Nudging Farmers to Use Fertilizer: Evidence from Kenya

Esther Duflo, Michael Kremer, and Jonathan Robinson*

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Many policymakers advocate heavy subsidies to boost fertilizer use and raise agricultural productivity. In contrast, most economists assume that farmers already take advantage of potential profit opportunities, and argue that heavy subsidies are distortionary, environmentally unsound, regressive, and lead to politicization and inefficiency in fertilizer supply. In earlier work, we show that fertilizer is profitable for farmers in Western Kenya. Yet, usage is low, pointing to possible inefficiencies. In this paper, we build a model with a small fixed cost of purchasing fertilizer in which some farmers are present-biased and partially naïve. Farmers therefore procrastinate, postponing purchasing fertilizer until proceeds from the harvest are spent. Consistent with the model, small time-limited reductions in the cost of purchasing fertilizer at the time of harvest induce substantial increases in fertilizer use, as much as considerably larger price cuts later in the season. Such small time-limited discounts could help present-biased farmers commit to fertilizer use without substantially distorting decisions of non-procrastinating farmers and incurring other costs of heavy subsidies.

* The authors are respectively from MIT (Department of Economics and Abdul Latif Jameel Poverty Action Lab); Harvard, Brookings, CGD, J-PAL, and NBER; and UC Santa Cruz and J-PAL. We thank John Ikoluot, Edward Masinde, Chris Namulundu, Evite Ochiel, Andrew Wabwire, and Samwel Wandera, for outstanding fieldwork, Jessica Cohen, Anthony Keats, Jessica Leino, Owen Ozier, and Ian Tomb for excellent research assistance, and International Child Support (Kenya), Elizabeth Beasley and David Evans for work setting up the project. We thank Abhijit Banerjee for his persistent encouragement and many extremely helpful conversations, as well as Orley Ashenfelter, Rachel Glennerster, and seminar participants at Berkeley, EBRD, LSE, Northwestern, UCSD, and USC.

"The rest of the world is fed because of the use of good seed and inorganic fertilizer, full stop. This technology has not been used in most of Africa. The only way you can help farmers get access to it is give it away free or subsidize it heavily."

Stephen Carr, former World Bank specialist on Sub-Saharan African agriculture, quoted in Dugger, 2005.

Many agricultural experts see use of modern inputs, in particular fertilizer, as key to agricultural productivity. Pointing to the strong relationship between fertilizer use and yields in test plots, they argue that fertilizer generates high returns and that dramatic growth in agricultural yields in Asia and the stagnation of yields in Africa can largely be explained by increased fertilizer use in Asia and continued low use in Africa (Morris, Kelly, Kopicki, and Byerlee, 2007; Anderson, Herdt, and Scobie 1985, 1988; Hopper, 1993); Tomich, Kilby, and Johnston, 1995). Based on this logic, Ellis (1992) and Sachs (2004) argue for fertilizer subsidies. Many governments have heavily subsidized fertilizer. In India, for example, fertilizer subsidies amounted to 0.75% of GDP in 1999–2000 (Gulati and Narayanan, 2003). In Zambia, fertilizer subsidies consume almost 2% of the government's budget (World Development Report, 2008).

In contrast, the Chicago tradition associated with Schultz (1964) starts with the presumption that farmers are rational profit maximizers, so subsidies will distort fertilizer use away from optimal levels. Others have argued that fertilizer subsidies create large costs beyond these Harberger triangles. They are typically regressive as wealthier farmers and those with more land often benefit most from subsidies (Donovan 2004) and loans for fertilizer often go to the politically connected and have low repayment rates. While moderate fertilizer use is environmentally appropriate, overuse of fertilizer induced by subsidies can cause environmental damage (World Bank 2007). Furthermore, fertilizer subsidies may lead to government involvement in fertilizer distribution, politicization, and very costly failures to supply the right kind of fertilizer at the right time (Ellis 1992; Bates, 1981).

In part due to the dominance of the anti-subsidy view among economists and international financial institutions, fertilizer subsidies have been rolled back in recent decades. Recently, however, they have seen a resurgence. For example, after Malawi's removal of fertilizer subsidies was followed by a famine, the country reinstated a two-thirds subsidy on fertilizer. This was followed by an agricultural boom which many, including Jeffrey Sachs, attribute to the restoration of the fertilizer subsidies (Dugger, 2007).

A key assumption in the Chicago tradition case against fertilizer subsidies is that farmers would use an optimal quantity of fertilizer without subsidies. To reconcile low fertilizer use with the large increases in yield from fertilizer use found in agricultural research stations, many economists note that conditions on these stations differ from those on real-world farms, and returns may be much lower in real conditions, where farmers cannot use other inputs optimally. There is evidence that fertilizer is complementary with improved seed, irrigation, greater attention to weeding, and other changes in agricultural practice, that farmers may have difficulty in implementing. However, in previous work we implemented a series of trials with farmers on their own farms in a region of Western Kenya where fertilizer use is low. Those trials showed that, when used in limited quantities, fertilizer generates 70% annual returns, on average (Duflo, Kremer, and Robinson, 2008), even without other changes in agricultural practices. Low investment rates in the face of such high returns are particularly puzzling since fertilizer is well-known and long-used in the area. Moreover, since fertilizer is divisible, standard theory would not predict credit constraints would lead to low investment traps in this context.[2] There could of course be fixed costs in buying or learning to use fertilizer (for example, making a trip to the store). Indeed, small fixed costs of this type will play an important role in our model. However, such costs would have to be implausibly large to justify the lack of fertilizer investment in the standard model.[3]

In this paper we argue that just as behavioral biases limit investment in attractive financial investments in pension plans by workers in the United States (Choi, Laibson, Madrian, and Metrick, 2002, Choi, Laibson and Madrian, 2008), they may limit profitable investments in fertilizer by farmers in developing countries. We set out a simple model of biases in farmer decision-making inspired by models of procrastination from the psychology and economics literature (see O'Donoghue and Rabin, 1999). In the model some farmers are (stochastically) present-biased and at least partially naïve, systematically underestimating the odds that they will be impatient in the future, at least in the case when they are patient today. Going to the store, buying fertilizer and perhaps deciding what type of fertilizer to use and how much to buy, involves a utility cost. Even if this cost is small, so long as farmers discount future utility, even farmers that plan to use fertilizer will choose to defer incurring the cost until the last moment possible, if they expect to still be willing to purchase the fertilizer later. However, farmers who end up being impatient in the last period in which buying is possible, will then fail to invest in fertilizer altogether.

[2] Indeed, profits are likely concave rather than convex in fertilizer use per acre. Since farmers always have the option of applying fertilizer intensely on some land while leaving other pieces of land unfertilized, returns must be non-increasing.

[3] For instance, consider a farmer making \$1 a day (with an average hourly wage of \$0.13 over an 8 hour workday) for whom it takes 1 hour to travel to town to buy fertilizer and who can only initially afford \$1 worth of fertilizer. In Duflo, Kremer, and Robinson (2008), we show that using ½ teaspoon top dressing fertilizer yields returns of 36.0% over approximately 3 or 4 months. Even assuming that the farmer only uses fertilizer once per year, netting out the lost wages would leave the farmer with a 23% rate of return over a few months.

We find suggestive evidence that farmers behave this way: after participating in on-field farm trials, 97% of farmers say that they will use fertilizer in the next season but only 38% actually follow through on these plans. Similarly, 79% of farmers say that they do not use fertilizer because they can't afford it, even though fertilizer is divisible and all farmers have at least some income immediately after the harvest.

The model implies that if offered just after harvest, when farmers have money, small, time-limited discounts on fertilizer could induce sizeable changes in fertilizer use. In particular early discounts of the same order of magnitude as the psychic costs associated with fertilizer purchase can induce the same increase in fertilizer use as in much larger discounts of the order of magnitude of the out-of-pocket costs of fertilizer later in the season. Moreover ex ante (before the harvest) farmers would choose to be eligible for the discount early on, so as to have an option to commit to fertilizer use. In collaboration with International Child Support (Kenya) an NGO, we designed and tested a program based on these predictions and compared it to alternative interventions, such as fertilizer subsidies or reminders to use fertilizer. The results are consistent with the model, and a simple calibration exercise suggests that about 71% of farmers are stochastically present-biased, that about 16% are always patient, and that about 13% are always impatient. This yields a prediction that roughly 55% of farmers should never use fertilizer in the seasons we follow them. The corresponding empirical figure is 52% of comparison farmers do not use fertilizer in any season for which we have data.[4]

[4] An alternative possibility, which we cannot distinguish empirically, is that 13% of farmers have land which is unsuitable for fertilizer.

While the particular interventions tested are probably too expensive for wide-spread adoption, the model suggests that a "paternalistic libertarian" (Thaler and Sunstein, 2008) approach of small time-limited discounts could potentially help time-inconsistent farmers commit themselves to invest in fertilizer while avoiding large distortions in fertilizer use among time-consistent farmers and the fiscal, environmental and political economy costs of large subsidies.

Although this paper focuses on behavioral barriers to fertilizer use, we do not see this as the only barrier to adoption, and in fact believe that these individual behavioral barriers may interact with uncertainty about how best to use fertilizer to create a powerful obstacle to social learning. In another paper in progress we note that in our context social learning about fertilizer use is limited at best. A program which allowed farmers to experiment with fertilizer on their own farms increased their own fertilizer usage, but had very limited spillover effects on their neighbors or those with whom they reported discussing agriculture. As discussed in the last section, we argue that the behavioral biases we highlight here may contribute to an environment in which farmers do not invest in discussing agriculture with their neighbors.

The rest of the paper is structured as follows. Section Two presents background information on agriculture and fertilizer in Western Kenya. Section Three presents a model in which behavioral biases may lead to procrastination in individuals' decisions whether to use fertilizer. Section Four describes the Savings and Fertilizer Initiative (SAFI) and the experimental design. Section Five reports results on the impact of the program on fertilizer use and argues they are consistent with the model. Section Six examines alternative hypotheses. Finally, we conclude with a discussion of the potential policy implications.

2. Background on Fertilizer use in Western Kenya

Busia District is a relatively poor area in Western Kenya. Maize is the staple food and is most farmers' main crop. There are two agricultural seasons each year. The major agricultural season is the "long rains" (from March/April to July/August). The "short rains" (from July/August until December/January), is a shorter, less productive, season. Soil fertility is relatively low and, based on evidence from experimental model farms (see Kenyan Agricultural Research Institute, 1994)[5], the Kenyan Ministry of Agriculture recommends that farmers use hybrid seeds and fertilizer both at planting and as top dressing when the maize plant is knee-high, approximately 1-2 months after planting.[6] Fertilizer is available in small quantities at market centers (and occasionally in local shops outside of market centers.) Our rough estimate is that the typical farmer would take roughly 30 minutes of walking to reach the nearest market center.

Experiments based on actual farmer plots, suggest that real-world farmers may in fact find it difficult to profitably use the high levels of fertilizer and the combination of hybrid seed and fertilizer at planting and top-dressing that the Ministry of Agriculture recommends. We find low, even negative returns to this, although it is plausible that returns might be higher if farmers changed other farming practices. However, a more conservative strategy of using only ½ teaspoon of fertilizer per plant as top dressing, after it is clear that seeds have

[5] The two main fertilizer varieties that are used are Di-Ammonium Phospate (DAP), which is applied at planting, and Calcium Ammonium Nitrate (CAN), which is applied as top dressing.

[6] The long rains planting is 2 to 3 months after the short run harvest, and maize is top-dressed roughly 5 months after the harvest. The short rains planting is about 1 month after the long rains harvest, and maize is top-dressed takes place 2-3 months after the harvest

germinated, yields an average return of 70% on an annualized basis on real-world farms even in the absence of other complementary changes in farmer behavior, (Duflo, Kremer, and Robinson, 2008). This suggests that while there may well be a role for learning about how to change farming practices in ways that are complementary with large amounts of fertilizer, farmers could profitably use modest amounts of fertilizer. [7]

Despite, these large potential returns of fertilizer when used correctly, only 40% of farmers in our sample report ever having used fertilizer and only 29% report using it in at least one of the two growing seasons before the program.[8]

When asked why they do not use fertilizer, farmers rarely say fertilizer is unprofitable, unsuitable for their soil, or too risky: Instead, they overwhelmingly reply that they want to use fertilizer but do not have the money to purchase it. In small-scale agricultural trials we conducted, only 9% said that fertilizer was unprofitable while 79% reported not having enough money. At first this seems difficult to take at face value: fertilizer can be bought in small quantities (as low as one kilogram) and with annualized returns of 70%, investing a small amount and investing the proceeds would eventually yield sufficient money to rapidly generate sufficient funds to fertilize an entire plot. Even poor farmers could presumably reallocate some of the proceeds of their harvest from consumption to fertilizer investment.

[7] In Duflo, Kremer, and Robinson (2008) we estimate that the increase in absolute income from using fertilizer at top dressing on the amount of land that the average farmer devotes to maize (which is 0.93 acres in our data) would be Ksh 1,100 ($33 at PPP), a little over a months' wage.

[8] These figures differ slightly from the results presented in Duflo, Kremer, and Robinson (2008) because we use a different sample of farmers.

One way to reconcile farmers' claims that they do not have money to buy fertilizer with the fact that even poor farmers have resources available at the time of harvest is that farmers may intend to save in order to purchase fertilizer later but fail to follow through on those plans. In fact, 97.7% of farmers who participated in the demonstration plot program reported that they planned to use fertilizer in the following season. However, only 36.8% of them actually followed through on their plans and used fertilizer in the season in which they said they would. Thus, it appears that even those who are initially planning to use fertilizer often have no money to invest in fertilizer at the time it needs to be applied, for planting or top dressing, several months later.[9]

3. Model

Below we propose a similar model of procrastination similar to those advanced to explain the failure of many workers in developed countries to take advantage of profitable financial investments (O'Donoghue and Rabin, (1999)) and derive testable implications. In the model, some farmers are present biased, with a rate of time preference which is stochastically determined every period. When they are very present-biased, farmers consume all they have. When they are moderately present biased, farmers make plans to use fertilizer. But early in the season, patient farmers overestimate the probability that they will be patient again, and thus they postpone the purchase of fertilizer until later, and save in cash instead. Later, if they turn out to be impatient, they consume all of their savings instead of investing in fertilizer, resulting in a lower rate of usage of fertilizer than the farmer in the early period would have wanted.

[9] Of course, farmers could also have reported an intention to use fertilizer due to social desirability bias.

3.1 Assumptions

Preferences and Beliefs

Suppose that some fraction of farmers γ discount the future at an exponential rate which is lower than the annualized rate of return to fertilizer. An additional fraction of farmers ψ are impatient and have discount rates which are higher than the return to fertilizer, and so never use fertilizer.

The remaining proportion, $1-\gamma-\psi=\phi$, are (stochastically) present-biased, and systematically understate the extent of this present bias. In particular suppose that in period k, these farmers discount every future period at a stochastic rate β_k (for simplicity we assume that there is no discounting between future periods). In each period k, with some probability p, the farmer is fairly patient $(\beta_k=\beta_H)$, and with probability $(1-p)$, the farmer is quite impatient $(\beta_k=\beta_L)$. Furthermore, while farmers do recognize that there is a chance that they will be impatient in the future, they overestimate the probability that they will be patient. Specifically, the probability that a patient farmer believes that she will still be patient in the future is $\tilde{p}>p$. Impatient farmers could also overestimate the probability that they will be patient in the future, but as we will see below it is not necessary in the model. Finally, for simplicity, we assume per-period utility in any period is simply consumption in that period, less the utility cost described below.

Timing and Production

There are three periods. In *period 1*, the farmer harvests maize, receives income $x > 1$; and decides how much to consume, how much to save, and whether to purchase fertilizer for the next season. Saving is costless and has no return. We treat the decision to buy fertilizer as binary: the farmer either buys 1 unit of fertilizer or none. Purchasing one unit of fertilizer in period 1 costs 1, plus a utility cost f (encompassing the cost of deciding what type of fertilizer to use and how much to buy, as well as the time cost of going to the shop to get it). We assume f is small relative to the out-of-pocket cost of fertilizer.

In *period 2*, which can be thought of as the time of planting for the next season, farmers receive no income but can consume out of their savings. Those with at least wealth 1 can buy fertilizer (at price 1, plus utility cost f).

In *period 3*, farmers receive y if they have purchased fertilizer, and zero otherwise.

Assumptions on Parameters

We assume:

$$\beta_h y > 1 + f \qquad (1)$$

and

$$\beta_L y < 1 + \beta_L f. \qquad (2)$$

The first condition ensures that a patient farmer prefers using fertilizer to not using fertilizer, even if it has to be purchased right away. The second ensures that an impatient farmer will prefer to consume now rather than to save in order to invest in fertilizer, even if it is possible to delay the decision and shopping costs of purchasing fertilizer to a future period.

3.2 Results

By assumption (1), the γ farmers who are always patient will always use fertilizer. By assumption (2), the ψ farmers who are always impatient will never use fertilizer.

We now consider the problem of a present-biased farmer deciding whether (and when) to buy fertilizer. To solve the model, we work backwards, beginning with the problem of a farmer in period 2, who must choose between consuming one unit, or investing it in fertilizer. Assumption (1) implies that a farmer who has sufficient wealth and is patient in period two will use fertilizer. Assumption (2) implies that a farmer who is impatient in period 2 will not use fertilizer.

Now consider the problem of a farmer in period 1. First, observe that a farmer who is impatient in period 1 will consume x, and will not save any money: seen from period 1, the gain from saving one unit is at best $\beta_L y - \beta_L f$ (if the farmer ends up being patient and buys fertilizer), which, by assumption (2), is smaller than 1 (the loss in consumption in period 1 from purchasing fertilizer).

Now consider a farmer who is patient in period 1. Investing in fertilizer today dominates consuming everything today: the farmer's utility if she purchases 1 unit of fertilizer and consumes the rest is $x - 1 - f + \beta_H y$, while her utility is x if she consumes everything today. By assumption (1), utility from buying fertilizer is higher than not buying.

Now, in period 1, should a patient farmer buy the fertilizer right away, or plan to wait to do it in period 2? If a farmer who is patient today has a sufficiently high subjective probability of being patient again (and therefore a high probability of buying fertilizer in period two), then it is best to postpone paying the utility cost. To see this, note that if the farmer waits, ends up being patient in period 2, and thus purchases fertilizer (which she believes will happen with probability $\tilde{p}$), her utility is $x - 1 + \beta_H(y - f)$. If she ends up being impatient (which she believes will happen with probability $1 - \tilde{p}$), her utility is $x - 1 + \beta_H$. Thus her expected utility from postponing buying fertilizer is greater than her expected utility from purchasing immediately if:

$$x - 1 + \tilde{p}(\beta_H f + \beta y) + (1 - \tilde{p})\beta_H > x - 1 - f + \beta_H y.$$

Rearranging, we obtain:

$$f(1 - \tilde{p}\beta_H) > \beta(y - 1)(1 - \tilde{p}).$$

When $\tilde{p} = 0$, the right hand side is equal to $\beta_H(y - 1)$. If we assume that the utility cost of using fertilizer is small enough that $\beta_H(y - 1)$ is larger than f, then the left hand side of the inequality is larger than the right hand side. Both sides of the inequality decline with $\tilde{p}$, but the right hand side is steeper. For $\tilde{p} = 1$, the left hand side is larger than the right hand side (which is equal to zero) Thus, there is a $\tilde{p}^*$ in the interval (0,1) such that for every $\tilde{p} > \tilde{p}^*$, a farmer who is intending to use fertilizer later prefers to save in the saving technology with no return in period 1, and plans to buy fertilizer in period 2.

Note that since impatient period one farmers will not save in any case, it is not necessary that people believe they will be more patient in the future than they are in the present for this procrastination problem to arise. Instead, it is only necessary that patient farmers overestimate the probability that they will continue to be patient in the future. This particular form of naiveté seems intuitively appealing, since it just requires that people somewhat overestimate their own tendency to be consistent over time: it may be easy for people who are patient today to believe that their future selves will tend to be more patient than they actually will. This tendency to believe that future tastes will more closely resemble current tastes than they actually will, termed projection bias, has found considerable empirical support (Loewenstein, O'Donoghue, and Rabin, 2003),

Impact of Time-Limited Discount

Now, assume that $\tilde{p} > \tilde{p}^*$, so that if the costs of purchasing fertilizer are equal in each time period, a farmer who is patient in period 1 will postpone the purchase until period 2. Consider the impact of a discount on fertilizer, valid in period 1 only. In order to make the farmer indifferent between purchasing fertilizer in period 1 and saving one unit for the period 2 farmer, the discount δ_1 needs to be such that:

$$f - \delta_1 = \beta_H (y-1)(1-\tilde{p}) + \tilde{p} f \beta_H.$$

To see whether this needs to be a large discount, in relationship to the return to fertilizer, divide both sides by $y - 1$:

$$\frac{f - \delta_1}{y-1} = \beta_H (1-\tilde{p}) + \frac{\tilde{p} f \beta_H}{y-1}.$$

When $\tilde{p}$ is close to 1 (which is the condition under which the farmer will need a discount in period 1 to purchase fertilizer in period one, assuming f<< 1), the discount thus needs to be roughly proportional to the utility cost of using fertilizer, rather than to the cost of fertilizer itself.

To see this, note that as $\tilde{p}$ approaches 1, the necessary discount approaches $\delta_1 = f(1 - \beta_H)$. The intuition is that the only additional cost that a farmer who has patient in period 1 has to immediately bear when choosing between saving one unit and buying one unit of fertilizer is the utility cost of purchasing the fertilizer. Thus, the farmer just needs to be compensated for incurring the decision and shopping cost f up front, rather than later. Even a small discount, or a reduction in the utility cost (such as free delivery in period 1) may then be sufficient to induce the farmer to switch to buying fertilizer in period 1, instead of relying on her period 2 self to purchase fertilizer .

What will be the effect of an (unanticipated) discount on fertilizer in period 2 on an eventual purchase? If it is unanticipated, it will not affect the period 1 decision. An impatient period 2 farmer will decide to use fertilizer if $f - \delta_2 = \beta_L y - 1$. In order to induce fertilizer purchase, the discount now needs to be large enough to compensate an impatient farmer for postponing one unit of consumption, not only for incurring the utility cost f: it now needs to be commensurate with 1-$\beta_L y$.Thus, a small discount in period 1 will have a larger effect on adoption of fertilizer than a small discount in period 2, and as large an effect as a large discount in period 2.

Finally, let us examine what will happen if the farmer can commit ex-ante to the date at which she gets a small discount $\delta = \delta_1$. To do this we introduce a period 0 (before the period

1 harvest) when the farmer must decide when the discount will be offered. Regardless of whether the farmer in period 0 is impatient or patient, she equally values consumption in periods 1 through 3. Thus, viewed from period 0, the farmer would like to use fertilizer in period 2, and is indifferent between paying the cost of purchasing the fertilizer in period 1 or in period 2. For any discount smaller than δ_2, she believes that, with probability $1-\tilde{p}$, the period 2 farmer will not purchase fertilizer if the responsibility is handed over by the period 1 farmer. In turn, as long as $\tilde{p} > \tilde{p}^*$, she knows that, in the absence of the discount, with probability $1-\tilde{p}$, she will not buy fertilizer in period 1 either, even if she is patient. Therefore, the period zero time-inconsistent farmer will request the discount in period 1, in order to induce the patient farmer to act in period 1, and tie the hands of period 2 farmers.

In the simplest model, the fraction γ of farmers who are always patient would be indifferent between getting the free delivery in period 1 and period 2. However, if they could potentially invest at a positive return between periods one and two or had any option value for delaying investments in fertilizer in case more pressing needs arose, these farmers would want to save, and request late delivery of fertilizer.

To summarize, the model gives rise to the following predictions.

1. Some farmers will make plans to use fertilizer but will not subsequently follow through on their plans.
2. Farmers will switch in and out of fertilizer use.
3. A reduction in the utility cost of using fertilizer in period 1 will increase fertilizer purchases and usage more than a similar reduction offered in period 2, A larger

subsidy will be needed in period 2 to induce the same increase in usage as a small subsidy in period 1.

4. When farmers are offered ex-ante the choice between a discount in period 1 and a discount in period 2, they will choose a discount in period 1.

4. Testing the Model

As noted above, there is some empirical evidence if favor of predictions 1 and 2: in a sample of farmers who participated in the demonstration plot program, two thirds of those who had made plans to use fertilizer do not end up carrying through with these plans (implication 1). We also find significant switching between using and not using fertilizer (implication 2): 24.2% of farmers who did not participate in any treatment transition between using and not using fertilizer from the main growing season to the next year's main growing season. Suri (2007) finds similar results in a nationally representative sample.

Predictions 3 and 4 of the model suggest that some simple interventions could have large impacts on fertilizer use. To test these predictions, we collaborated with International Child Support (ICS) – Africa, a Dutch NGO which has a long-lasting presence in Western Kenya, and which was well known and respected by farmers, to design and evaluate a program which would encourage fertilizer use if farmers did indeed behave according to the model. To test the predictions of the model, we implemented two versions of the program, and compared it with alternative interventions, such as a fertilizer subsidy and reminder visits.

The SAFI Program

The main program was called the Savings and Fertilizer Initiative (SAFI) program. The program was first piloted with minor variations over several seasons on a very small scale with the farmers that participated in the experiments described in Duflo et al. (2008). In these pilot programs, we focused on acceptance of the program and willingness to buy from ICS.[13] In 2003 and 2004, the program was implemented on a larger scale, to more precisely estimate its impact on fertilizer usage.

- Basic SAFI

In its simplest form, the SAFI program was offered at harvest, and offered free delivery of any combination of planting or top dressing fertilizer. The basic SAFI program worked as follows: a field officer visited farmers immediately after harvest, and offered them an opportunity to buy a voucher for fertilizer, at the regular price,[14] but with free delivery. The farmer had to decide during the visit whether or not to participate in the program, and could buy any amount of fertilizer.[15] To ensure that short term liquidity constraints did not prevent farmers from making a decision on the spot, farmers were offered the option of paying either in cash or in maize (valued at the market price). To avoid distorting farmers' decision by offering free maize marketing services, farmers also had the option of selling maize without purchasing fertilizer. Across the various seasons, the majority (66%) of those that purchased fertilizer through the program bought with cash, which suggests that maize was not overvalued in the program. Participating farmers chose a delivery date and received a

[13] Below, we will show some results from these pilot programs.

[14] At the time of this project, 1 kg of planting fertilizer (CAN) cost 30 Kenyan shillings (about US $0.43) and 1 kg of top dressing fertilizer (DAP) cost 35 shillings (US $0.50).

[15] The largest quantity of fertilizer purchased through the program was 36 kilograms.

voucher specifying the quantity purchased and the delivery date. Choosing late delivery would provide somewhat stronger commitment to use fertilizer since fertilizer can potentially be re-sold (at some cost) and the vouchers themselves were non-transferable.

The basic SAFI program could have reduced the utility cost of fertilizer use, and thus reduced procrastination, in two ways. First, it can save a trip to town to buy fertilizer, which is typically about a 30 minute trip from the farmers' residences. Suri (2007) argues that distance to a fertilizer provider accounts for her surprising finding that those who would have had the highest return to fertilizer use are some of the least likely to use fertilizer. Fertilizer is typically available in major market centers around the time it is needed for application for maize crops. Since most farmers travel to market centers occasionally for shopping or other errands, they could pick up fertilizer.[16]

Second, and more speculatively by requiring an immediate decision during the field officer's visit, and offering a simple option the program may have reduced time spent thinking through which type of fertilizer to use, and in what quantity.

- SAFI with ex-ante choice of timing

To test prediction 4 of the model, in the second season of the experiment, farmers were visited *before* the harvest (period 0 in our model) and offered the opportunity to decide when they wanted to be visited again later to receive a SAFI program: farmers were told that, during this visit, they would have the opportunity to pay for fertilizer and to choose a delivery

[16] On average, farmers who bought fertilizer through the SAFI program bought 3.7 kilograms of fertilizer (at a total cost of 135 Kenyan shillings), which is an amount that could easily be carried so it is unlikely that a farmer would have to arrange for transportation for an amount that small. It would take the average farmer roughly an hour to walk to town, buy fertilizer, and walk back. For a farmer who makes $1 a day over an 8 hour workday, the SAFI program would save her about $0.13 in lost work time, or about 10% of the cost of the fertilizer.

date. As discussed earlier, in a standard exponential model, farmers would be expected to choose a late visit: those who want to use fertilizer would then save for fertilizer in period 1, and be prepared for fertilizer purchase in period 2. If farmers were present-biased but completely naïve, they would also have chosen a late delivery date, since they expect to be patient in the future. This would lead to low ultimate adoption. In our model, even farmers who perceive a very small probability of being present-biased in the future will chose to get the delivery option in period 1 as long as they know they have some chance to be patient in period 1 and impatient in period 2, and the ultimate impact of SAFI with ex ante choice of timing on fertilizer use should be similar to that of the basic SAFI.

4.2 Experimental Design

To test the prediction of the model, the two versions of the SAFI programs were implemented as part of a randomized field experiment. The sample frame consisted of parents of children enrolled in grades 5 and 6 in 16 schools in Busia district, Western Kenya. The school provided information on one contact parent per child (about half the parents on the list were fathers, and half were mothers), and farmers were randomly selected from this contact list. The program was then offered to this individual farmer, but data was collected on all the plots farmed by the household.[17]

[17] In monogamous households, husband and wife typically farm one common plot. In polygamous households (26.6% of our sample), the husband and each wife typically farm separate plots, but share resources to some extent. Fertilizer bought by the sampled farmer could therefore have been used on someone else's plot. Below we consider that a household uses fertilizer if fertilizer is used on any of the plots

The experiment took place over two seasons. In the first season (after the 2003 short rain harvest, in order to facilitate fertilizer purchase for the 2004 Long Rains season), a sample of farmers was randomly selected to receive the basic SAFI program. The randomization took place at the individual farmer level after stratification by school, class, and participation in two prior agricultural programs (a program to provide farmers with small amounts of fertilizer in the form of "starter kits" which they could use on their own farm, and a program to set up demonstration plots on the school property).

In the following season (the 2004 short rains), the program was repeated, but with an enriched design to test the main empirical predictions of the model in Section 3 as well as some predictions of alternative models. All treatment groups were randomized at the individual level after stratification for school, class, previous program participation, and 2003 treatment status.

First, a new set of farmers was randomly selected to receive a basic SAFI visit. Second, a group of farmer was offered SAFI with ex ante choice of timing (as described above)

Third, to test the hypothesis that small reductions in the utility cost of fertilizer have a bigger effect if offered in period 1, another group of farmers was visited close to the time fertilizer needs to be applied for top dressing (approximately 2-4 months after the previous season's harvest, the equivalent of period 2 in our model), and offered the option to buy fertilizer with free delivery. To calibrate the effect of a discount, a fourth group of farmers was visited during the same period, and offered fertilizer at a 50% discount. This allows us to compare the effect of a 50% subsidy to the effect of the small discount offered by the SAFI program. In all of these programs, farmers could choose to buy either fertilizer for planting, top dressing, or both. However, one caveat to bear in mind is that in the late visits, many farmers had already planted, and could only use top dressing fertilizer in that season. If farmers preferred fertilizer at planting, however, they could have bought planting fertilizer for use in the next season, so a standard model would suggest that these farmers should have taken advantage of the discount for later use.

Finally, in each of the intervention groups as well as in the comparison group, a random subset of farmers was offered the option to sell a set quantity of maize at a favorable price to the field officer before the program took place. As we discuss in more detail in section 6 below, the objective of this additional treatment was to test the alternative hypothesis that the SAFI program was just seen by the farmers as a safer way to protect their savings than available alternatives. The purchase of maize put some cash in the hands of the farmers who accepted the offer, which is more liquid than maize, and thus arguably easier to waste. If the main reason why farmers purchased fertilizer under the SAFI program is because of a aversion to hold liquidity, the purchase of maize should have encouraged them to take SAFI up. Under our model, this would make no difference, however.

Figures 1 summarize the experimental design for this second season.

5. Results

5.1 **Data and Pre-Intervention Summary Statistics**

The main outcome of interest is fertilizer use, with fertilizer purchase through the program as an intermediate outcome. We have administrative data from ICS on fertilizer purchase under the program. Data on fertilizer use was collected at baseline (before the 2003 short rains harvest) for that season and for previous season. We later visited farmers to collect fertilizer usage data for the three seasons following the first SAFI program (i.e. both seasons in 2004 and 1 season in 2005). The baseline data also included demographic and some wealth characteristics of the sampled households. In households where different members farm different plots (which is typically the case in polygamous household), we asked each member individually about fertilizer use on their own plot, and we asked the head of the household (the husband) about fertilizer use on each plot. The data is aggregated at the household level.

Table 1 shows descriptive statistics. In season one, 211 farmers were eligible to participate in the basic SAFI program and 713 farmers constituted a comparison group. In season two, 228 farmers were eligible to participate in the basic SAFI program, 235 were eligible for the SAFI with ex ante choice of timing; 160 were offered fertilizer at the normal retail price with free delivery at top-dressing time; and 160 were offered fertilizer at half price with free delivery at top dressing time. An additional 141 farmers served as a comparison group.

There were some relatively minor pre-treatment differences between groups in each season. In season one 43% of both SAFI and comparison groups had previously ever used fertilizer. However, there were some pre-treatment differences in other observables: comparison group farmers had 0.6 more years of education (a difference which is significant at the 10% level), and were about 5% less likely to live in a home with mud floors, mud walls, or a thatch roof, (though only the difference in the probability of having a mud floor is statistically significant, at 10%).[18]

[18] Appendix Table 1 suggests attrition patterns were similar across groups. Regressions of indicators for appearance in the pre-treatment background and post-treatment fertilizer adoption questionnaires on being sampled for treatment yield no significant differences between groups. Overall, 1,232 farmers were sampled,

In season two, the comparison group was more likely to have used fertilizer prior to the program. (Table 1, Panel B) The point estimate for previous fertilizer usage is 51% for the comparison group, but only between 38% and 44% for the various treatment groups. Many of these differences are significant at the 10% level (the difference is significant at 5% for the 50% subsidy group). In addition, the comparison group has significantly (at 10%) more years of education than the group offered SAFI with the ex ante timing choice.

These pre-treatment differences are in general relatively minor, and would, if anything, bias our estimated effects downwards. We present results with and without controls for variables with significant differences prior to treatment – in all cases, the inclusion of these controls does not substantially affect our results.

5.2 The SAFI Program

The SAFI program was popular with farmers. In season one, 31% of the farmers who were offered SAFI bought fertilizer through the program. In season 2, 38% bought fertilizer through the basic version, and 44% when offered the ex ante choice of timing. The fraction of farmers who purchase fertilizer is of course not equal to the impact of the program on use: Some program farmers who were going to use fertilizer anyway presumably bought fertilizer through SAFI, to take advantage of the free delivery. In addition, some farmers may not have used fertilizer purchased through SAFI on their maize crop: they could have kept it, sold it, used it on some other crop, or the fertilizer could have been spoiled. In the 2005 adoption

and we obtained adoption data for 925 of them (75.1%). There were few refusals. Nearly all of those who do not appear in the dataset were not known by other parents in the school and so could not be traced, or were not at home when ICS enumerators visited their homes.

questionnaire: 76.6% of the farmers who purchased fertilizer under SAFI reported using it on their own plot, 7.3% on the plot of their wife or husband, and 8.1% reported saving the fertilizer for use in another season. The remainder reported that they had used the fertilizer on a different crop (1.6%) or that the fertilizer had been spoiled.

Overall, in both seasons, the SAFI program had a significant and fairly sizeable impact on fertilizer use. In season one 45% of farmers offered the SAFI program report using fertilizer in that season, compared to 34% of those in the comparison group. The 11 percentage point difference is significant at the 1% level. (See Table 1, Panel A). In season two (the 2004 short rains), the basic SAFI program increased adoption by 10.5% (Panel B Table 1): 39% of farmers offered SAFI in the second season bought fertilizer under the program.

Table 3 confirms these results in a regression framework. For season 1, we run regressions of the following form:

$$y_i = \alpha + \beta_1^{LR} T_{1_i}^{LR} + X_i + \epsilon_i \, , \qquad (3)$$

where y_i is a dummy indicating whether the household of farmer i is using fertilizer, $T_{1_i}^{LR}$ is a dummy indicating whether farmer i was offered the SAFI program in season 1, and X_i is a vector of control variables, including the school and class from which the parent was sampled, education of the primary respondent, previous fertilizer usage, gender, income, and whether the farmer's home has mud walls, a mud floor, or a thatch roof, and whether the farmer received s starter kid in the past.[19] The table presents fertilizer usage statistics for the season of the program, and the two subsequent seasons.

Both specifications suggest a positive and significant program impact on fertilizer adoption in season one: the specification with sparser controls suggests that the program led to an 11.4 percentage point increase in fertilizer adoption, while that with fuller controls suggests a 14.3 percentage point increase. Both are significant at the 1% level. Given a baseline usage rate of 24.7% (last row, Table 3), these effects represent a 46-58% increase relative to the comparison group.

The remaining columns show that the SAFI program does not have persistent impacts: in the short rains of 2004, and the long rains of 2005 (the two subsequent seasons), fertilizer usage drops back to the level of the comparison group. This lack of persistence would be expected under our model, since the only role of SAFI in this program is to induce the farmer to buy the fertilizer early in the season, rather than later. In contrast, in learning by doing models, and models of credit constraints, inducing use in one period would in general affect the state variables of wealth and knowledge and thus future behavior.

Panel B shows the impact of the SAFI program in the second season on fertilizer usage. The regression has the same form as for the season one regression, but includes dummies for all the other SAFI treatments, and controls for a dummy for long rains treatment status (${T_1}_i^{LR}$):[20]

$$y_i = \alpha + \beta_1^{SR} T_{1i}^{SR} + \beta_2^{SR} T_{2i}^{SR} + \beta_3^{SR} T_{3i}^{SR} + \beta_4^{SR} T_{4i}^{SR} + \beta_5^{SR} B_i^{SR} + \beta_6^{SR} (B_i^{SR} * T_1^{SR}) + \beta_7 X_i + \epsilon_i \quad (4)$$

[19] The starter kit was an intervention conducted in a previous season, which we discuss in a companion paper. It involved distributing a small quantity of fertilizer to farmers to let them experiment with fertilizer.

In this regression, T_{1i}^{SR} represents the basic SAFI program, and T_{2i}^{SR} through T_{4i}^{SR} represent the other treatment groups: respectively SAFI with ex ante choice of timing; the visit at top-dressing time which offered fertilizer at full price: and the visit at top-dressing time which offered fertilizer with a 50% subsidy. The dummy B^{SR} is a dummy equal to 1 if the farmer was offered the opportunity to sell maize at above market price during the post-harvest visit.[21] As before, we present regressions with and without full sets of controls, for Season 1 (before the programs were offered), Season 2 (the season the programs were offered), and Season 3 (one season after the programs were offered).

The first row in panel B, columns (3) and (4) show the impact of the basic SAFI program on adoption of fertilizer in the season it was offered. Without control variables, the point estimate for the effect (18 percentage points) is even larger than in the first season. Since, as we saw earlier, adoption was slightly greater in the comparison group before the program was introduced, the point estimate of the effect increases slightly when controlling for past adoption, to 21.3 percentage points. Given a baseline usage rate of 29.7% in the comparison group, these effects represent proportional increases of 61%-72%. Columns (1) and (2) show that, reassuringly, there is no difference in adoption across SAFI groups in the season before it was offered. Columns (5) and (6) replicate the results found for the first season: the impact of the SAFI program is not persistent.

These results suggest that a properly timed reduction in the utility cost of using fertilizer can substantially increase adoption. Free delivery saves the farmer a trip to the nearest market town to get the fertilizer, and since taking advantage of free delivery required deciding on the

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[20] Treatment was stratified by prior treatment status.

[21] 50.7% of the farmers accepted the offer and did sell some maize to the field officer.

type and quantity of fertilizer to order during the visit, the program may have reduced the cost of time spent making these decisions and thus the chance of procrastination on those costs. It is therefore plausible that the reason why this program increased adoption is time inconsistency and procrastination as posited in the model.

The second row of panel B reports the impact of the SAFI with ex ante choice of timing on fertilizer adoption. The model predicts that, as long as $\tilde{p} > 0$, even quite naïve farmers ($\tilde{p} < p$) would want to induce their period 1 selves to purchase fertilizer by requesting the offer of free delivery at that time: farmers who are planning to use fertilizer and know they may sometimes be time-inconsistent will then request early delivery. Under the model, farmers who know they are time consistent and plan to use fertilizer should be indifferent, but factors outside the model such as the option value of using the money otherwise suggest they would probably request late delivery. Overall SAFI with the ex ante choice of timing should thus have the same impact on fertilizer take up as the basic SAFI.[22] If anything, the effect of "SAFI with ex ante timing choice" on fertilizer use is stronger than that of the basic SAFI program (26% versus 21%), though the difference is not significant.

The statistics on purchase shed some light on those results. Overall, 44% of farmers purchased fertilizer under SAFI with ex ante timing choice (compared to 38% without timing choice). Almost half of the farmers (44%) asked the field officer to do so immediately after

[22] This prediction is related, but slightly different that that of Ariely and Wertenbroch's (2002) finding that students allowed to choose assignment deadlines in advanced choose deadlines that help them space their work and perform better than those who cannot choose a deadline, but worse than those who were imposed evenly spaced deadline. In their experiment, students did not choose deadlines that were optimal from the point of view of maximizing the performance on those assignments (imposing spaced deadlines maximizes their performance).

harvest, and 46% of those actually bought fertilizer. 52% of farmers requested late delivery and 39% of those who requested late delivery eventually purchased fertilizer (the remaining 4% declined to participate in the SAFI). The group of farmers requesting late delivery is likely composed of two types of people: the fraction γ farmers who are time consistent and always want to use fertilizer, and for whom late delivery is probably optimal since it does not reduce the chance of adopting fertilizer in normal conditions, but provides flexibility to deal with shocks (outside the model), and a remaining group of farmers who do not intend to use fertilizer (for example because the know that the probability that they will be impatient in the future is very high), but want to keep the option open.

These results are important because they help rule out some alternative stories: the fact that almost half the farmers chose early delivery is an indication of preference for commitment, which is predicted by our model and not predicted by a standard exponential model. The fact that the effect of the SAFI with ex ante choice of timing is at least as large as the effect of the basic SAFI helps rule out an "impulse purchase" effect in which when farmers are offered fertilizer at harvest, when they have money and maize, they feel "flush" and buy it without thinking, as an impulsive purchase (under this hypothesis, if the field officers had offered beer or dresses at that point, they would have bought those). The pre-harvest season is known as the "hungry season", and the field officer is not proposing that the farmer buys anything at this point, but that she contemplates buying fertilizer in the future: thus, the decision on when to call the field officer back is clearly not an impulsive decision.

Thus, the impact of the two versions of the SAFI suggest that time inconsistency and procrastination may play a role in explaining low fertilizer use. To rule out alternative explanation of the role SAFI played in inducing farmers to use fertilizer, in season two, we tried two alternative programs with random subsets of the farmers, which allow us to test alternative hypotheses, and additional implications of the model.

5.2. Free Delivery, Free Delivery with Subsidy

Both versions of the SAFI program offered free delivery. Our interpretation is that the resulting decrease in the utility cost of using fertilizer is small enough that it would be unlikely to induce large changes in fertilizer use in a purely time-consistent model. However, an alternative explanation is that the free delivery is a substantial cost reduction.[23] To test this hypothesis and test prediction 4 in our model, we offered free delivery later in the season (corresponding to period 2), and free was less popular than delivery with a 50% subsidy.

As shown in table 1, panel B, free delivery later in the season did not lead to fertilizer purchases from ICS as often as under the SAFI program (20% under free delivery vs 39% in the SAFI). When offered a 50% subsidy late in the season, 46% of farmers bought fertilizer.[24] Table 3 (columns 3 and 4) presents the impact of the different programs on fertilizer use, and shows very consistent results: The offer of free delivery late in the season increased fertilizer

[23] Another situation where the SAFI program could have significant impact on fertilizer use without helping partially naïve farmers solve a time-inconsistency problem is the Banerjee-Mullainathan (2008b) model, where the long run utility gain of using fertilizer are small due to endogenous non-convexity in the utility function. In this case, even a small utility cost of using fertilizer will be sufficient to discourage farmers from using fertilizer. In this case, reducing the utility cost could potentially increase fertilizer use a lot.

[24] As mentioned earlier, one issue when interpreting these results is that fertilizer can be used either at planting or at top dressing (when the plant is knee high), or both. Since farmers in the subsidy and full price groups were visited after planting, it was too late for them to buy planting fertilizer for use in that season (however, while very few of the farmers who were offered fertilizer at full price at topdressing bought planting fertilizer, 17% of the farmers offered the subsidy actually bought planting fertilizer - presumably to either sell it or use it in a future season. By contrast, SAFI farmers could chose between planting and top dressing fertilizer, or could get both. This would complicate interpretation of the comparison between the programs if fertilizer at top dressing were not effective. However, our earlier estimates (Duflo, Kremer, Robinson, 2008) suggest that the average rate of return to using fertilizer at top dressing only is 70%. We view the decision between using fertilizer at planting rather than top dressing as a timing decision similar to when to buy.

use by 9 to 10 percentage points (not significant), less than half the increase due to the SAFI program (or SAFI with ex ante timing choice). The difference between the percentage point increase due to SAFI and the percentage point increase due to free delivery is significant at the 8 percent level. Thus, the timing of the offer is extremely important. Interestingly, a 50% subsidy at the same period significantly increases fertilizer use (by 13 to 14 percentage points), but by *less* than a small decrease at harvest time (although we cannot reject equality of the effect). This shows that prediction 4 of the model does hold in practice.

5.3 Calibration

It is possible to roughly calibrate the model to determine the fraction of farmers who are time-inconsistent and the probability of them being patient each period.

Recall that a fraction γ of farmers are always patient and always use fertilizer and a fraction ψ of farmers are always impatient and never use fertilizer.[25] The remaining fraction $1 - \gamma - \psi = \phi$ of farmers are time inconsistent (as described above), and patient in any period with probability p.

To solve for the parameters of the model, note that the model implies that the fraction of farmers using fertilizer without the SAFI program is $\phi p^2 + \gamma$ (since time inconsistent farmers use fertilizer only if patient in both periods 1 and 2). Taking the average comparison group usage from the two SAFI seasons in Table 3, this quantity is equal to about 0.27 (Columns 1-

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[25] An additional interpretation is that these farmers are not interested in using fertilizer or do not use fertilizer because it is not profitable on their land.

[27] Another reason why take up is higher than in the full-scale basic SAFI is that in the pilot SAFI, the field officer harvested with the farmer, and SAFI was offered on the very day of the harvest. In the full scale version of the SAFI program, the visit took place in the week following the harvest.

4). Under SAFI, all time-inconsistent farmers who are patient in the first period will use fertilizer, as will all time-consistent farmers. Hence the proportion of farmers using fertilizer will be $\phi p + \gamma$. Using the regression-adjusted estimates with full controls in Table 3, this percentage is about 0.44 in our dataset.

A third equation gives the percentage of non-program farmers that we would expect to find using fertilizer in the 3 seasons that we follow them. This percentage is given by $\gamma + \phi(p^2)^3$, and is equal to 0.16 in our dataset. Solving these equations gives us that $p = 0.40$, $\phi = 0.71$, $\gamma = 0.16$, and $\psi = 0.13$.

These estimates are in line with our finding that 52% of comparison farmers do not use fertilizer in any season in which we observe them (we followed farmers for 3 years after the first SAFI). Given the parameters above, we would predict that $\psi + \phi(1 - p^2)^3 = 0.13 + 0.71 * .84^3 = 0.55$ of farmers would not use fertilizer in those 3 seasons. Note that this estimate was derived solely from data on average use, not from looking at the correlation in fertilizer use over time, so this provides some out-of-sample validation of our results.

6 Alternative Explanations

The empirical results in this section are consistent with the predictions of the model in section 2. We now review three alternative models which could have similar qualitative predictions, and explore whether these models can explain the data.

6.1 Time-Consistent Farmers with a Utility Cost of Using Fertilizer

An alternative explanation for the large impact of the free delivery of fertilizer is that farmers are time-consistent in the way they discount the future, but the cost of acquiring fertilizer is high and prevents adoption for many, or fertilizer is not available in small quantities, leading to credit constraints. While we have argued that fertilizer is available in small quantities in most market centers, the cost of reaching those centers may be large, or farmers may not trust that fertilizer sold in small quantities, rather than the original packaging is unadulterated. In this case, free delivery of fertilizer from a trusted source may increase purchase substantially.

Under this hypothesis, however, we might expect that free delivery at the time of top dressing would increase adoption as much as free delivery right after harvest, which is not what we found in Table 3. A possible explanation for those results is that rational, time consistent farmers with declining marginal utility of consumption could have spent down most of their savings by period two, not anticipating the discount. When free delivery is offered in period 2, given the resources left in period 2, they may not want to sacrifice period 2 consumption to get the fertilizer at full price, even if the utility cost of shopping, f, is equal to zero. If fertilizer is offered at a 50% discount however, it may be worthwhile to forego some consumption to purchase the fertilizer.

Under this alternative model, informing farmers around harvest time that free delivery would be available at some point before it is needed would increase fertilizer use as much as offering them the fertilizer at that time. We can investigate this issue with results from earlier, small-scale iterations of the SAFI program. Prior to implementing the full scale SAFI program described above, ICS conducted a number of small pilot SAFI programs with farmers who had previously participated in demonstration plots in their farms (see Duflo, Kremer, and Robinson, (2008) for a description of demonstration plots). Three randomly assigned variants were conducted in different seasons in different villages, each with its own comparison group. The farmers were always informed about the program immediately after harvest. In the first variant pilot SAFI program farmers were asked to pay for the fertilizer right away (as in the basic SAFI program). In the second variant farmers were informed about the program, asked whether they wanted to order fertilizer, and given a few days before the field officer returned to collect the money and provide the voucher. The third variant was similar, but the field officer only went back to collect the money just before planting.

For the three pilot SAFI programs, data is available only on purchase under the program, not on eventual fertilizer use. In all the versions of the program, between 60% and 70% of the farmers initially ordered fertilizer. These rates are substantially higher than under the full-scale SAFI program, most likely because these were farmers with whom ICS had been working intensely for several months. [27] When the field officer did not immediately collect the payment, fertilizer purchase falls significantly: when farmers are given a few days to pay for the fertilizer, the fraction who actually purchase fertilizer falls from 64% to 30%; and when they are given a few months, purchase falls to 17%. (See Table 4) These differences in purchase rates are significant even when controlling for various background characteristics (see odd numbered columns in Table 4).

These comparisons exploit variations in the way the programs were conducted from year to year, in different villages. Although farmers selected into the various options are similar along background characteristics (see Appendix Table 2), and although a comparison group was randomly drawn each year and subsequent fertilizer use is similar among the comparison farmers in each season (figures available on request), it is theoretically possible that differences in fertilizer purchases could come from differences between seasons or villages.

To confirm that the SAFI options themselves, rather than differences between villages, explain the differential take-up results, 52 farmers in the same schools were offered different options in the same season. Though the sample size is small, the results follow the same stark pattern: among farmers who had to pay for fertilizer the day after the harvest, 47% purchased fertilizer. Among farmers who had to wait a few days to pay, 47% of farmers initially ordered fertilizer, but only 29% eventually purchased fertilizer. Among farmers who had to wait until the time of top dressing to pay, 50% initially made an order but none eventually purchased fertilizer. While this extreme result is probably not representative of what would happen in a larger sample, the sharp decline across the options is evident.

6.2 Sophisticated Farmers

Another alternative hypothesis is that farmers are time inconsistent (as in our model) but fully sophisticated, and that in the patient period, farmers see purchasing fertilizer through ICS a way to protect resources from impulsive period two purchases (by themselves or their family). In the context of our model, suppose that patient farmers correctly assesses the probability of being impatient in the future, but that it is also possible to re-sell fertilizer at some cost in the future, and that the sum of this cost plus the return on fertilizer is lower than the discount rate of an impatient farmer. Then patient period one farmers will correctly anticipate that with some reasonably high probability, they will be impatient enough in period 2 that they will re-sell any fertilizer that has been purchased. In this case, farmers would have paid a purchase cost f in period 1, and a resale cost in period 2, but wound up without fertilizer at the end. Anticipating this, patient fully sophisticated farmers in period 1 may prefer to delay fertilizer purchase until period 2 to see if they are still patient at that time, rather than to buy in period one and risk incurring resale costs, even though they anticipate that this will prevent them from using fertilizer much of the time.

Data on the choice of delivery time under the basic SAFI program provide some evidence against this hypothesis. Recall that vouchers could only be redeemed against fertilizer at the time chosen by the farmer at the time of purchase, and could not be exchanged for cash. This feature was introduced precisely to be useful to farmers needing a strong commitment. Under the hypothesis above, patient sophisticated farmers would take advantage of the SAFI program to lock up resources to protect them from impatient period 2 farmers by requesting delivery of the time of application of fertilizer just before the time of application. In practice, however, all farmers requested almost immediate fertilizer delivery. (This could be because they thought there was some hazard rate of ICS bankruptcy or because they wanted to keep the flexibility of selling back the fertilizer in case of a serious problem, but in any case, there does not seem to be strong motivation to guard against resale by future selves.) The evidence we presented earlier suggests that almost nobody sold the fertilizer after buying it. While our data is from self-reports, and the farmers may have felt bad admitting to the field officer that they re-sold the fertilizer, field officers were very careful to emphasize to farmers that this was not a subsidy program, and that the farmers were free to do whatever they wanted with the fertilizer they bought under the program. 84% of the farmers report having used the fertilizer on their plot or that of a spouse, 8.1% still had the fertilizer, and planned to use it in another season, and 1.6% of farmers reported that the fertilizer had been spoiled. Thus, unless farmers lied about fertilizer use, the upper bound on the fraction re-sold is probably 6%. This suggests that while selling fertilizer is possible in theory, this is probably sufficiently costly in practice, and involves sufficient time delays and fixed costs of searching for buyers that even impatient period 2 farmers do not think it is worthwhile.

Further evidence against the hypothesis that the main benefit of the program for farmers was the opportunity of strong commitment it offered comes from the farmers from whom an ICS field officer offered to purchase some maize at a premium price at the very beginning of the SAFI visit. Maize is less liquid than cash (farmers must go to market to sell it, and there is no guarantee that they can find a buyer at the market price immediately), so it is less likely that maize would be used for an impulse purchase, or could be taken away by a neighbor or relative in need of help. Therefore, farmers may be more likely to want to protect cash than maize (in the above model of sophisticated farmers). If this were the case, farmers who have cash in their hands would be more likely to purchase fertilizer under SAFI. In order to test this hypothesis, we introduced a sub-group in all the treatment groups (and in the comparison groups) in which the field officer offered to buy a small quantity of maize from farmers at a price above the market price. Half the farmers accepted the offer and sold an average of 180 Kenyan shillings (US $2.50) worth of maize, which is equivalent to the cost (at the time) of about 7.5 kilograms of top-dressing fertilizer. Thus, this treatment predicts having some amount of cash on hand. Table 3 shows the result of the effect of the treatment and its interaction with the SAFI program on fertilizer use: neither the main effect nor the interaction with the SAFI treatment is significant. Table 2 shows that 36% of farmers who sold maize at a premium price bought fertilizer under the SAFI program, very similar to the 38% of farmers who bought fertilizer under the basic SAFI program.

6.3 An Absent-Minded Farmer

Another possible alternative explanation is that while they farmers are aware of their own time inconsistency problems, they deal with so many competing pressures and issues that they simply do not remember to buy fertilizer early in the season even when they know they should (see, for instance Banerjee and Mullainathan, 2008).[28] Under this hypothesis, the field officer's visit acts as a reminder to the farmer to buy fertilizer.

A "reminder" intervention provides little support for this explanation. During collection of post-treatment adoption data in 2005 (2 seasons after the initial SAFI treatment, and 1 season after the second), field officers visited farmers right after harvest (at the same time the SAFI intervention would normally be conducted), and read the farmer a script, reminding them that fertilizer was available at nearby shops and that we had met many farmers in the area who had made plans to use fertilizer, but subsequently did not manage to implement them. The field officer then urged the farmers to buy fertilizer early if they thought they were likely to have this problem. (Note that this intervention would also increase fertilizer take up under our model if it raised $\tilde{p}$, making farmers more aware of their time inconsistency problem) To measure the impact of the intervention, field officers surveyed farmers at the time of top dressing for the following season to determine if they had purchased fertilizer or planned to. The reminder intervention did not significantly affect whether the farmers either bought or planned to buy top dressing fertilizer by the time they were surveyed. (See Table 5)

7. Policy Implications?

Our model suggests small, time-limited discounts can potentially help present-biased farmers overcome procrastination problems, while minimally distorting the investment decisions of farmers who do not suffer from such problems. Empirically, small, time-limited reductions in

[28] The results on the offer of free delivery visits suggest that farmers do not forget to buy fertilizer altogether, since reminding farmers to buy fertilizer at top-dressing time it is not as effective as reminding them earlier.

the cost of purchasing fertilizer at the time of harvest induce substantial increases in fertilizer use, comparable to those induced by much larger price later in the season.

The SAFI program itself, with its delivery of fertilizer to farmers by field officers, is too expensive (in terms of staff costs) to be cost effective and therefore could not be directly adopted as policy. However, preliminary results from a pilot program designed to mimic key elements of SAFI without free delivery and thus expensive visits to farms suggest that time-limited coupons for small discounts on fertilizer could cost effectively increase take up. During school meetings, coupons for a reduction of 6 Kenyan shillings (17%) in the price of up to 5 kilograms of fertilizer were distributed to 94 parents (there was no comparison group). Coupons had to be redeemed at a set of identified shops in the region within 10 days, and field officers observed fertilizer sales in these selected location to ensure that the coupons were actually redeemed by farmers, 31% of farmers who received the coupon, purchased fertilizer (most of them at the very end of the ten-day period). It is striking that a 17% reduction in the price of fertilizer immediately after harvest, which still required a visit to the shop, led to almost as large an increase in fertilizer purchases as a 50% reduction in the cost of fertilizer with free delivery at the time fertilizer needs to be used. Since we did not monitor farmers to see who actually used fertilizer, we cannot know how much of this was offset in reduced purchases from other sources. We also cannot rule out the possibility of some resale of fertilizer, but we believe it is unlikely there was much resale since prices on the resale market typically involve substantial discounts, and the total discount farmers received for 5 kg of fertilizer was only Ksh. 30 (about US $0.50). This makes a strategy of purchase for resale, therefore, seem unattractive.

A policy of small, time-limited subsidies may therefore be attractive. It would increase fertilizer use for present-biased farmers, but would create minimal distortions in behavior of farmers who were not present-biased. It would thus presumably be environmentally more attractive than heavy subsidies, and would not set off heavy rent-seeking as large subsidies. One important caveat is that this policy of small, time-limited discounts does not achieve the first best from the perspective of a hypothetical period zero farmer, since farmers who are impatient in period one will not take advantage of such a discount. Indeed, it is worth noting that while the SAFI program boosted fertilizer use substantially from pre-existing levels, take-up likely remained quite low. So while we would argue that small time-limited subsidies are likely to be preferable to a laissez-faire policy for a wide range of parameter values, with even a small proportion of procrastinating farmers, it is much harder to rank the "paternalistic libertarian" policy described here and the sort of heavy fertilizer subsidization policy adopted by Malawi and advocated by Jeffrey Sachs. Moving towards higher subsidies could potentially induce all farmers to adopt, including those that are always impatient and never use fertilizer, and in our model that would be desirable. But in a more complicated model, for example one with heterogeneity in returns to fertilizer, or potential for overuse of fertilizer on individual plots instead of the binary decision between non-use and use that we assume, such heavy subsidies would distort the behavior of patient farmers and lead them either purchase more fertilizer than would have been optimal even from their period zero perspective or to use fertilizer where it was not appropriate. More work will be required to weigh the costs of these distortions, as well as the political economy or environmental distortions associated with heavy subsidies, against the benefits of heavy subsidies in encouraging more time-inconsistent farmers to use fertilizer.

While we argue that psychological factors limit fertilizer use, we do not think this is the only distortion. In particular, it seems likely that there are important barriers to social learning in this environment**.** The same experiments with model farms which suggest high returns to modest quantities of fertilizer at top dressing in appropriate quantities suggest low or even negative returns to fertilizer at planting or in larger quantities. We asked a sample of farmers who do not currently use fertilizer about the type and amount of fertilizer they thought best to use, and based on the experiments conducted on real-world farms in our sample, many of the farmers would have had negative returns had they used fertilizer in this way (in fact, we estimate that the mean of the distribution of returns would have been negative).

An intervention which allowed farmers the opportunity to experiment with fertilizer on their own farms led to substantial increases on adoption, presumably through a learning channel. How is this possible when farmers have been using fertilizer in the area for many years, and presumably have had ample opportunity for experimentation? One clue is that these increases did not spill over to geographical neighbors or agricultural contacts (defined as people with whom farmers say they speak with regularly about agriculture). Indeed, we found that neighbors and agricultural contact knew very little about each others' agricultural practices or results. However, this is not because people cannot learn from experience on others' farms. If the contact was invited to witness the treatment herself, then the contact became substantially more likely to invest in fertilizer later on. Rather, it seems that misinformation is prevalent because people in the area do not seem to exchange information about agriculture. In related work, we build a model in which people can build up knowledge about agriculture by deliberately investing in communicating about agriculture, but only find it worthwhile to do so if potential conversation partners in fact have valuable information.

Depending on parameter values; there may be multiple equilibria, some with little communication and some with lots of communication, potentially moving the system to worse equilibria. In the model, behavioral problems of the type outlined here inhibit social learning.

In this context, a two-tiered policy to encourage fertilizer usage may be appropriate, with free starter kits for a limited amount of fertilizer (say enough for one-quarter of an acre), and small time-limited discounts on enough fertilizer for a larger amount of fertilizer (e.g., three acres). Such a policy could potentially address both social learning and behavioral problems in adoption of fertilizer, since provision of starter kits could allow farmers to experiment with fertilizer use on their own farms, and small-time limited discounts on a larger amount of land could help overcome time consistency problems. (Note that small discounts need only apply to limited amounts of fertilizer to overcome the cost f).

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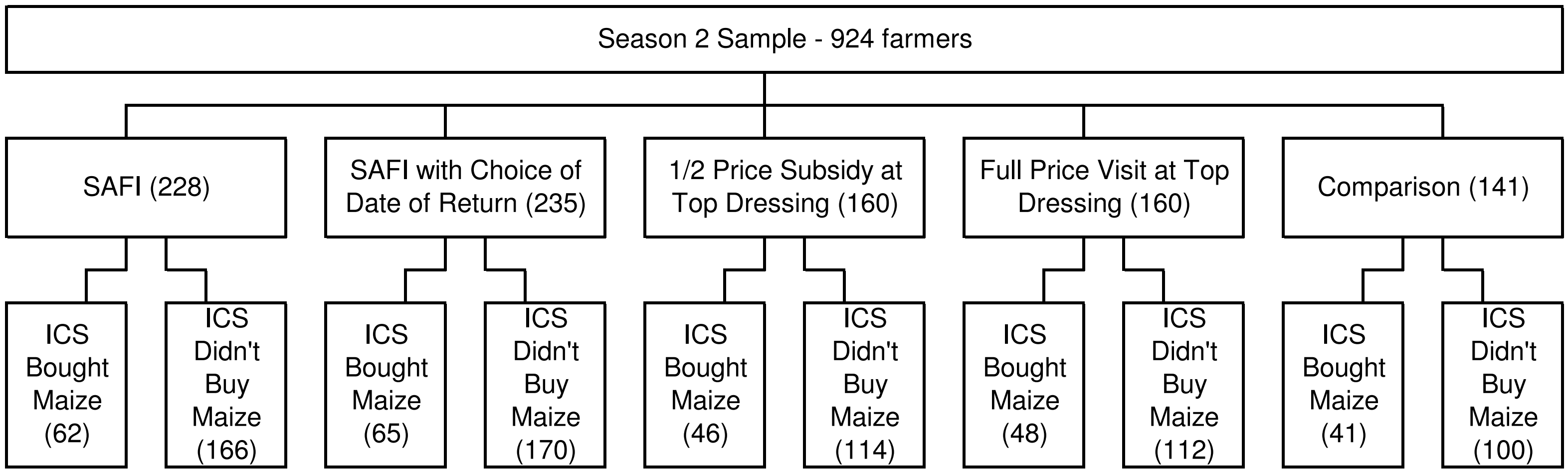

Finally, within each cell, farmers were randomly selected for a "reminder" visit that occurred just before top dressing.
In total, 88 farmers were sampled for the reminder, and 107 served as reminder comparison farmers

Figure 1. Experimental Design for School-Based Starter Kit Program for 2004 Short Rains

Notes: Number of farmers include all farmers that were traced for the baseline questionnaire (prior to the Season 1 treatments).
Sampling for all Season 2 treatments is stratified by Season 1 treatments.

Table 1. SAFI & Subsidy Programs

Panel A. SAFI for Season 1	SAFI (1)	Comparison (2)	Difference (3)
SAFI Season 1			
Income (in 1,000 Kenyan shillings)	2.10	2.86	-0.77
	(5.51)	(6.70)	(0.52)
Years Education Household Head	6.62	7.20	-0.58
	(3.96)	(4.13)	(0.321)*
Household had Used Fertilizer Prior	0.43	0.43	0.01
to Season 1	(0.50)	(0.50)	(0.04)
Home has Mud Walls	0.91	0.87	0.04
	(0.29)	(0.33)	(0.03)
Home has Mud Floor	0.90	0.85	0.05
	(0.31)	(0.36)	(0.027)*
Home has Thatch Roof	0.56	0.52	0.05
	(0.50)	(0.50)	(0.04)
Observations	211	713	924
Post Treatment Behavior			
Household bought fertilizer through	0.31	-	-
program	(0.46)	-	-
Observations	242	-	
Adoption in Season of Program	0.45	0.34	0.11
	(0.50)	(0.47)	(0.038)***
Observations	204	673	

Note: In each Panel, means and standard deviations for each variable are presented, along with differences (and standard errors of the differences) between each treatment group and the comparison group. The comparison group in Panel A consists of those not sampled for both SAFI, even if they had been sampled for other treatments (see text and Table 2).
Exchange rate was roughly 70 Kenyan shillings to US $1 during the study period.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 1 (continued). SAFI & Subsidy Programs

	SAFI	SAFI with Ex-Ante Timing Choice	Subsidy at Top Dressing	Full Price at Top Dressing	Comparison
	(1)	(2)	(3)	(4)	(5)
SAFI Season 2					
Means					
Baseline Characteristics					
Income (in 1,000 Kenyan shillings)	2.84	2.86	2.29	2.81	2.40
	(7.53)	(7.36)	(4.01)	(6.68)	(4.47)
Years Education Household Head	6.99	6.84	7.13	6.99	7.58
	(3.98)	(4.12)	(4.13)	(4.02)	(4.30)
Household had Used Fertilizer Prior	0.42	0.41	0.38	0.44	0.51
to Season 1	(0.49)	(0.49)	(0.49)	(0.50)	(0.50)
Home has Mud Walls	0.88	0.89	0.86	0.91	0.87
	(0.33)	(0.32)	(0.35)	(0.29)	(0.34)
Home has Mud Floor	0.83	0.88	0.85	0.89	0.86
	(0.38)	(0.33)	(0.36)	(0.32)	(0.35)
Home has Thatch Roof	0.53	0.53	0.49	0.55	0.53
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Observations	228	235	160	160	141
Post Treatment Behavior					
HH bought fertilizer through program	0.39	0.41	0.46	0.20	-
	(0.49)	(0.49)	(0.50)	(0.40)	-
Observations	208	207	145	143	-
Adoption in Season of Program	0.38	0.47	0.41	0.33	0.28
	(0.49)	(0.50)	(0.49)	(0.47)	(0.45)
Observations	179	208	133	135	102
Differences Between Treatment and Comparison					
Baseline Characteristics					
Income	0.440	0.456	-0.110	0.402	-
	(0.727)	(0.714)	(0.514)	(0.692)	-
Years Education Household Head	-0.595	-0.740	-0.456	-0.588	-
	(0.440)	(0.446)*	(0.487)	(0.479)	-
Household had Used Fertilizer Prior	-0.094	-0.100	-0.129	-0.073	-
to Season 1	(0.053)*	(0.053)*	(0.057)**	(0.058)	-
Home has Mud Walls	0.005	0.013	-0.012	0.034	
	(0.035)	(0.035)	(0.040)	(0.036)	
Home has Mud Floor	-0.034	0.018	-0.010	0.029	
	(0.040)	(0.036)	(0.041)	(0.038)	
Home has Thatch Roof	0.006	0.003	-0.031	0.025	
	(0.054)	(0.053)	(0.058)	(0.058)	
Observations	228	235	160	160	141
Post Treatment Behavior					
Adoption in Season of Program	0.105	0.197	0.139	0.051	-
	(0.059)*	(0.059)***	(0.063)**	(0.060)	-
Observations	179	208	133	135	-

Note: In each Panel, means and standard deviations for each variable are presented, along with differences (and standard errors of the differences) between each treatment group and the comparison group. The comparison group consists of those not sampled for both SAFI, even if they had been sampled for other treatments (see text and Table 2).
The number of observations is the number of farmers in each group with non-missing adoption data in the season of the program.
Exchange rate was roughly 70 Kenyan shillings to US $1 during the study period.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2. Comparing Various SAFI Options (Season 2)

Panel A. Regression Results	*Bought Fertilizer* (1)
SAFI, No Choice, NGO Did not Buy Maize	0.380
	(0.040)***
SAFI, Ex-Ante Choice of Timing, NGO Did not Buy Maize	0.443
	(0.041)***
SAFI, NGO Bought Maize	0.362
	(0.045)***
Subsidy at Top Dressing	0.462
	(0.042)***
Full Price Visit at Top Dressing	0.196
	(0.033)***
Observations	703

			Testing Against		
Panel B. Pairwise F-tests	Type 1	Type 2	Type 3	Type 4	Type 5
Type 1: SAFI, No Choice, NGO Did not Buy Maize	-	0.270	0.765	0.154	0.001***
Type 2: SAFI, Ex-Ante Choice of Timing, NGO Did not Buy Maize	-	-	0.182	0.743	0.001***
Type 3: SAFI, NGO Bought Maize	-	-	-	0.102	0.003***
Type 4: Subsidy at Top Dressing	-	-	-	-	0.001***
Type 5: Full Price Visit at Top Dressing	-	-	-	-	-

Notes: Significance levels in Panel A are for the hypothesis test that the given proportions equal 0.
The figures in Panel B are p-values for pairwise F-tests which test for the equality of takeup under the various SAFI options.
For all programs listed above, respondents were allowed to buy either DAP (for planting) or CAN (for top dressing) fertilizer.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. Adoption for Parents Sampled for SAFI & Subsidy Programs

	Used Fertilizer Season 1		Used Fertilizer Season 2		Used Fertilizer Season 3	
	(1)	(2)	(3)	(4)	(5)	(6)
SAFI Season 1	0.114	0.143	0.007	0.007	0.006	0.01
	(0.035)***	(0.038)***	(0.041)	(0.044)	(0.037)	(0.041)
Starter Kit Farmer	0.059	0.080	0.024	0.005	-0.009	-0.027
	(0.042)	(0.046)*	(0.047)	(0.051)	(0.043)	(0.048)
Starter Kit Farmer * Demonstration Plot School	-0.026	-0.061	0.024	-0.005	0.004	-0.031
	(0.060)	(0.066)	(0.068)	(0.075)	(0.063)	(0.070)
Demonstration Plot School	0.006	0.441	0.362	0.464	0.362	0.437
	(0.314)	(0.435)	(0.460)	(0.463)	(0.335)	(0.465)
Household had Used Fertilizer Prior to Season 1	0.369	0.315	0.319	0.284	0.281	0.251
	(0.031)***	(0.035)***	(0.035)***	(0.040)***	(0.033)***	(0.037)***
Male		0.012		0.014		0.026
		(0.033)		(0.037)		(0.034)
Home has mud walls		-0.193		-0.183		-0.021
		(0.081)**		(0.091)**		(0.085)
Education primary respondent		0.004		-0.004		0.015
		(0.004)		(0.005)		(0.005)***
Income in past month (in 1,000 Kenyan shillings)		0.004		0.006		0.002
		(0.003)		(0.003)**		(0.003)
Observations	876	716	756	626	902	734

Panel B. 2004 Season 2 Treatments	Used Fertilizer Season 1		Used Fertilizer Season 2		Used Fertilizer Season 3	
	(1)	(2)	(3)	(4)	(5)	(6)
SAFI Season 2	0.000	0.041	0.182	0.213	-0.010	0.004
	(0.051)	(0.057)	(0.060)***	(0.065)***	(0.055)	(0.060)
SAFI Season 2 with Ex-Ante Choice of Timing	0.008	0.048	0.248	0.263	-0.015	0.015
	(0.051)	(0.056)	(0.058)***	(0.064)***	(0.054)	(0.060)
Half Price Subsidy Visit at Top Dressing	-0.035	-0.038	0.142	0.132	0.024	0.042
	(0.052)	(0.057)	(0.059)**	(0.065)**	(0.054)	(0.061)
Full Price Visit at Top Dressing	-0.065	-0.034	0.096	0.106	-0.053	-0.031
	(0.052)	(0.058)	(0.059)	(0.066)	(0.054)	(0.061)
Bought Maize	0.026	0.003	0.011	-0.010	0.026	0.005
	(0.051)	(0.056)	(0.058)	(0.063)	(0.054)	(0.059)
Bought Maize * SAFI Season 2	-0.079	-0.066	-0.142	-0.164	-0.044	-0.043
	(0.065)	(0.072)	(0.073)*	(0.081)**	(0.069)	(0.076)
Household had Used Fertilizer Prior to Season 1	0.369	0.314	0.325	0.282	0.279	0.248
	(0.031)***	(0.035)***	(0.035)***	(0.040)***	(0.033)***	(0.037)***
Male		0.012		0.019		0.029
		(0.033)		(0.037)		(0.035)
Home has mud walls		-0.198		-0.195		-0.017
		(0.081)**		(0.091)**		-0.086
Education primary respondent		0.004		-0.003		0.015
		(0.004)		(0.005)		(0.005)***
Income in past month (in 1,000 Kenyan shillings)		0.004		0.006		0.003
		(0.003)		(0.003)**		(0.003)
Mean Usage in Comparison Group	0.247	0.228	0.297	0.300	0.392	0.397
Observations	876	716	756	626	902	734

Note: Dependent variable is an indicator equal to 1 if the farmer adopted planting or top dressing fertilizer in the given season. All regressions control for school, and whether the farmer was a parent of a Standard 5 or 6 child (see text). Panel B also include controls for the Season 1 Treatments listed in Panel A.
The comparison group means listed in the bottom of the table are for individuals that did not participate in either SAFI, were not offered fertilizer at any price, and did not participate in the starter kit program. This accounts for the difference in mean usage between this Table and Table 1.
There are fewer observations than in Table 1 because of missing values for previous usage. For all programs listed above, respondents were allowed to buy either DAP (for planting) or CAN (for top dressing) fertilizer.
Exchange rate was roughly 70 Kenyan shillings to US $1 during the study period.
Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Acceptance of Various Commitment Savings Pilot Products (SAFI Program)

	--------------- All Pilots ---------------				Versions Offered in Same Season			
	Initially Accepted	*Initially Accepted*	*Bought Fertilizer*	*Bought Fertilizer*	*Initially Accepted*	*Initially Accepted*	*Bought Fertilizer*	*Bought Fertilizer*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SAFI Variants								
option 1: take-it-or-leave-it	0.637	0.591	0.637	0.651	0.471	0.580	0.471	0.644
	(0.048)***	(0.079)***	(0.044)***	(0.074)***	(0.125)***	(0.210)***	(0.097)***	(0.163)***
option 2: return in a few days	0.700	0.662	0.300	0.311	0.471	0.514	0.294	0.395
to collect money	(0.068)***	(0.086)***	(0.063)***	(0.080)***	(0.125)***	(0.165)***	(0.097)***	(0.128)***
option 3: return in a few months	0.606	0.563	0.169	0.164	0.500	0.555	0.000	0.090
to collect money	(0.057)***	(0.069)***	(0.053)***	(0.064)**	(0.121)***	(0.150)***	(0.094)	(0.117)
Other Controls								
Household had Used Fertilizer		0.144		0.114		0.244		0.080
Prior to the Program		(0.068)**		(0.064)*		(0.175)		(0.136)
Years of Education Household Head		-0.002		-0.008		-0.024		-0.026
		(0.009)		(0.008)		(0.023)		(0.018)
School Controls	No	Yes	No	Yes	No	Yes	No	Yes
F-test, option 1 = option 2 (p-value)	0.451	0.397	0.001***	0.001***	1.000	0.725	0.202	0.095*
F-test, option 1 = option 3 (p-value)	0.671	0.716	0.001***	0.001***	0.866	0.895	0.001***	0.001***
F-test, option 2 = option 3 (p-value)	0.290	0.269	0.114	0.079*	0.866	0.816	0.034**	0.03**
Observations	223	222	223	222	52	52	52	52

Notes: Figures are from the pilot SAFI programs, which were conducted mostly among farmers that participated in demonstration plot trials. Averages are pooled across a number of different seasons.
The dependent variable is take-up rate (not actual usage of fertilizer).
Means are reported, along with p-values for F-tests for pairwise testing of take-up rates.
Including fuller controls gives similar results but reduce the sample size (since fuller controls are only available for some individuals).
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Reminder Intervention

	Bought Top Dressing Fertilizer			Planned to Buy Top Dressing Fertilizer			Bought or Planned to Buy Top Dressing Fertilizer		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SAFI Season 2	-0.035	-0.026	-0.088	0.053	0.036	0.038	0.019	0.015	0.000
	(0.055)	(0.056)	(0.072)	(0.075)	(0.077)	(0.094)	(0.072)	(0.074)	(0.093)
Household had Used Fertilizer Prior		0.069	0.057		0.105	0.149		0.141	0.142
to Season 1		-0.058	-0.074		-0.081	-0.096		(0.077)*	-0.096
Male			0.036			-0.132			-0.117
			(0.069)			(0.090)			(0.090)
Home has mud walls			-0.137			-0.101			-0.197
			(0.154)			(0.206)			(0.198)
Education primary respondent			0.008			0.003			0.011
			(0.010)			(0.013)			(0.013)
Income in past month			-0.001			0.002			0
(in 1,000 Kenyan shillings)			(0.005)			(0.006)			(0.006)
Mean of Dependent Variable among Comp. Farmers	0.224	0.206	0.240	0.33	0.345	0.295	0.514	0.510	0.493
Observations	195	188	141	172	166	121	193	186	139

Notes: See text for description of program. The dependent variable in columns 1-3 is an indicator variable equal to 1 if the farmer had already bought top dressing fertilizer, the dependent variable in columns 4-6 is an indicator variable equal to 1 if the farmer planned to buy top dressing fertilizer that season, and the dependent variable in columns 7-9 is an indicator variable equal to 1 if the farmer had already bought or planned to buy fertilizer in that season.
In addition to variables listed, all regressions control for all starter kit, SAFI, and subsidy treatments.
The mean of the dependent variables is presented for the reminder comparison group.
The program took place during the 2004 Short Rains growing season (referred to as the second season in the text).
Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table A1. Examining Differential Response Rates

	Completed 2004 Background Questionnaire	Completed 2005 Adoption Questionnaire	Completed 2005 Adoption Questionnaire
	(1)	(2)	(3)
Starter Kit Farmer	0.009	0.047	0.047
	(0.039)	(0.038)	(0.038)
Demonstration Plot School	-0.261	0.245	0.245
	(0.319)	(0.316)	(0.316)
Starter Kit Farmer * Demonstration Plot School	0.054	0.035	0.035
	(0.050)	(0.050)	(0.050)
SAFI Season 1	0.043	0.050	0.050
	(0.043)	(0.042)	(0.042)
SAFI Season 2	0.003	0.002	0.002
	(0.054)	(0.054)	(0.054)
SAFI Season 2 with Choice	0.041	0.037	0.037
	(0.054)	(0.053)	(0.053)
Subsidy Season 2	0.082	0.083	0.083
	(0.059)	(0.059)	(0.059)
Full Price Visit Season 2	0.109	0.088	0.088
	(0.060)*	(0.059)	(0.059)
ICS Bought Maize Season 2	0.026	0.000	0.000
	(0.034)	(0.033)	(0.033)
Sample	Whole Sample	Whole Sample	Only those that completed Background
Mean of Dependent Variable	0.751	0.754	0.906
Observations	1230	1230	1230

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%

Regressions control for school and for interactions between the demonstration plot and the various treatments.

Overall, 90.6% of respondents that completed the 2004 questionnaire also completed the 2005 questionnaire.

Table A2. Verifying Randomization for Pilot SAFI Programs

	Household had Ever Used Fertilizer Before	Years Education	Home has Mud Walls	Home has Mud Floors	Home has Thatch Roof	Income in Month Prior to Survey^	Number of Children	Acres of Land Owned
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SAFI Variants								
option 1: take-it-or-leave-it	0.455	7.223	0.780	0.810	0.420	1.829	7.298	3.990
	(0.500)	(3.419)	(0.416)	(0.394)	(0.496)	(2.715)	(2.758)	(3.097)
option 2: return in a few days	0.340	6.040	0.780	0.840	0.460	1.672	7.000	4.391
to collect money	(0.479)	(4.130)	(0.418)	(0.370)	(0.503)	(2.275)	(2.678)	(3.508)
option 3: return in a few months	0.352	4.254	0.833	0.722	0.556	2.359	9.471	3.844
to collect money	(0.481)	(4.013)	(0.383)	(0.461)	(0.511)	(5.814)	(3.281)	(2.663)
F-test, option 1 = option 2 (p-value)	0.470	0.162	0.901	0.565	0.452	0.665	0.834	0.355
F-test, option 1 = option 3 (p-value)	0.847	0.077*	0.350	0.965	0.630	0.332	0.208	0.645
F-test, option 2 = option 3 (p-value)	0.732	0.475	0.400	0.681	0.995	0.220	0.166	0.905
Observations	222	222	168	168	168	169	158	163

Notes: Figures are from the pilot SAFI programs, which were conducted mostly among farmers that participated in demonstration plot trials.
Means are reported, with standard deviations in parentheses.
The bottom of the table reports p-values of F-tests for pairwise testing of means across SAFI options.
^Income is measured in 1,000 Kenyan shillings. Exchange rate was roughly 70 shillings to $1 US during the sample period.
* significant at 10%; ** significant at 5%; *** significant at 1%