

USING LOTTERIES TO ENCOURAGE SAVING: EXPERIMENTAL EVIDENCE FROM KENYA^{*}

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We conduct a field experiment that randomly assigned 311 informal residents of Nairobi to either a prize-linked savings account (PLS)—a product that incorporate stochastic returns to deposits—against standard, interest-bearing accounts of equivalent expected value. In the PLS treatment, individuals could only enter the lottery conditional on their making a deposit. We implement a third treatment arm that provides feedback on lottery results unconditionally to test for regret aversion. Individuals saving with PLS with feedback made 42% more deposits on average over the project period than participants who received a fixed incentive of equal expected value. We do not observe any effects of the lottery incentive on the amount deposited with PLS or on savings with other products. Lastly, we document limited evidence that use of PLS results in a 15% increase in gambling activity. We argue that the effects on deposit frequency are due to regret aversion, a hypothesis which receives support from the presence of larger treatment effects conditional on winning the lottery but being unable to claim the prize.

JEL Classifications: D14, E21, G11

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I. INTRODUCTION

The ability to save is one of the most important avenues toward economic development; it provides a means to smooth consumption under incomplete insurance and it makes possible productive investments in the presence of credit constraints. There exists, however, a host of obstacles that prevent poor households from accruing savings to their advantage. There are supply-side limitations to formal finance, such as high initial and transaction costs, that may be prohibitive for the poor. As a result, they often have to resort to methods of saving that can be costly and have limited functionality (Banerjee and Duflo 2007; Collins et al. 2009; Karlan et al. 2014; Schaner 2011).

On the demand side, knowledge gaps, mistrust of financial institutions, and behavioral biases prevent the poor from saving as much as they would like. In Kenya, around 80% of adults have an account with a financial institution or mobile money yet only 30% report using them to save (Demirguc-Kunt et al. 2018). Policies that target costs on the supply side are known to increase account ownership but have been less effective at encouraging usage (Dupas and Robinson 2013; Karlan et al. 2016). Meanwhile, savings products designed to address behavioral barriers have been shown to be extremely cost-effective, especially compared to direct subsidies.¹ Track-keeping objects (Akbas et al. 2016), SMS reminders (Karlan et al. 2010), and default contributions (Chetty and Friedman 2014; Somville and Vandewalle 2018; Thaler and Benartzi 2004) which address undersaving due to limited attention. Binding commitment devices, in the form of account restrictions (Ashraf et al. 2006) or the application of social pressure (Dupas and Robinson 2013), can help individuals with time-inconsistent behavior follow through on saving. This literature has demonstrated the importance of product design or *choice architecture* in financial decisionmaking.

This article examines the potential of prize-linked savings (PLS)—a savings product that incorporate lottery-like payoffs—in encouraging saving. The key novelty of PLS accounts is that users receive a stochastic payoff in addition to, or in lieu of, certain interest payments. Common among PLS products is that consumers face no risk of negative returns, at least guaranteeing the full principal amount. PLS have been in use since at least the 18th century and presently exist in various forms around the globe (Kearney et al. 2010; Murphy 2005). Any kind of savings product that allows consumers to enter raffles or earn lottery tickets conditional on deposits may be considered PLS. NS&I Premium Bonds in the U.K., the now-defunct “A-Million-A-Month” Account in South Africa are prominent examples of this type of savings product.

We conducted a laboratory and field experiment to analyze the effects of PLS on savings behavior over time. We provided a mobile savings product to 311 informal residents in Nairobi, Kenya and observed account activity over a 60-day period. Using mobile savings allowed us to minimize transactions costs and to collect detailed data on individual transactions. Roughly one-third of our sample

¹Karlan and Zinman (2018) estimate very low interest rate elasticities and limited impacts of easing account ownership requirements. Schaner (2018) boost short-run individual savings by USD 1.38 with rates of up to 20%.

was randomly assigned a savings account which matched contributions at 5%. A second group was assigned an account that yielded stochastic returns equal in expectation to the 5% match through a daily lottery. Each day, participants received a lottery ticket whose earnings were proportional to amount saved that day instead of a certain match. We compared the match and lottery groups to determine how PLS impacts savings behavior. We find that participants using PLS made 42% more deposits on average over the project period than participants receiving the matching incentive. This amounts to 5-6 additional days that treated participants made deposits to their savings account. We find no effect of PLS on total amount saved, a finding largely consistent with earlier experimental results. Consequently, we find no evidence that PLS displaced savings from other sources. On gambling behavior, we find that participants who used PLS with feedback reported higher gambling activity 15 percentage points more than the control group.

There are a host of theoretical explanations behind the apparent demand for PLS as opposed to standard savings. Our second objective is to quantify the role of regret aversion (Bell 1983; Loomes and Sugden 1982) as a specific mechanism driving our treatment effects. Regret theory refers to a class of behavioral models that posit that individuals minimize anticipated regret arising from the comparison of prospects against foregone outcomes. In the context of uncertainty, regret aversion has been shown to promote apparently risk averse and risk-seeking behavior (Zeelenberg et al. 1996).

To test for regret aversion, we implemented a third treatment wherein participants received the same PLS account with the additional feature that they received a lottery ticket and observed the lottery results only after they had made a deposit that day. That feedback about hypothetical lottery results affects decisions to save is a central prediction of regret aversion. We find that when the resolution of lotteries depends on saving, the effect of PLS on deposits is 20% smaller than when feedback is always given. In other words, participants assigned to PLS with feedback are motivated to save (and enter the lottery) in anticipation of regret they may feel from having a winning ticket but not being able to claim the prize. Exploiting the longitudinal nature of our data, we also find that recent experiences of regret increase the likelihood of making a deposit in subsequent days by 8%. Together, our evidence points to the importance of regret aversion in demand for PLS.

This study is one of the first field experiments conducted on PLS in a low-income setting. Two laboratory studies provide evidence of a positive effect of stochastic returns on saving. Atalay et al. (2014) conducted an online portfolio-choice experiment that resulted in participants saving an additional 12 percentage points more with lottery-linked and regular savings than with regular savings alone. Notably, participants who saw an increase in total savings shifted away from lottery expenditures and consumption rather than from regular savings. Filiz-Ozbay et al. (2015) found participants are more likely to delay payments with lottery-like returns compared to guaranteed interest of equivalent expected value. Outside the laboratory, evidence surrounding PLS is more limited. Our study comes closest to Gertler et al. (2017), which studies the long-term effects

of PLS in Mexico. They found that bank branches offering PLS saw 41% more account openings and that these continued to be used five years after the lottery incentives expire. Loibl et al. (2016) conducted a randomized evaluation of IDAs in the U.S. that incorporated a lottery-based savings match. That study found no significant effect of the program relative to guaranteed matching, even when it was bundled with reminder calls and frequent deposit deadlines. They attribute the result to liquidity constraints among their sample, which potentially precluded the benefits of behavioral interventions. Lottery-based incentives applied in other domains, including labor supply (Brune 2015) and health-related behaviors (Bjorkman Nyqvist et al. 2015; Kimmel et al. 2012), are found to have significant effects. We contribute to this line of research by testing for and quantifying the role of regret aversion as an underlying behavioral mechanism.

Our experiment also joins a strand of the behavioral literature studying the applicability of regret aversion. (Zeelenberg and Pieters 2004) is a cross-sectional study of Dutch lotteries that showed that feedback about winnings in one lottery elicits feelings of regret and that it influences decisions to play. (Filiz-Ozbay and Ozbay 2007) finds evidence that regret felt by bidders who lose can explain over-bidding in first price auctions. As in this study, they utilize the manipulation of feedback about the winning bid to test for regret aversion. The present study contributes to this literature in examining the implications of regret aversion in repeated settings. Namely, we find evidence that regret aversion appears more intense among those who recently experienced regret. A recent paper by Imas et al. (2016) argues that regret aversion results in an *undervaluation* of lotteries in repeated settings because frequent experiences of regret may dissuade individuals from making risky choices and because feedback provides individuals the opportunity to learn about the incentives. Regret aversion in repeated settings remain a largely unexplored area of research.

The remainder of the paper is structured as follows. Section II describes our experimental design, Section III outlines our estimation strategy, Section IV discusses our main results, and Section V concludes.

II. EXPERIMENTAL DESIGN

II.A. Sampling Frame

We conducted our experiment in conjunction with the Busara Center for Behavioral Economics with 311 participants recruited from Nairobi’s low-income neighborhoods. Three quarters of our sample reside in Kibera, the city’s largest informal settlement. We drew a random sample of participants over 18 years old using SMS and phone calls from the Busara Center’s active pool of over 11,000 Nairobi residents. Nearly 60% of our sample is female with a median age of 28 years. Less than half of the participants in our sample reported that they are employed with only 5% reported receiving a regular income. The employed in our sample largely work in retail or are students. The median PPP-adjusted

monthly income among those employed is USD 77.²

Approximately 55% of our sample saves regularly with a majority of savers utilizing rotating savings and credit associations (ROSCA), a type of informal group savings. The average stock of savings among these individuals amount to USD 23. A significant fraction of savers also report using M-Shwari, a mobile service that provides a lockbox account and offers short-term credit.³ Mobile transactions are made with M-Pesa, an SMS-based money system made accessible by the ubiquity of mobile phones in Kenya.

The surge of mobile phone usage in Kenya has allowed the recent popularity of mobile sports betting. SportPesa, one of the most popular mobile gambling services, reports over 800,000 registered users as of 2015 (Kemibaro 2015). In our sample, 24% of participants at baseline report that they have some problem with gambling. 11% of participants report that they gamble at a casino, bet money at racetracks or sporting events, played the sweepstakes, or played cards for money daily or more frequently in the last 12 months.

II.B. Data Collection

Participants were first invited to the lab at the Busara Center where they completed a computerized questionnaire and behavioral tasks. Experimental sessions included up to 25 participants at a time and were administered in English by research assistants. The following outlines the schedule of tasks during the lab portion of the study:

1. Coin toss task (Eckel and Grossman 2002)⁴
2. Titration task for temporal discounting (Cornsweet 1962)
3. Willingness-to-pay to play a lottery
4. Candian Problem Gambling Index (Ferris and Wynne 2001)
5. Internal locus of control (Rotter 1966)
6. Demographics questionnaire

At the conclusion of the demographics questionnaire, participants received KES 200 for completing the session and an additional KES 50 for arriving on time. Lab sessions took place over five weeks in May and June of 2014. We refer to this period before beginning the savings program as the baseline.

²Monetary payouts were in Kenyan shillings (KES). We report USD values calculated at purchasing power parity using a conversion factor for private consumption of 38.15 in 2013. The price level ratio of PPP conversion factor (GDP) to KES market exchange rate for 2011 was 0.444.

³The savings product we designed is comparable to M-Shwari in that it also offered commitment savings and a 5% return on deposits.

⁴This elicitation method produces interval estimates of the coefficient of relative risk aversion, ρ , under the assumption of constant relative risk aversion. We take the midpoint of the upper and lower intervals as point estimates. For participants with $\rho \geq 3.46$ and $\rho \leq 0$, we use boundary values as point estimates.

Following the lab session, participants were enrolled in the 60-day savings program and randomly assigned to one of three incentive schemes: one fixed match and two lottery-based matches. Savings incentives are detailed in Section II.D. Each participant received KES 20 airtime credit and asked to practice saving using Sambaza. Participants then received business-card sized handouts which described their savings program and bonuses. We provided participants simple instructions for saving and listed the number to our project phone. This was the number through which the savings program operated that also functioned as a help line for participants.

All participants completed the savings program by August 2014. In September 2014, we called participants and conducted an endline survey that included questions on outside savings, gambling activity, and program feedback. We obtained endline surveys for all but 27 of the 311 participants. We find no evidence that completion of the endline survey correlates with treatment assignment.

II.C. Mobile Savings Product

We implemented our 60-day mobile-phone savings program over Safaricom’s Sambaza airtime sharing service. Using Sambaza, Safaricom users can send airtime to each other free of charge. Participants saved into our program by sending airtime to a designated project phone that held the airtime in an account for each user.

Participants received two SMS messages every morning after the first morning of the project period. The first message arrived at 8:00 daily summarizing how much the participant saved the previous day, how much the participant earned through a matching contribution or winnings, and their total balance. An hour later, participants received a beginning-of-day message encouraging them to save that day. Participants were allowed to send in savings at any time but any savings sent in after first message with the lottery results would be counted towards the next day’s total. We used a custom-developed administrative system to manage the savings program. This system logged airtime sent to our project phone, maintained an internal ledger of balances, sent automated SMS confirmations after every transaction, and conducted the daily lottery game.

Participants enrolled in the savings program for two consecutive periods of 30 days starting from the day of a participant’s lab session. On a participant’s 30th day, a field officer called them and asked if they wished to withdraw any amount of their balance. Participants who requested withdrawals were sent transfers equal to their plus a withdrawal fee compensation. The product we provided was a “lockbox” account where regular withdrawals outside of this opportunity were prohibited.⁵ Transfers were made using the mobile money system M-Pesa to minimize transaction costs. M-Pesa accounts are associated with a SIM card and transactions are made via SMS. Participants could deposit and withdraw money from the account at any of more than 10,000 agents throughout Kenya, including those located in the informal settlements where our participants reside.

Participants were called and notified a few days before the end of their second 30-day period that the program would be ending soon. After receiving the end-of-day message on their 60th day, participants were unenrolled from the program and were no longer allowed to save. Field officers called participants to confirm final balances and sent M-Pesa transfers equal to total balances net of withdrawals shortly after. Participants paid no explicit fees to participate in our program.

II.D. Treatment

Participants enrolled in the savings program were randomized into one of three different incentive schemes. Table 1 reports summary statistics and tests for balance across treatment groups of several pre-treatment characteristics. We find

⁵This feature is commonplace among informal savings and is increasingly incorporated into savings interventions. Ashraf et al. (2006) provides evidence that commitment savings increases long-term savings among women who exhibit present-biased time preferences. Commitment savings may also be advantageous when intrahousehold bargaining hinders saving (Banerjee and Duflo 2007; Schaner 2011).

no overall imbalance based on a test of joint significance across all observables.⁶

1. *Matching contributions:* Participants in the matching group earned a 5% matching contribution on any amount that they saved on a particular day. The match was automatically added to the mobile account. The amount of the incentive and the participants' daily balance were reported every morning via SMS. We take this group as our control group.
2. *Prize-linked savings with feedback:* Every day, participants earned a lottery ticket transmitted via SMS that could win a cash prize in proportion to the amount they saved on the same day.

A lottery ticket was a random sequence of four numbers between 1 and 9, inclusive. Each morning, our administrative system randomly generated a winning sequence of four numbers. Prizes were awarded according to how well a participant's lottery numbers matched the winning numbers. If the first or second numbers matched, a 10% match of savings was awarded. If both the first and second numbers matched, a 100% match of savings was awarded. Finally if all numbers matched, a prize of 200 times the daily savings was awarded. The expected earnings on this lottery ticket were equal to the 5% match earned in the control group—*i.e.* the expected payoffs were equivalent but by a mean-preserving increase in risk.

Our system entered winnings into the internal ledger and reported lottery results via SMS the following day. Participants with winning lottery tickets who did not save could not claim the prize but received feedback on their lottery results daily. We henceforth refer to this group as the PLS group.

3. *Prize-linked savings without feedback:* This scheme is identical to the Lottery treatment except participants in this third group only received lottery tickets and made aware of their potential winnings if they made a non-zero deposit the previous day. We henceforth refer to this group as the No Feedback group.

⁶We account for the correlation of treatment to usage of a savings account in Section III.

Table 1: Baseline balance by treatment group

	(1) No Feedback - Control	(2) PLS - Control	(3) No Feedback - PLS	(4) Control mean (SD)	(5) Obs.
Female	0.07 (0.07)	0.10 (0.07)	0.03 (0.07)	0.52 (0.50)	311
Age	0.78 (1.39)	0.72 (1.34)	-0.05 (1.35)	30.75 (9.83)	311
Completed std. 8	-0.02 (0.02)	-0.02 (0.02)	0.00 (0.02)	0.99 (0.10)	311
Married/co-habiting	0.10 (0.07)	0.09 (0.07)	-0.01 (0.07)	0.42 (0.50)	311
No. of children	0.23 (0.24)	0.24 (0.25)	0.01 (0.25)	1.75 (1.70)	311
Currently saves	0.05 (0.07)	-0.10 (0.07)	-0.15** (0.07)	0.56 (0.50)	311
Total savings last month	-17.81 (11.88)	-7.04 (12.55)	10.77 (9.23)	58.82 (106.26)	311
Monthly income	-3.68 (17.63)	-0.59 (16.85)	3.09 (15.46)	112.05 (137.13)	311
Employment status	0.05 (0.07)	-0.03 (0.07)	-0.08 (0.07)	0.50 (0.50)	311
Coefficient of relative risk aversion	0.08 (0.18)	-0.03 (0.17)	-0.12 (0.18)	1.16 (1.27)	311
Locus of control	0.48 (1.40)	-0.83 (1.46)	-1.31 (1.37)	69.81 (10.78)	311
Standardized CPGI	-0.11 (0.13)	-0.22* (0.12)	-0.11 (0.12)	-0.00 (1.00)	311
Exp. discount factor	-0.05* (0.03)	-0.01 (0.03)	0.04 (0.03)	0.33 (0.20)	311
Joint test p -value	0.44	0.72	0.42		

Notes: The first three columns report the difference of means across treatment groups with standard errors in parentheses. Column 4 reports the mean of the control group with SD in parentheses. The bottom row reports the p -value of a joint test of significance for each hypothesis. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level.

III. EMPIRICAL STRATEGY

We use the following reduced-form specification to estimate the treatment effect of lottery incentives on participant outcomes.

$$Y_i = \beta_0 + \beta_1 \text{NF}_i + \beta_2 \text{PLS}_i + \varepsilon_i \quad (1)$$

Y_i refers to the outcome variables for individual i measured after the end of the savings program. NF_i indicates assignment to the No Feedback group and PLS_i indicates assignment to the PLS group. The omitted group is the control group. We test $\beta_1 = 0$ and $\beta_2 = 0$ to identify the effects of PLS and PLS without feedback relative to the control group. We additionally test $\beta_2 - \beta_1 = 0$ for differential effects between the two PLS treatments. Standard errors are clustered at the individual level.

To improve precision and to control for potential selection bias, we apply covariate adjustment with a vector of baseline indicators.⁷ We obtain the covariate-adjusted treatment effect estimate by estimating Equation 1 including the demeaned covariate vector \mathbf{X}_i as an additive term and as an interaction with the treatment indicator.

$$Y_i = \beta_0 + \beta_1 \text{NF}_i + \beta_2 \text{PLS}_i + \mathbf{X}_i' \gamma_0 + \text{NF}_i \mathbf{X}_i' \gamma_1 + \text{PLS}_i \mathbf{X}_i' \gamma_2 + \varepsilon_i \quad (2)$$

The set of indicators partitions our sample so that our estimate remains unbiased for the average treatment effect (Lin 2013). As in Equation 1, we test $\beta_1 = 0$ and $\beta_2 = 0$ to identify the effects of the PLS with and without feedback relative to the matching group and test $\beta_2 - \beta_1 = 0$ for differential effects between the two PLS treatments. Standard errors are clustered at the individual level. Equation 1 is our preferred specification and report results with covariate adjustment for robustness.

We might expect that the errors of each outcome variable are correlated. Instead of estimating these equations separately, we estimate the system of seemingly unrelated regressions (SUR) to improve the precision of the coefficient estimates (Zellner 1962). SUR estimation is equivalent to OLS when the error terms are in fact uncorrelated between regressions or when each equation contains the same set of regressors. We perform joint estimation over outcome groups for Equation 1 and Equation 2 separately.

We control for the family-wise error rate (FWER) to correct for multiple inference. We compute adjusted p -values within categories of outcome variables using the free step-down resampling method (Anderson 2008; Westfall and Young 1993). This approach sets the size of the test to exactly the desired critical value. We apply this correction over outcome variables in each family and separately

⁷We include as control variables 1. Participant is female, 2. Participant is younger than 30 years old, 3. Participant completed primary school, 4. Participant is married, 5. Participant has at least one child dependant, 6. Participant uses a savings account, and 7. Above median CPGI score.

for each hypothesis test. For each variable, we apply the procedure with 10,000 iterations and report both unadjusted and adjusted p -values.

IV. RESULTS

By the end of the project, the median participant in the control group contributed USD 3.86 to the mobile savings account over 8 deposits. The total saved by the control group amounts to less than 5% of the median monthly income (USD 77.24) and 17% of the median monthly savings (USD 22.91). 13% of the control group did not use their accounts at all. Despite the relatively high 5% rate of return on deposits, minimal saving is consistent with estimates of low interest rate elasticities (Karlán and Zinman 2018). Table 2 compares the lottery results with the expected probabilities of each type of lottery match.

Table 2: Observed and expected lottery results

	Freq.	Pct. observed	Pct. expected
No match	7065	81.49	62.43
One match	1518	17.51	22.22
Two matches	86	0.99	1.23
Complete match	1	0.01	0.00

Notes: The first column tabulates the frequency of observed lottery ticket matches. The second and third columns report the observed and expected probabilities, respectively, of each type of lottery match. A lottery ticket was a random sequence of four numbers between 1 and 9, inclusive. Prizes were awarded according to how well a participant's lottery numbers matched the winning numbers. If the first or second numbers matched, a 10% match of savings was awarded. If *both* the first and second numbers matched, a 100% match of savings was awarded. If all numbers matched, a prize of 200 times the daily savings was awarded.

IV.A. PLS Increases Deposit Frequency

We find that participants in the PLS group made between 5-6 more deposit transactions ($\hat{\beta} = 5.71, p < 0.05$) over the entire project period compared to those receiving the match incentive. Column 2 of Table 3 reports a moderately sized effect of 0.38 SD over the average frequency of deposits in the control group. This result is further robust to the inclusion of control variables and significant at the 10% level with FWER adjusted p -values. These effects exhibit no heterogeneity across demographic characteristics, risk attitudes, or temporal discounting.⁸ Participants in the PLS treatment had an additional 5 days on average that they chose to make at least one deposit relative to the control ($\hat{\beta} = 4.94, p < 0.05$). This suggests that the effect on the frequency of deposits occurs on the daily extensive margin; it is not driven by participants depositing

⁸We report the full set of heterogeneity results in an appendix available online.

more often within a day. This result is robust to covariate adjustment and is significant at the 10% level after FWER corrections.

Table 3: Treatment effects – Mobile savings

	Effect estimates			Sample	
	(1)	(2)	(3)	(4)	(5)
	No Feedback	PLS	PLS- No Feedback	Control Mean (SD)	Obs.
Total no. of deposits	4.59* (2.52) [0.19]	5.71** (2.45) [0.07*]	1.13 (2.84) [0.89]	13.66 (15.08)	311
No. of days saved	3.93* (2.05) [0.17]	4.94** (2.08) [0.06*]	1.01 (2.32) [0.89]	11.78 (12.93)	311
Total deposit amount	-0.79 (3.34) [0.83]	-1.60 (2.91) [0.59]	-0.81 (2.88) [0.89]	14.87 (24.48)	311
Total withdrawal amount	0.53 (0.94) [0.83]	1.63** (0.74) [0.07*]	1.10 (1.02) [0.61]	1.07 (4.53)	311

Notes: Columns 1–3 report OLS estimates of the treatment effect. Standard errors are in parentheses and FWER adjusted p -values are in brackets. Observations are at the individual level. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level. Stars on the coefficient estimates reflect unadjusted p -values.

Panel A of Figure 1 traces the cumulative path of deposits made over the duration of the project. The average number of deposits for the PLS group are greater than for the control group over all periods, though we are only able to statistically distinguish cumulative values at the end of the 60-day period.

Figure 1: Number of deposits and amount deposited over project period



Notes: Panel A plots the cumulative number of deposits made by the average participant over the 60-day savings period by treatment assignment. Panel B plots the cumulative amount deposited by the average participant. Error bars for totals by the end of the project are within one standard error of the group means.

While effects on number of deposits are considerable, we find no effect of either PLS treatment on total amount deposited over the project period. Panel B of Figure 1 plots the cumulative deposit amounts, averaged by treatment group, over the 60-day period. We cannot distinguish total deposit amounts between any of the three incentive schemes. Participants in the PLS group withdrew a larger amount relative to the control on average ($\hat{\beta} = 1.63, p < 0.05$) but we are unable to detect statistically significant differences in the final balance across treatment groups.

Our results are consistent with a general finding among earlier field experiments on lottery-based incentives that behavioral responses occur on the extensive, but not intensive, margin. Brune (2015) test a stochastic incentive in Malawi wherein tea harvesters entered a lottery conditional on attendance and could increase their probability of a prize according to their output. That study found significant improvements in workplace attendance, allowing workers to enter the lottery, but without changes in output. Loibl et al. (2016), examined features of the Individual Development Account program in the U.S. and found no effect of PLS over certain returns of equal expected value. A recent experiment by Gertler et al. (2017) randomized the provision of PLS across banks in Mexico and observed a 43% increase in the number of account openings in the month the lotteries were in effect but without affecting balances.⁹

Other experimental results, which *do* find effects on savings amount are to some degree at odds with our own. Atalay et al. (2014) conducted an online portfolio-choice experiment in the U.S. that resulted in subjects saving an additional 12 percentage points more with prize-linked and regular savings than with regular savings alone. Dizon and Lybbert (2016) replicate this design in an experiment conducted in Haiti and identify a 22% increase in savings.¹⁰ In an experiment with undergraduates, Filiz-Ozbay et al. (2015) found that subjects are willing to accept a lower rate of return to delay a payment when the return is stochastic than when it is deterministic. The experimental design of these three studies differed from this one in two respects. First, subjects in those lab studies were supplied with an endowment with which to make portfolio allocations. With a median monthly income of USD 77, households in our study may be too liquidity constrained to sustain a larger balance with PLS. Baseline correlations suggest that monthly income is predictive of savings in the mobile product, though we do not observe heterogeneity of the treatment effect conditional on income. Second, our sample already had access to a number of competing savings products, both formal and informal, which could have dampened demand for PLS savings. Certainly, this discussion does not preclude other factors which could affect the external validity of the results presented here.

⁹Gertler et al. (2017) observes effects on account openings but not on transactions compared to the control group. Our study opened accounts for all participants in the sample.

¹⁰Dizon and Lybbert (2016) emphasize that savings responded to the presence of the stochastic component rather than expected returns.

IV.B. The Role of Regret Aversion

That potential savers respond to PLS by making more frequent deposits without a corresponding increase in balance can be partially rationalized as the subdivision of lotteries to reduce risk (Samuelson 1963). Under this hypothesis, risk averse individuals will subdivide bets over a greater number of gambles so that the risk of a low return is minimized. Since PLS offers returns equivalent in expectation to the matching incentive, we would expect risk averse individuals to save no more with PLS than with the standard account even without liquidity constraints. Yet another explanation for our findings is the “entertainment” utility hypothesis of gambling (Conlisk 1993). That is, consumers will behave in ways that enable them to make gambles because they derive consumption utility from simply playing and irrespective of potential earnings. Under this hypothesis, an increase in the number of deposits in the treatment group is expected if merely making a deposit on a certain day qualifies participants to play the lottery for that day. Recall that participants had almost five more active days—and thus play the lottery five more times—than the control group. Unsurprisingly, participants are not making more deposits *within* days since this does not affect lottery eligibility. For these reasons we expect the PLS to induce more deposits without a corresponding increase in amount saved.

Our study was designed to investigate the role of regret aversion as a specific mechanism explaining demand for PLS. Regret theory is a class of behavioral models that incorporate an individual’s aversion to feelings of regret—an emotional response to foregone opportunities due to action or inaction. Bell (1983) and Loomes and Sugden (1982) were one of the first to formalize this as a complication to expected utility theory. Where expected utility depends only on final outcomes, (dis)utility from regret (rejoicing) depends on the difference between the realized outcome and the best foregone outcome. Additionally, regret theory assumes that individuals can anticipate the psychological consequences of the decisions and therefore take them into account *ex ante*. These class of theories received attention due to their ability to rationalize behavioral deviations from expected utility theory (e.g. the Allais paradoxes).

Zeelenberg et al. (1996) and Zeelenberg and Pieters (2004) demonstrate how the minimization of anticipated regret can rationalize risk-seeking behavior among risk-averse individuals in situations of *asymmetric feedback*. This describes, for example, choices between a lottery and a certain outcome where choosing the lottery leads to its resolution whereas choosing certainty typically does not involve a resolution of the lottery. Since regret derives from a comparison of foregone outcomes, choosing the lottery and receiving feedback involves the possibility of regret while choosing certainty does not. A regret-minimizing individual would thus find certainty favorable above and beyond her risk preferences. Conversely, providing feedback on the lottery regardless of choice (a situation of *symmetric feedback*), removes the role of regret aversion associated with certainty. Zeelenberg et al. (1996) introduced the central test for regret aversion based on this observation. It involves comparing choices between situations of asymmetric versus symmetric feedback, *ceteris paribus*, in order to

isolate the role of regret aversion.

We adapt this test in our own experiment as a way of quantifying the contribution of regret aversion in the demand for PLS. Recall that in the PLS treatment, the lottery involves no possibility of losses and that lotteries are resolved regardless of saving. Therefore, regret manifests when individuals choose not to save but learn about foregone winnings from the lottery. Regret-minimization predicts that individuals on the margin make deposits (and enter the lottery) in avoidance of this regret. We compare behavior with an alternate PLS treatment (the No Feedback group) which provided a day’s lottery results if and only if the individual made a deposit on that day. Participants in this condition correctly anticipate that choosing not to save involves no regret since they can remain unaware of their foregone lottery earnings. As a result, regret theory predicts greater deposits with feedback than without. Moreover, the difference in outcomes between the two treatments can be attributed to regret aversion alone.

Column 1 of Table 3 shows that the effect of No Feedback on the number of deposits are positive but smaller in magnitude to the effect of PLS and are not significant at the 5% level ($\hat{\beta} = 4.59, p < 0.10$). Column 3 reports on the difference between the PLS and No Feedback conditions, which we do not find statistically significant. The effect of No Feedback on number of days saved follows a similar pattern ($\hat{\beta} = 3.93, p < 0.10$) compared to PLS with feedback. Our estimates imply that approximately 20% of the PLS treatment effect can be attributed to regret aversion.

IV.C. Does Experienced Regret Affect Savings?

In the theory of regret outlined in the previous section, the anticipation of regret determines ex ante choice. That model makes no predictions regarding the role of recently experienced regret in individual choice. If participants feel the sting of foregone lottery winnings from yesterday, are they more likely to act on their regret aversion today?

We can leverage the panel structure of our data and the randomness of the lottery results to estimate the effect of recently experienced regret on deposits. If participants are saving in response to experienced regret of foregoing the prize, we expect to see an independent effect of winning the lottery among non-savers on the decision to save in the PLS group. Let $Y_{i,t}$ denote having made a deposit by participant i in period t . $\text{Win}_{i,t}$ is an indicator for having a winning lottery ticket from the pervious day announced in period t . We estimate the following equation conditional on assignment to the PLS group and not having saved one period prior.

$$Y_{i,t} = \pi \text{Win}_{i,t} + \omega_t + u_{i,t} \quad (3)$$

π is the additional effect from winning but not being able to claim the prize. ω_t is a period-specific fixed effect. We test the null hypothesis of $\pi = 0$.

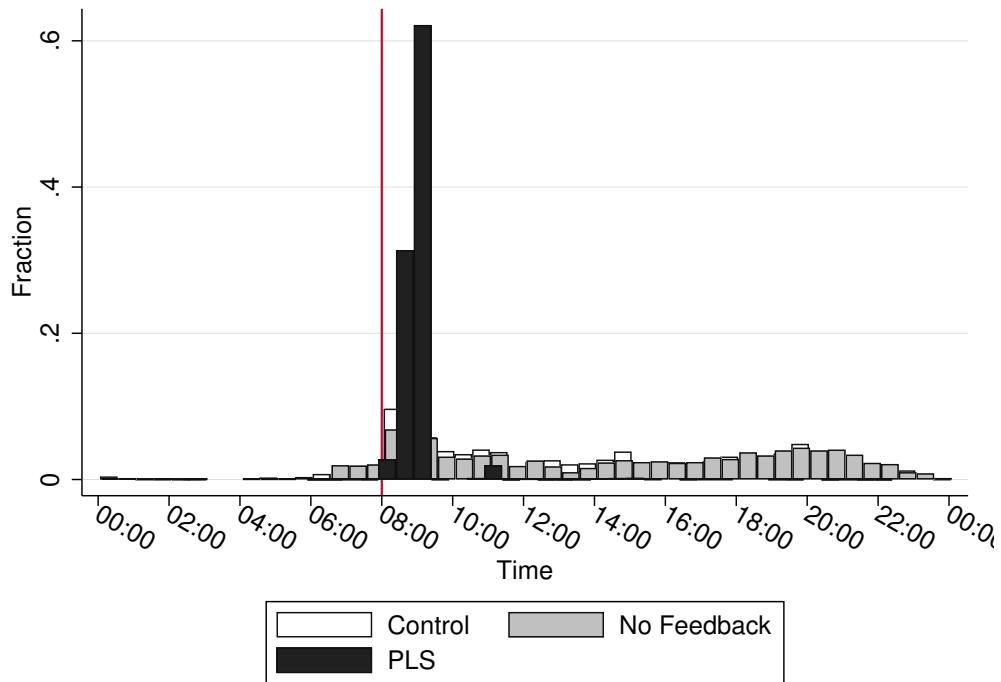
Table 4: Regression of deposits on treatment and lottery results

	Made a deposit
Winning ticket	0.02** (0.01)
Adjusted R^2	0.081
Control mean	0.20
Period 1 effect	
Observations	4473

Notes: This table reports estimates of a regression of having saved at period t on winning the lottery at t conditional on being in the PLS group and not having saved at $t = 1$. The unit of observation is individual-by-period. Standard errors are in parentheses and clustered at the individual level. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level.

Table 4 shows that the treatment effect is 2 percentage points ($p < 0.05$) higher after learning about a winning ticket than learning about a losing one. With an average daily effect of 0.08 of PLS, this account for a fourth of the group treatment effect. Additional evidence comes from Figure 2, which plots the distribution of deposits over time and shows timing suggestive of regret aversion. Nearly all deposits made in the PLS group occurred within an hour of announcing the lottery results from the previous day. We observe no similar pattern in the No Feedback and control groups. Together, the evidence suggests that recently experienced regret from foregone earnings improves the likelihood of entering the lottery in subsequent rounds.

Figure 2: Timing of deposits



Notes: This figure plots the empirical distribution of timing of all deposits over the project period. Each bin spans 30 minutes with a height equal to the fraction of all deposits within each treatment group. A vertical line marks 8:00, when participants received the first SMS that summarized how much the participant saved the previous day, how much the participant earned through a matching contribution or winnings, and their total balance. An hour later, participants received a second SMS encouraging them to save that day. Participants in PLS received a new lottery ticket with the second message.

IV.D. The Effect of PLS on Savings by Other Means

A related objective of this study is to examine whether PLS act as complements or substitutes to existing savings products. Unsurprisingly, we do not find evidence that PLS crowds out saving by other means since there was no treatment effect on amount saved using PLS. Table 5 reports no statistically significant effect on total saving through M-Pesa or ROSCAs. We do find, however, that respondents in PLS are 14 percentage points ($p < 0.05$) more likely to save with a ROSCA compared to the control group and 16 percentage points ($p < 0.05$) more likely relative to the No Feedback condition. This result is robust to the inclusion of covariates but is significant at the 10% level when correcting for multiple inference ($p < 0.10$). We find no effect of the No Feedback condition on informal saving. This finding is puzzling but one possible explanation is that participants may be borrowing from ROSCAs in order to fund their PLS deposits. Overall, we do not find that PLS cannibalizes savings from other sources in line with earlier experimental results (Atalay et al. 2014; Dizon and Lybbert 2016; Filiz-Ozbay et al. 2015).

Table 5: Treatment effects – Savings outside the project

	Effect estimates			Sample	
	(1) No Feedback	(2) PLS	(3) PLS- No Feedback	(4) Control Mean (SD)	(5) Obs.
Total savings last month	18.45 (25.16) [0.87]	-17.87 (14.64) [0.53]	-36.32 (24.06) [0.37]	80.31 (112.74)	284
M-Pesa savings last month	-5.42 (6.34) [0.87]	-6.71 (5.49) [0.53]	-1.29 (5.30) [0.81]	20.42 (44.67)	284
ROSCA savings last month	1.48 (6.76) [0.97]	7.37 (6.79) [0.53]	5.89 (7.33) [0.70]	22.24 (42.18)	283
Saves with a ROSCA	-0.02 (0.07) [0.97]	0.14** (0.07) [0.17]	0.16** (0.07) [0.10]	0.54 (0.50)	284

Notes: Columns 1–3 report OLS estimates of the treatment effect. Standard errors are in parentheses and FWER adjusted p -values are in brackets. Observations are at the individual level. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level. Stars on the coefficient estimates reflect unadjusted p -values.

IV.E. PLS Increases Self-Reported Gambling

At the end of the trial, we asked participants whether they gambled more than they usually do apart from participating in the savings program. As reported in Table 6, we find that participants in the PLS group self-report higher gambling behavior the savings program. On average, treated participants are 15 percentage points ($p < 0.05$) more likely to report gambling than the control group. This finding is robust to covariate adjustment and is significant at the 10% level after FWER adjustment. We find no average effects for participants

in the No Feedback group. Our measure for gambling activity is susceptible to experimenter demand though it is unclear in what direction this might bias our estimate. With this caveat in mind, the effect provides some evidence of a complementary relationship between PLS and broader gambling behavior.

Atalay et al. (2014) and Dizon and Lybbert (2016) both observe large reductions in gambling expenditure in order to finance savings with PLS. It is possible that while PLS is a substitute for gambling with a cash windfall (as in their study), it interacts differently when individuals already have a history of gambling. Cookson (2016) offered individuals in Nebraska access to an PLS and observed cash withdrawals at casinos as a measure of gambling behavior. They find reductions in transactions between 7-15% and credit the effect to substitution of casino gambling with PLS.

Table 6: Treatment effects – Gambling

	Effect estimates			Sample	
	(1) No Feedback	(2) PLS	(3) PLS- No Feedback	(4) Control Mean (SD)	(5) Obs.
Gamble more	0.06 (0.05) [0.61]	0.15*** (0.06) [0.05*]	0.08 (0.06) [0.47]	0.12 (0.32)	284
Gamble less	-0.02 (0.05) [0.88]	0.04 (0.06) [0.80]	0.06 (0.05) [0.56]	0.16 (0.37)	284
More tempted to gamble	0.09 (0.07) [0.61]	0.05 (0.07) [0.80]	-0.04 (0.07) [0.56]	0.47 (0.50)	284
Less tempted to gamble	-0.01 (0.03) [0.88]	0.03 (0.04) [0.80]	0.04 (0.04) [0.56]	0.06 (0.25)	284

Notes: Columns 1–3 report OLS estimates of the treatment effect. Standard errors are in parentheses and FWER adjusted p -values are in brackets. Observations are at the individual level. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level. Stars on the coefficient estimates reflect unadjusted p -values.

V. CONCLUSION

If PLS contribute to problem gambling, the program is potentially welfare-decreasing for households susceptible to problem gambling.

Moreover, the study’s particular experimental design allows us to identify dynamic effects: participants make more frequent deposits to their accounts with lottery-like incentives. This result suggests that a non-pecuniary appeal of gambling, unrelated to prize amounts, may be enough to induce a change in savings behavior. PLS may thus improve utilization among existing account holders and be able to attract new savers to open formal savings accounts. Frequent deposits may also have long-term benefits by encouraging the formation of a savings habit (Alessie and Teppa 2009). From a policy perspective, PLS may not be revenue

neutral compared to matching if financial institutions incur greater transaction costs as a result of more frequent deposits.

By taking advantage of savers' preference for gambling, stochastic incentive schemes like PLS represent a promising policy tool to overcome behavioral barriers to saving. We conducted a randomized experiment testing a PLS product with informal residents in Nairobi, Kenya. Utilizing a mobile savings platform, we randomly assign respondents to a savings account with a certain, matching incentive, a lottery incentive, and a lottery incentive with feedback on ex post potential lottery winnings. We set the fixed match equivalent in expectation to the lottery prize so that comparing the two groups identifies the effect of stochastic incentives compared to deterministic incentives holding amount constant. After observing account transactions over a 60-day savings period, we find that participants in the PLS group made between 5-6 more deposit transactions than the matched payments group without a corresponding increase in amount saved. These results suggest that savers are making more deposits in order to "play" and experience a non-pecuniary benefit from the lottery. We further find that participants in the PLS group are more likely to report increased gambling after the end of the savings program.

If PLS increase deposits but are ineffective at increasing a key outcome like savings, are they still useful from a policy perspective? If playing the lottery is appealing to potential savers, PLS may be able to attract new savers to open accounts. PLS can also improve utilization among existing account holders. Frequent deposits may have long-term benefits by encouraging the formation of a savings habit (Alessie and Teppa 2009). Compared to a fixed match, lottery incentives may not be revenue neutral if financial institutions incur greater transaction costs as a result of more frequent deposits. If PLS contribute to problem gambling, the program is potentially welfare-decreasing for poor households already susceptible to costly gambling behavior. Overall, we document important differences between PLS and fixed-incentive schemes when it comes to encouraging savings and show that product design is crucial in determining welfare implications.

REFERENCES

- Akbas, Merve et al. *How to Help the Poor to Save a Bit: Evidence from a Field Experiment in Kenya*. Tech. rep. Institute for the Study of Labor (IZA), 2016.
- Alessie, Rob and Federica Teppa. “Saving and habit formation: evidence from Dutch panel data”. en. In: *Empirical Economics* 38.2 (Mar. 2009), pp. 385–407. ISSN: 0377-7332, 1435-8921. DOI: 10.1007/s00181-009-0272-z.
- Anderson, Michael L. “Multiple Inference and Gender Differences in the Effects of Early Intervention: A Reevaluation of the Abecedarian, Perry Preschool, and Early Training Projects”. In: *Journal of the American Statistical Association* 103.484 (2008), pp. 1481–1495. ISSN: 0162-1459. DOI: 10.1198/016214508000000841.
- Ashraf, Nava, Dean Karlan, and Wesley Yin. “Tying Odysseus to the Mast: Evidence From a Commitment Savings Product in the Philippines”. en. In: *The Quarterly Journal of Economics* 121.2 (May 2006), pp. 635–672. ISSN: 0033-5533, 1531-4650. DOI: 10.1162/qjec.2006.121.2.635.
- Atalay, Kadir et al. “Savings and prize-linked savings accounts”. In: *Journal of Economic Behavior & Organization* 107, Part A (Nov. 2014), pp. 86–106. ISSN: 0167-2681. DOI: 10.1016/j.jebo.2014.07.015.
- Banerjee, Abhijit V. and Esther Duflo. “The Economic Lives of the Poor”. In: *The Journal of Economic Perspectives* 21.1 (Jan. 2007), pp. 141–167. DOI: 10.1257/089533007780095556.
- Bell, David E. “Risk premiums for decision regret”. In: *Management Science* 29.10 (1983), pp. 1156–1166.
- Bjorkman Nyqvist, Martina et al. “Using Lotteries to Incentivize Safer Sexual Behavior: Evidence from a Randomized Controlled Trial on HIV Prevention”. In: *World Bank Policy Research Working Paper* 7215 (2015).
- Brune, Lasse. “The Effect of Lottery-Incentives on Labor Supply: A Firm Experiment in Malawi”. In: (2015).
- Chetty, Raj and John N. Friedman. “Active vs. Passive Decisions and Crowd-Out in Retirement Savings Accounts: Evidence from Denmark.” Quarterly”. In: *Journal of Economics* (2014), pp. 1311–1346.
- Collins, Daryl et al. *Portfolios of the Poor: How the World’s Poor Live on \$2 a Day*. en. Google-Books-ID: XZIF1gshRL0C. Princeton University Press, Apr. 2009. ISBN: 978-1-4008-2996-5.
- Conlisk, John. “The utility of gambling”. In: *Journal of Risk and Uncertainty* 6.3 (1993), pp. 255–275.
- Cookson, J. Anthony. *When Saving is Gambling*. SSRN Scholarly Paper ID 2517126. Rochester, NY: Social Science Research Network, Jan. 2016.
- Cornsweet, Tom N. “The Staircase-Method in Psychophysics”. In: *The American Journal of Psychology* 75.3 (1962), pp. 485–491. ISSN: 0002-9556. DOI: 10.2307/1419876.
- Demirguc-Kunt, Asli et al. *The Global Findex Database 2017: Measuring financial inclusion and the fintech revolution*. The World Bank, 2018.

- Dizon, Felipe and Travis J. Lybbert. “Leveraging the Lottery for Financial Inclusion: Lotto-Linked Savings Accounts in Haiti”. In: (2016).
- Dupas, Pascaline and Jonathan Robinson. “Why don’t the poor save more? Evidence from health savings experiments”. In: *The American Economic Review* 103.4 (2013), pp. 1138–71.
- Eckel, Catherine C and Philip J Grossman. “Sex differences and statistical stereotyping in attitudes toward financial risk”. In: *Evolution and Human Behavior* 23.4 (2002), pp. 281–295.
- Ferris, Jackie and Harold Wynne. “The Canadian problem gambling index”. In: *Ottawa, ON: Canadian Centre on Substance Abuse* (2001).
- Filiz-Ozbay, Emel and Erkut Y. Ozbay. “Auctions with anticipated regret: Theory and experiment”. In: *The American Economic Review* 97.4 (2007), pp. 1407–1418.
- Filiz-Ozbay, Emel et al. “Do lottery payments induce savings behavior? Evidence from the lab”. In: *Journal of Public Economics* 126 (June 2015), pp. 1–24. ISSN: 0047-2727. DOI: 10.1016/j.jpubeco.2015.02.007.
- Gertler, Paul et al. “The Long-Term Effects of Temporary Incentives to Save: Evidence from a Field Experiment in Mexico”. In: (2017).
- Imas, Alex, Diego Lamé, and Alistair J. Wilson. “Regret in One-Shot and Recurrent Decisions: A Cautionary Tale”. In: (2016). Publisher: CESifo Working Paper Series.
- Karlan, Dean and Jonathan Zinman. “Price and control elasticities of demand for savings”. In: *Journal of Development Economics* 130 (Jan. 2018), pp. 145–159. ISSN: 0304-3878. DOI: 10.1016/j.jdeveco.2017.10.004.
- Karlan, Dean et al. *Getting to the top of mind: How reminders increase saving*. Tech. rep. National Bureau of Economic Research, 2010.
- Karlan, Dean, Aishwarya Lakshmi Ratan, and Jonathan Zinman. “Savings by and for the Poor: A Research Review and Agenda”. en. In: *Review of Income and Wealth* 60.1 (Mar. 2014), pp. 36–78. ISSN: 1475-4991. DOI: 10.1111/roiw.12101.
- Karlan, Dean S. et al. “Banking the Unbanked? Evidence from Three Countries”. In: (2016).
- Kearney, Melissa Schettini et al. *Making Savers Winners: An Overview of Prize-Linked Savings Products*. NBER Working Paper 16433. National Bureau of Economic Research, Inc, 2010.
- Kemibaro, Moses. *SportPesa Is ‘Blowing Up’ As Kenya’s Largest Online Sports Betting Service*. May 2015.
- Kimmel, Stephen E. et al. “Randomized trial of lottery-based incentives to improve warfarin adherence”. English. In: *American Heart Journal* 164.2 (Aug. 2012), pp. 268–274. ISSN: 0002-8703, 1097-6744. DOI: 10.1016/j.ahj.2012.05.005.
- Lin, Winston. “Agnostic notes on regression adjustments to experimental data: Reexamining Freedman’s critique”. EN. In: *The Annals of Applied Statistics* 7.1 (Mar. 2013), pp. 295–318. ISSN: 1932-6157, 1941-7330. DOI: 10.1214/12-AOAS583.

- Loibl, Căzilia et al. *Testing Strategies to Increase Saving and Retention in Individual Development Account Programs*. SSRN Scholarly Paper ID 2735625. Rochester, NY: Social Science Research Network, Feb. 2016.
- Loomes, Graham and Robert Sugden. "Regret theory: An alternative theory of rational choice under uncertainty". In: *The economic journal* 92.368 (1982), pp. 805–824.
- Murphy, Anne L. "Lotteries in the 1690s: Investment or Gamble?" In: *Financial History Review* 12.02 (2005), pp. 227–246.
- Rotter, Julian B. "Generalized expectancies for internal versus external control of reinforcement". In: *Psychological Monographs: General and Applied* 80.1 (1966), pp. 1–28. ISSN: 0096-9753(Print). DOI: 10.1037/h0092976.
- Samuelson, Paul A. "Risk and uncertainty: A fallacy of large numbers". In: (1963).
- Schaner, Simone. "The Cost of Convenience? Transaction Costs, Bargaining Power, and Savings Account Use in Kenya". In: 2013c. *Dartmouth College Working Paper*, available at: http://www.dartmouth.edu/~sschaner/main_files/Schaner_ATM.pdf (2011).
- "The Persistent Power of Behavioral Change: Long-Run Impacts of Temporary Savings Subsidies for the Poor". en. In: *American Economic Journal: Applied Economics* 10.3 (July 2018), pp. 67–100. ISSN: 1945-7782, 1945-7790. DOI: 10.1257/app.20170453.
- Somville, Vincent and Lore Vandewalle. "Saving by Default: Evidence from a Field Experiment in Rural India". en. In: *American Economic Journal: Applied Economics* 10.3 (July 2018), pp. 39–66. ISSN: 1945-7782, 1945-7790. DOI: 10.1257/app.20160547.
- Thaler, Richard H. and Shlomo Benartzi. "Save More Tomorrow™: Using Behavioral Economics to Increase Employee Saving". In: *Journal of Political Economy* 112.S1 (2004), S164–S187. ISSN: 0022-3808. DOI: 10.1086/380085.
- Westfall, Peter H. and S. Stanley Young. *Resampling-Based Multiple Testing: Examples and Methods for P-Value Adjustment*. en. John Wiley & Sons, Jan. 1993. ISBN: 978-0-471-55761-6.
- Zeelenberg, Marcel and Rik Pieters. "Consequences of regret aversion in real life: The case of the Dutch postcode lottery". In: *Organizational Behavior and Human Decision Processes* 93.2 (2004), pp. 155–168.
- Zeelenberg, Marcel et al. "Consequences of Regret Aversion: Effects of Expected Feedback on Risky Decision Making". In: *Organizational Behavior and Human Decision Processes* 65.2 (Feb. 1996), pp. 148–158. ISSN: 0749-5978. DOI: 10.1006/obhd.1996.0013.
- Zellner, Arnold. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias". In: *Journal of the American Statistical Association* 57.298 (June 1962), pp. 348–368. ISSN: 0162-1459. DOI: 10.1080/01621459.1962.10480664.