MS period
May-July 2013	Harvest 2013
Aug 2013	3rd Follow-up Survey

MS refers to the Matched Savings Intervention

Table A2: Impact of treatments on attrition from follow-up surveys

Dependent variable: Attrition from...	(1) 1st follow-up survey	(2) 2nd follow-up survey	(3) 3rd follow-up survey	(4) 2nd *and* 3rd follow-up
Voucher (T1)	-0.010	0.054	0.010	0.002
	[0.024]	[0.034]	[0.025]	[0.018]
Information (T2)	-0.006	0.021	-0.023	-0.006
	[0.024]	[0.025]	[0.017]	[0.014]
Voucher & Info (T3)	0.006	0.019	-0.006	-0.017
	[0.024]	[0.027]	[0.019]	[0.013]
Match (T4)	-0.008	0.048*	0.004	0.003
	[0.026]	[0.028]	[0.021]	[0.016]
Voucher & Match (T5)	0.010	0.034	-0.015	-0.007
	[0.027]	[0.027]	[0.025]	[0.019]
Observations	1,589	1,589	1,589	1,589
p-val joint significance of 4 savings treatments	0.960	0.479	0.360	0.590
mean in control group	10.0%	11.0%	6.9%	3.5%

Note: *** p<0.01, ** p<0.05, * p<0.1 Standard errors (clustered by 94 localities) in parentheses. Each regression includes fixed effects for stratification cell (groups of three localities) and no other control. Dependent variable is an indicator equal to 1 if respondent attrited from given follow-up survey (i.e., attrition is always with respect to initial study participant list).

Table A3: Scoring coefficients in Principal Component Analysis of well-being indicators

Variable	Scoring coefficient
Per capita daily consumption (MZN)	0.6819
Total assets (MZN)	0.3146
Made housing improvement (dummy)	0.1856
Nutrition index	0.6338

Scores of variables estimating economic well-being when using a Principal Component Analysis