How Important are Investment Indivisibilities for Development? Experimental Evidence from Uganda*

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Abstract

Theoretically, indivisible investments can lead to lower development, poverty traps, and risk-loving behavior. Testing this, we offered peri-urban Ugandans a choice between a safer, lower payoff and a riskier, larger payoff lottery; 27% of participants choose the riskier lottery, with winners investing more in land and durable business assets, eventually increasing income. In contrast, winning the small lottery has only transitory impacts on business inventory and livestock. Our quantitative model shows that the aggregate effects of financial deepening are sizable if the indivisible investment can be accumulated (e.g., capital) but not if it is in fixed supply (e.g., land).

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1 Introduction

Theory suggests that high-yield, indivisible investment opportunities can play crucial roles in development. In particular, at the micro level, they can help explain entrepreneurship decisions and savings dynamics (Buera, 2009; Midrigan and Xu, 2014), can lead to poverty traps (Banerjee and Newman, 1993; Buera et al., 2014), and are important in predicting the effects of financial interventions and poverty programs (Kaboski and Townsend, 2011; Buera et al., 2015; Banerjee et al., 2019; Buera et al., 2020). At the aggregate level, they are also critical in understanding the quantitative importance of financial frictions on output, productivity, and investment (Buera et al., 2014; Midrigan and Xu, 2014).

Indivisibilities in high-yield investments imply that some households could significantly increase profitability if they had a large amount of additional capital to invest, but may not be able do so with only small amounts of capital if financial frictions are severe (Dercon, 1998; Barrett et al., 2006; Santos and Barrett, 2011). If poor households lack access to credit, they cannot borrow money to make the indivisible investment. Likewise, if returns to incremental savings are low, households may not be able or find it worthwhile to save for indivisible investments even when they are high-yield. In the presence of financial frictions, households with high-yield indivisible investment opportunities may fall into poverty traps, and the indivisible investment opportunities may induce the same households to make risk-loving choices for the chance to obtain a sufficiently high payout to make the investment (Kwang, 1965; Chetty and Szeidl, 2007; Lybbert and Barrett, 2011).

We use a field experiment to test the extent to which households will select into a riskier, lower expected value lottery for the chance to obtain a much larger payoff than a safer but lower payoff lottery in peri-urban Uganda where financial services are scant. The experiment enables us to empirically assess the rate at which participants take up the riskier lottery, the characteristics of those selecting the riskier lottery, the investment choices of lottery winners, and the effect of winning the lottery on income and consumption. We motivate the experiment with a model of indivisible investment opportunities in an environment without credit or interest-bearing savings. The model shows that households with a high-yield invisible investment opportunity may be unable to escape poverty traps if they lack access to finance and sufficient wealth to fund the investment.

Next, we show that although poor households are generally risk averse (Rosenzweig and Binswanger, 1993; Donovan, 2021), the presence of high-yield indivisible investment opportunities can induce some households to make risk-loving choices. Our model predicts that high productivity households with assets below what is needed for the indivisible investment are characterized by risk-loving behavior with varying levels of patience and impatience, due to high potential returns. They may also have higher initial savings, in an attempt to finance the indivisible investment good. The lottery experiment poses households with an actual choice between a lottery that pays out approximately \$100 with 50% probability or lottery with lower expected value that pays out approximately \$475 with 10% probability, allowing us to characterize who chooses the riskier lottery. The randomly selected winners receive the payout of their chosen lottery as a cash grant via mobile money. We follow up at 4 months, 18 months, and 6 years with a survey which allows us to empirically assess how investment goods vary by lottery choice.

We find that a substantial share of the sample, 27 percent, does indeed prefer the riskier option. These riskier choices are more common among males, well-known to have lower underlying risk aversion (e.g., Meissner et al. (2023)), but consistent with the model, the risky option is also preferred by high-saving, investment-oriented households. Those choosing the riskier lottery have higher crop income, business assets, and total wealth and are more likely to report a desire for credit to make a business investment. We also find that only winners of the riskier, larger payoff lottery sustain higher levels of investment in indivisible goods at the second endline. Large lottery winners invest in durable business assets (e.g., a generator) and land, and land exhibits substantial capital gains. In contrast, small lottery winners make short-lived investments in small livestock (e.g., chickens) and business inventory (e.g., retail goods).

In evaluating impacts of winning the grant on the household, we use both a basic OLS specification and a seemingly unrelated regression (SUR). The necessity of a household budget summing up to equal income plus assets implies that the equations which estimate impacts on consumption, savings, investment, income, and borrowing are not independent, and so we use SUR to impose a cross-equation budget constraint. In doing so, we highlight the application of a method commonly used in the estimation of demand systems to the analysis of cash grants.

The model suggests that high-productivity households with new access to a large sum of money invest it and should be able to make large gains in income over time. In the short run (4 months after the lotteries pay out to winners), we find no significant impact on either consumption or income, by small or large lottery winners. In the medium run (18 months after payout), however, we find that large lottery winners have higher consumption, while winning the small grant still has no significant impact on either consumption or income. In a long run follow-up survey (6 years after payout), we find a substantial increase in income for large lottery winners with some (imprecise) evidence of gains to consumption. This is consistent with findings from Balboni et al. (2022) in which a household's ability to leverage a randomized transfer of wealth to work its way out of poverty depends on initial levels of wealth.

Finally, we calibrate the model to reflect participants' actual lottery choices and income and savings distributions, and we use the calibrated model to simulate the impact of financial services expansion. We show that the impacts of relaxing financial frictions on aggregate development in the area depend critically on the elasticity of the supply of the investment good. If the lumpy investment is elastically supplied to a community (e.g., tractors for a farm or refrigerators for a business), then access to credit or savings expands the set of people able to invest, and the increase in demand expands the amount of real investment in the community. In this case, financial services can increase income, investment, and economic mobility. If instead the lumpy investment is inelastically supplied in the community (e.g., land), then increased demand from expanding financial services manifests largely in an increase in prices rather than real investment. The model's results relate closely to our experimental results, since general equilibrium effects may be quite relevant for an investment like land, which is in fixed supply.

Our paper contributes to the literature on the aggregate importance of financial frictions, poverty traps, cash grants, and the impacts of financial services expansion. We add empirical and quantitative guidance to a macro literature on financial frictions and poverty traps. Banerjee and Newman (1993), Galor and Zeira (1993), and Piketty (1997) are examples of models with indivisibilities, where financial frictions lead to poverty traps. Later work showed that indivisible decisions, when embedded in quantitative models with intensive margins and mapped to the data, did not lead to macro multiplicities, but only micro poverty traps as in Buera (2009). This resulted in lower aggregate output (Buera et al., 2014; Midrigan and Xu, 2014) and slower convergence (Buera and Shin, 2013). These theories all lead to demand for financing but also risk. We contribute to these findings by showing the empirical importance of both indivisibilities and risk-loving behavior linked together, and using these empirical results to discipline their quantitative importance.

Other closely related papers present empirical evidence on poverty traps and indivisibilities in developing economies. Balboni et al. (2022) examine the impact of a uniform livestock asset grant in Bangladesh and show that the impact is an s-shaped function of the initial assets of the recipient. Our work complements theirs: we allow for an endogenous relationship between productivity and initial wealth, which would confound empirics based on the initial level of assets, so we focus instead on risk preference. Through our use of a risky versus safer lottery, we also examine whether some groups may experience differentially larger returns to investment. Relatedly, Banerjee et al. (2019) present empirical evidence that despite low average returns, microcredit does indeed break a poverty trap for "gung-ho" entrepreneurs, those with prior business experience who exhibit higher than average returns to business investment. In non-experimental settings, Lybbert et al also examine livestock-based poverty traps empirically in a series of papers (e.g., Lybbert et al., 2004; Carter and Lybbert, 2012), and they highlight the role of risk taking (Lybbert and Barrett, 2011). McKenzie and Woodruff (2006) present evidence for poverty traps with observational data on Mexican microenterprises. These papers emphasize business investment and livestock as indivisible investments driving poverty trap dynamics. To this literature, we contribute novel findings on the role of land and capital gains in generating poverty traps.[1] In some cases, rental markets can be a way of overcoming investment indivisibilities (e.g., Bassi et al., 2022; Caunedo and Kala, 2021), but rental is less useful if capital gains are an important part of the return. Our findings on land also complement recent work by Acampora et al. (2022), who show that market imperfections lead to the under-utilization of land rentals and lower aggregate returns to land.

Cash grants have become a popular approach to identifying the marginal returns of capital for entrepreneurs (De Mel et al., 2008, 2014) and the returns to poverty programs more generally (Blattman et al., 2014, 2016; Haushofer and Shapiro, 2016, 2018; Egger et al., 2019). Recent work by Banerjee et al. (2023) shows that cash grants of equivalent value have greater impact on revenues and enterprise ownership when delivered as a lump sum (rather than through multiple disbursements of smaller size). This is consistent

[1] Although land is in principle divisible, whether property rights are customary or formal, it is generally divided into discrete plots both in its use and any transactions and titling.

with work by Casaburi and Macchiavello (2019), Herskowitz (2021), and Gertler et al. (2023) who show demand for lumpiness, as evidenced by demand for less frequent but larger payments, the use of gambling to finance lumpy expenses, and greater take-up of prize-linked savings when there is the possibility of winning a large cash lottery, respectively. Other related work by Beaman et al. (2023) shows evidence of selection into borrowing that reveals which farmers have high returns to capital. We combine experimental variation in grant payouts with a choice between a safer, lower payoff lottery and a riskier, higher payoff lottery to reveal which respondents face high-yield, indivisible investment opportunities.

Our simulations of the aggregate impacts of financial frictions are an additional contribution. Methodologically, we contribute to an emerging literature using experiments in conjunction with macro development models (e.g., Buera et al., 2014; Bergquist et al., 2019; Donovan, 2021; Lagakos et al., 2018; Buera et al., 2020).[2] While these papers use the results of RCTs to discipline simulated impacts of scaled policies in the macroeconomy, our paper is novel in using an experiment to actually test an existing theory of macrodevelopment and quantify its implications. We focus on financial services and illustrate that, even when indivisibilities can lead to micro-level poverty traps where financial services may seem particularly needed and powerful, their scaled impact can depend critically on the elasticity of the supply of the relevant capital.

The rest of the paper is organized as follows. Section 2 presents our simple motivating model. Section 3 summarizes our experimental methodology and data collection. Section 4 characterizes the types of households that select into the large lottery. Section 5 describes the effect of lottery winnings on investment and the household budget in general. Finally, Section 6 calibrates the model to our data and simulates the macroeconomic consequences of credit injections and redistribution.

2 Model and Motivation

In this section, we develop a simple model to illustrate mechanisms through which the combination of high-yield indivisible investments and financial frictions can lead to both poverty traps and behavior that is risk-loving and impatient. This provides motivation for our empirical experiment. Although we focus on qualitative patterns of individual decisions here, the model is parametric, since it will be later used for quantitative analysis in Section 6.

2.1 Set Up

We discuss the preferences, income streams, and investment decisions of households in turn.

2.1.1 Preferences

Households have time-additive preferences over consumption:

$$V_0 = \mathbb{E}_t \Sigma_{t=0}^{\infty} \beta^t \frac{c_t^{1-\nu}}{1-\nu},$$

[2]See Buera et al. (2020) for a review of this literature.

where ν is the (positive) coefficient of relative risk aversion, reflecting the underlying assumption that individuals are risk averse by nature. We assume that a fraction $1-p$ of them die each period and are replaced by an equal mass of newborn households with no initial wealth. Therefore, $\beta = \hat{\beta}p$ reflects time discounting, a product of the discount factor $\hat{\beta}$ and the survival probability p. The expectation is over realizations of death but also shocks to labor income, e_t, and capital income, y_t. (Here we loosely refer to capital income and capital to capture any investment income, but keep in mind that empirically, land will be the relevant investment good.)

2.1.2 Income

Labor income is a product of permanent and transitory components, both of which are stochastic. Specifically, we assume that

$$e_t = \bar{e}\varepsilon_t$$

where $\bar{e}$ is a permanent component and ε_t are idiosyncratic, independently- and identically-distributed (iid), lognormal innovations with log mean equal to zero and (log) variance of σ_e^2.

Capital income is a function of the amount of capital k_t and entrepreneurial ability z_t:

$$y\left(z,k\right) = z_t k_t^{\alpha} - \delta k_t.$$

We assume $0 < \alpha < 1$ so that the production function exhibits diminishing returns to scale. The term, δk_t, is the maintenance expense associated with having k_t units of capital. Like labor income, capital income is also stochastic, since z_t, in parallel fashion, also follows a stochastic process:

$$z_t = \bar{z}v_t$$

where v_t are iid., lognormal innovations with mean zero and variance σ_v^2.

2.1.3 Financial Environment and Investment Decisions

Households choose their liquid assets and capital. While capital produces capital income, liquid assets a_{t+1} earns an interest rate of r. In principle, liquid wealth can be negative but savings decisions are bounded below, since borrowing is limited by the value of available capital as collateral. We assume that households can borrow up to a multiple θ of this value

$$a_{t+1} \geq -\theta P_t k_{t+1}.$$

Capital can be bought and sold at the price P_t, but, critically, to capture the indivisibility of investment in a simple fashion, we assume it is divided into discrete units and for simplicity we assume that agents can only purchase one unit of indivisible capital. Hence, agents face the binary choice: $k_t \in \{0, k_1\}$. where k_1 represents the size of capital relative to typical income.

Denoting the price of capital P_t, the household's budget constraint is:

$$c_t + a_{t+1} + k_{t+1} - k_t = e_t + \left(1+r\right)a_t + z_t k_t^{\alpha} + \left(1-\delta\right)P_t k_t. \tag{1}$$

One can reformulate the household's problem recursively with cash on hand, $l = e + (1+r)\,a + zk^{\alpha} + (1-\delta)\,Pk$, as the only endogenous state variable. The value function then becomes:

$$V(l;\bar{e},\bar{z}) = \max_{c,a',k' in\{0,k_1\}} \frac{c^{1-\nu}}{1-\nu} + \beta\mathbb{E}V\,(l';\bar{e},\bar{z})$$

subject to:

$$c + a' + Pk' \leq l, \tag{2}$$

$$a' \geq -\theta Pk', \tag{3}$$

and

$$l' = e' + (1+r)\,a' + z'\,(k')^{\alpha} + (1-\delta)\,Pk'. \tag{4}$$

We normalize P to one in the initial steady state prior to interventions.

2.2 Model Results: Poverty Traps and Risk Loving Behavior

We first show how the model generates poverty traps and risk-loving lottery choices. We then summarize how the model motivates our experiment and empirics.

2.2.1 Optimal Choices and Poverty Traps

Poverty traps arise in the model due to the indivisible investment. One can show that the household will never invest if productivity is so low that the return from investing in capital is less than the return to saving in assets. That is, a necessary (though not sufficient) condition for the household to invest is that the expected return to investing k_1 exceed the value of saving that same amount:

$$\exp(\sigma_v^2/2)\bar{z}k_1^{\alpha} + (1-\delta)\underline{k} \geq (1+r)\,k_1$$

The return to saving (right-hand side) is constant, whereas the return to investing (left-hand side) is increasing in $\bar{z}$. When this constraint holds with equality, it defines a lower bound $\bar{z}^* = (r+\delta)\,k_1^{1-\alpha}\exp(-\sigma_e^2/2)$ on entrepreneurial productivity such that for lower levels of $\bar{z}$, no investments are made.[3] The poverty trap and risk-loving behavior on which we focus are therefore characteristic of those with high entrepreneurial productivity and a desire to invest, a key finding that we will examine empirically.

We now discuss the model's more interesting qualitative predictions with respect to poverty traps, savings behavior, and risk. We present simulated examples of optimal behavior for a particular value of $\bar{z} > \bar{z}^*$, e, and $k = 0$ in Figure 1. We also set the parameters of the financial system such that households have no access to credit, i.e., $\theta = 0$ or interest bearing savings, i.e., $r = 0$.[4] (All parameters follow our later empirical

[3] Again, this is a necessary though not sufficient condition because households are risk averse. The precise threshold to invest therefore depends on the level of liquidity and labor income, i.e., a $\bar{z}^{**}(l,\bar{e}) \geq \bar{z}^*$ defined by $V_0(l;\bar{e},\bar{z}^{**}) = V_k(l;\bar{e},\bar{z}^{**})$, where the two value functions are for $k = 0$ and $k = k_1$, respectively.

[4] These stark assumptions are simply illustrative at this point, but they will not be too far off from our empirical setting, where credit levels are quite limited and formal savings accounts bear no interest. We will maintain these parameter values for a benchmark in our quantitative work of Section B.

calibration in Section B.) Moreover, for easier exposition, we present the value functions and optimal policies (i.e., behavioral decisions) as functions of liquid assets, $a = l - e$, a simple transform of cash-on-hand. The four panels shows the value function (upper-left), capital choice (upper-right), liquid assets — or savings choice (lower-left), and consumption choice. For each panel, the minimum amount of assets needed to invest in the indivisible capital, k_1, is critical, so we indicate it with the vertical, dashed, red line. (Though labeled k_1 for simplicity, this line is actually $k_1 - e$ under the transform.)

The upper-left panel shows the value function increases with the level of liquid assets but in a very non-linear way around the threshold, as we discuss below. The upper-right panel shows that if households' liquid assets exceed the minimum threshold, then they invest immediately in the indivisible capital. All households would like to, but poorer households are unable to invest given the borrowing constraint.

Looking at lower panels, we see that savings (left) and consumption (right) decisions are non-monotonic, with both dropping around the investment threshold. At the threshold, savings drops to zero, as the household puts all available resources into the indivisible capital because of its higher return. Indeed, consumption also falls to nearly zero, indicating that the threshold asset level to invest is only slightly higher than the needed investment; households are willing to sacrifice consumption, when high-yield investment opportunities are available. As assets increase beyond this threshold, however, consumption increases one-for-one as the marginal utility of present consumption exceeds the expected marginal utility of future consumption (which will likely have higher income because of the investment). Thus, households, though wealthy, are hand-to-mouth.[5]

The dashed blue line in the lower-left panel is the 45-degree line. The intersection of the savings policy function with this line defines a critical value of assets, a^*. Since the savings functions crosses the 45-degree line from below, this intersection defines an unstable steady state but also characterizes poverty trap dynamics: a household with assets above a^* will (in expectation) save up and increase its liquid assets over time to eventually invest in the high-yield indivisible investment. In contrast, a household with liquid assets below a^* will (in expectation) see its assets decline to the stable steady state at zero over time.

Looking at consumption decisions in the lower-right panel, one can see the importance of the threshold, which corresponds to a local peak in consumption. However, at asset levels below this peak, consumption is lower because assets are lower. At asset levels above this peak, consumption is lower despite assets being higher. Hence, households saving to invest display an apparent high level of patience, not because of an innate higher discount factor but because the household is saving to self-finance the high-yield indivisible investment in the future.

Finally, we return to the upper-left panel, to see how this behavior impacts the value function. Note that the slope of the value function reflects the marginal value of assets, which varies considerably. The marginal value of assets is highest just to the right of the threshold, given the low level of consumption. Indeed,

[5]This nonmonotonicity in consumption with indivisible investment was emphasized by Kaboski and Townsend (2011), and such people in advanced economies were later coined the "wealthy hand-to-mouth" by Kaplan and Violante (2014) and Kaplan et al. (2014).

to the right of this threshold, the value function exhibits the standard concavity in assets, reflective of the diminishing marginal utility of consumption implied by the assumed logarithmic utility function. However, to the left of the $\underline{k}$ threshold the function is convex, reflecting the declining consumption as assets approach the threshold level.

2.2.2 Lotteries and Risk

The convex region of the value function leads to a preference for risk which will motivate our empirical study. In the lottery experiments of the next section, we will offer a choice between four different lotteries: (i) a "safe now" lottery that pays Δ^S with probability π^S immediately; (ii) a "safe delayed" that pays off with 3 percent interest, i.e., $1.03\Delta^S$, next period with the same π^S probability; (iii) a "risky now" lottery that pays off $\Delta^R > \Delta^S$ but with only probability $\pi^R < \pi^S$; and (iv) a corresponding "risky delayed" lottery that pays $1.03\Delta^R$ next period with the same π^R probability. To assess these lotteries in the context of theory, we denote these four options as SN, SD, RN, and RD, respectively, and use these as superscripts on the value function to denote the value of choosing each lottery.[6] As in our empirical experiment, the risky lotteries have a slightly lower expected payout, so typically risk aversion would push households to choose the safe lottery. However, the indivisible investment opportunity, together with the borrowing constraint, lead to this choice depending on available cash-in-hand (and therefore, in our simplified example, liquid asset) levels.

The value function of being offered the lottery, V^L, is then:

$$V^L(l; \bar{e}, \bar{z}) = \max\{V^{SN}(l; \bar{e}, \bar{z}), V^{SD}(l; \bar{e}, \bar{z}), V^{RN}(l; \bar{e}, \bar{z}), V^{RD}(l; \bar{e}, \bar{z})\}.$$

Figure 2 illustrates V^L (black, solid line) relative to the original V (dashed, black line) and lottery choices by the level of available liquidity for various parameter values of β, $\bar{z} = z$, and $\bar{e} = e$. To connect with the points in the previous graph, we have labeled the level of k_1 as well as the critical value of a^* (within the l space). Clearly, since each lottery has nonnegative payoffs, V^L exceeds V at all points and across all figures. However, the value of the lottery choice (i.e., $V^L - V$) is greatest for a household whose assets are just below the threshold, since the lottery gives them the possibility of being able to quickly make the high-yield,

[6] The values of the immediate lotteries are simply:

$$V^{SN}(l; \bar{e}, \bar{z}) = \pi^S V\left(l + \Delta^S; \bar{e}, \bar{z}\right) + \left(1 - \pi^S\right) V(l; \bar{e}, \bar{z})$$

and

$$V^{RN}(l; \bar{e}, \bar{z}) = \pi^R V\left(l + \Delta^R; \bar{e}, \bar{z}\right) + \left(1 - \pi^R\right) V(l; \bar{e}, \bar{z})]$$

The delayed lotteries require defining continuation values conditional on winning the lottery, since current choices will anticipate future winnings. Define this for risk level $X \in \{S, R\}$ as

$$W^{XD}(l; \bar{e}, \bar{z}) = \max_{c,a',k'} \ln c + \beta \mathbb{E} V\left(l + \frac{1.03\Delta^X}{1+r}; \bar{e}, \bar{z}\right)$$

subject to the budget constraint and law of motion, constraints (2) and (4), respectively. The value of the delayed lotteries are then

$$V^{SD}(l; \bar{e}, \bar{z}) = \pi^S W^{SD}(l; \bar{e}, \bar{z}) + \left(1 - \pi^S\right) V(l; \bar{e}, \bar{z})$$

and

$$V^{RD}(l; \bar{e}, \bar{z}) = \pi^R W^{SD}(l; \bar{e}, \bar{z}) + \left(1 - \pi^R\right) V(l; \bar{e}, \bar{z}).$$

indivisible investment. Which lottery the household chooses depends on its asset levels, however, as well as parameter values.

The point of different values of parameters is to illustrate identification of β and heterogeneity with respect to z and e. The left-hand side figures are for impatient households, ($\beta = 0.8377$) while the right-hand side is for more patient households ($\beta = 0.96$). The top row demonstrates a high productivity household ($z = 1.609$) with average labor income ($e = 1$), the middle row a low productivity household ($z = 0.367$) with average labor income, and the bottom a high productivity household with low labor income. Note that in all cases, the underlying preferences are risk-averse, as we assume, and any risk-loving behavior comes from presence of the high-yield, indivisible investment and the possibility that the large lottery would enable them to make the investment k_1.

Consider the upper-left panel. When the household already has enough liquid assets to invest, it chooses the safe now lottery, since investing is irrelevant and the value function is concave. Similarly, households just below the threshold choose the "safe now" lottery, since winning it yields enough to make the investment, it pays off with a higher probability, and it pays off now (so the investment can be made immediately). In the intermediate ranges, as assets get further below the threshold, the choice moves to the "safe delayed", "risky now", and "risky delayed" choices. When assets are low enough that winning the "safe now" lottery will not quite enable immediate investment, the "safe delayed" is chosen because delaying increases the available resources next period. For still lower levels of assets, the "risky now" is preferred, as the household is willing to take the lower odds of winning because only the higher payout will enable it to invest. Again, at even lower levels, the "risky delayed" is preferred, when winning the "risky now" would still not enable immediate investment. Note that he risky lottery choices are largely confined to those regions below a^*, i.e., households for whom saving out of poverty is suboptimal. Finally, at the lowest level of investment, the "safe now" is again preferred. Here the household is so poor that even winning the highest payout of the "risky delayed" would not be enough for it to be close to investing, the investment opportunity is effectively irrelevant, and the value function is locally concave. It chooses not to delay because it is inherently impatient.

Moving down the panels on the left, we see that both the ordering and range of the various lottery choices and the poverty trap specifics are sensitive to both capital productivity and labor income. A low productivity household dissaves if it cannot immediately afford capital. The benefit of the lottery is much smaller, since moving over the threshold and investing is of less value when the household is low productivity. The risk-loving region is also much smaller. In the lower panel, the agent is productive, but it has lower labor income, and so it is more difficult to accumulate assets. A larger poverty trap exists, i.e., a^* is larger.

Looking at the right panels, we can see the impact of patience. These households are much more willing to save, and the assets accumulate relatively quickly. The poverty trap region therefore disappears, except for the poorest households with low-labor income in the lower-right panel because saving would take too long. Nevertheless, in all cases the choices for the large lottery disappear. Again, it is better for these households to take the small lottery and simply save up since even the small lottery helps them get past the poverty trap threshold.

The contrast between the left- and right-columns illustrates why we will need to assume that households are highly impatient in order to yield risk-loving behavior. The observed lottery choices will facilitate identification of the model. The heterogeneity in choices across different productivity and income underscores that the relationship between liquidity and lottery choice cannot be taken directly to the data in a simplistic fashion.

2.2.3 Experimental and Empirical Motivation

In summary, the model shows a connection between high-yield, indivisible investments, financial frictions, and poverty traps. The model leads to the following predictions that guide our empirics:

- high productivity households may have higher savings to eventually finance indivisible investment opportunities;
- risky lotteries can be attractive, even though they are lower-expected value, in order to help finance indivisible investments;
- those choosing risky lotteries are high productivity; and
- high productivity households may exhibit either patience or impatience in their lottery choice.

Our empirics in turn use a field experiment to measure the extent to which households select into a riskier lottery, which types of households choose the riskier lottery, what types of indivisible investments they make upon winning, and whether households choosing and winning the riskier lottery are able to escape poverty.

3 Field Experiment

Our experiment presents participants with actual lotteries that mirror the theoretical lotteries of the previous section. This section provides details of the design and implementation of our lottery experiment as well as our data collection.

3.1 Experimental Design

To draw our sample, we worked with a prominent microfinance bank that was hoping to expand services. They identified three geographically dispersed, underbanked districts where marginal populations lacked financial services and they were considering expanding their services which we used for our sample: Ntungamo, Ibanda, and Kagadi.[7] All three are district capitals with populations of roughly 20,000-30,000. The surveyed neighborhoods are best described as peri-urban and rural. Using a neighborhood census of each of the targeted neighborhoods, we randomly selected a sample of 1,048 participants, each from a distinct household.[8]

[7] We piloted a related project in Mpigi in order to evaluate our survey instruments and other protocols.

[8] Neighborhoods were randomly selected by placing a grid across each city and randomly selecting gridpoints overlaid on a map of each city. Gridpoints that fell in manufacturing zones, parks, or other unpopulated areas were omitted. We then conducted a census of the neighborhood around gridpoints. From the census, we selected the sample, stratifying by use of formal financial services, expressed desire for a savings account, and occupation (entrepreneur, salaried employee, or farmer). We also stratified over gender and whether or not the recipient was a head of household.

We oversampled entrepreneurs and those who lacked formal financial services (i.e., had no formal loan or savings account at the time). All three districts are evenly represented in the sample: 350 participants come from Ntungano, 349 from Ibanda, and 349 from Kagadi.

The timing of the experiment was as follows. In October and November 2015, we conducted a baseline interview of households including questions on their household demographics, income, consumption, agricultural and business activities, assets, borrowing and savings, and hypothetical preferences over income, investment, risk and willingness to delay payment for higher returns. At the end of the survey, all households were offered a free, zero-interest formal savings account at a microfinance bank with a local branch. In February and March of 2017, approximately 16 months after participants received their savings accounts, we conducted the midline survey, where we resurveyed participants about their updated responses to select baseline questions and then implemented the cash lottery experiment described below. We then conducted a comprehensive first endline survey in June and July of 2017. We surveyed those who had chosen to receive delayed payments a month after the impatient sample who received non-delayed payments, so that all participants were surveyed 4 months after receiving their cash grants. The first endline survey consisted of similar questions to the baseline, but included additional questions about how recipients had used their grant money. We conducted a second endline survey, meant to track medium-run household outcomes and observe changes in grant effects over time, in September and November 2018, approximately 18 months after cash grant receipt. Finally, we conducted a third endline survey to track long-run outcomes in June and July 2023, 6 years after grant receipt.

The experiment at midline asked the participant to choose between the following two lotteries: (i) a 50 percent chance of winning a grant of 350,000 Ugandan shillings or UGX ($98 based on an exchange rate of 3,570 UGX = 1 USD in February, 2015) or (ii) a 10 percent chance of a grant of 1,700,000 UGX ($476).[9] The sizes of grants were chosen based on baseline questions about desired investment amounts and demand for credit.[10] As in the model of the previous section, the second lottery had both higher risk and a lower expected value ($47.60 vs. $49.00). We visually primed participants through "practice" lotteries in order to assist them in understanding the probabilities and the lottery. Finally, we gave participants the choice to receive their grants (conditional on winning) via mobile money either the following day or to delay payment for 30 days in return for 3 percent interest. Our use of mobile money and a minimum of one-day delay was designed to limit differential perceived risk in whether they would actually receive funds since no one received cash immediately in hand. After asking questions about how they would use their grants, we ran the lotteries using random number generators on tablets. Participants learned their outcomes immediately.

Table 1 shows the lottery choice preferences of the sample. 765 people (73% of the full sample) chose the small grant. The choice of the small, less risky lottery with no delay was therefore the most common.

[9] The effect of winning the lottery, thus, is identified conditional on lottery choice — whether the respondent selected into the small or large lottery. We do not cross-randomize participants into winning the lottery not of their choice due to budget limitations.

[10] Specifically, we asked at baseline whether they would invest if they had access to credit, and how much they would need to make their desired investment. The sizes of the grants approximately match the 10^{th} and 75^{th} percentile responses.

Despite its riskiness and lower expected payout, 283 people (27% of the full sample) chose the lottery for the larger grant. This is again quite a powerful result since the large lottery had a lower expected value and risk aversion tends to increase in lottery size (Holt and Laury, 2002). The small lottery payout was equivalent to roughly 1 month's average household income, while the large lottery equated to 4 – 5 months of average household income. As shown in the theory of high-yield indivisible investments in Section 2, participants may be willing to accept higher risk lotteries in order to enable a large, high return investment.

In the context of the model, we expect some individuals to be patient, i.e., those for whom the higher payoff from delayed payment enables the indivisible, high-yield investment. This patience may be among those choosing either the small or large lottery. (Recall the RD and SD regions in Figure 2.) Of those who chose the small lottery, 144 people (14% of the full sample) chose to delay the payment by a month in return for a larger payment, while the remaining 621 (59%) chose to receive the payment the next day. Of those who chose the large lottery, 78 participants (28% of the high risk sample, 7% of the full sample) were patient and willing to wait a month for a larger payout, while 205 (20% of the full sample) were impatient. The high level of impatience is perhaps surprising given the high foregone rate of return (43%, annualized and compounded) and non-negligible absolute return (equivalent to 2-6 days of income for the median household, depending on the size of the grant) and will require high discount rates in order to reconcile, as shown in Figure 2. The sizable fraction of people willing to choose a lower expected value, large lottery is consistent with the model's prediction driven by the presence of a high yield lumpy investment. We call these people and their choice "risk loving" throughout, though it is important to note that risk-loving behavior is expressed even though we assume risk aversion. While their choice of the lower expected value, large lottery is "risk loving" they are selecting it because of potential large investment payoffs not because of a relative preference for risk.

Knowing that the larger lottery (i.e., "risk loving" choice) was less likely to pay out and correctly anticipating that it would also be less popular, we increased the actual probability of winning the larger grant to 30% rather than the 10% probability communicated to participants, in order to increase the sample size of winners.[11] Table 2 presents the number of lottery winners in each category. We present the number of winners as a percentage of the people who made the choices. Of the 765 who chose the small lottery, 373 won the lottery for a win rate of 49%. Of the 283 who chose the large lottery, 85 won, for a win rate of 30%. Because of budget and sample size limitations, we did not randomize any participants into winning the small grant if they lost the large grant, or into winning the large grant if they lost the small grant.

The lotteries themselves provide our experimental variation. The lottery *choices* are of course endogenous, so we control for lottery choice in all specifications. Conditional on the lottery choice, the lottery *outcomes* are random. As discussed in Section 3.2, Tables 3 and 4 confirm balance between the treatment (grant

[11] This change was not disclosed to either the participants or the data collection team. One could be concerned about the possibility that the higher payout rate was inferred by participants, but there is no statistically significant difference in the probability that participants choose the large lottery in the last three days of surveying (accounting for 24% of the sample) within each district, among those surveyed on the enumerator's first visit attempt. This is consistent with participants maintaining the same evaluation of the large lottery's expected value over time.

recipients) and control (non-recipients) for both the small and large lotteries.

3.2 Data

We collected data over five survey waves: baseline, midline, first endline, second endline, and third endline. Each survey wave includes modules on income, consumption, agricultural activities, non-farm business activities, assets, borrowing and savings.[12] For several of the financial outcomes, we collect data in a multi-step process in order to improve measurement. First, we use questions about subcategories in order to prime the respondent about the many different specific sources of income, expenses, assets, and liabilities that may be relevant. Second, we summed the subcategories to get the total value and confirmed with the respondent whether the aggregate of the category reflects their perception. For example, income is collected as "typical monthly income" (revenues net of costs) using detailed questions about typical monthly revenues on subcategories — i.e., business, crop, livestock, and labor income — and typical costs, normalized to a monthly frequency, as well as direct questions on aggregate income and following up to see whether the participant viewed the aggregate or sum of the components as a better measure. We collect the respondent's income separately from household income because the former may be measured with less noise. The Data Appendix (Appendix A) describes these steps and measures in more detail.

Using these data, we look first at the use of the grant on investments: consumptive assets (home durables), productive divisible investments (small livestock and agricultural tools and business inventory), and productive indivisible investments (large livestock and ploughs, durable business assets, and land). Next we observe the impact of the grant on the other components of a household budget: consumption, savings, income, and net credit. The distinction between flows and stocks is important from a theoretical standpoint, as well as for our construction of the household's budget constraint. We measure income as a flow, and we measure savings, assets (business, agricultural, and land), and net credit as stocks. Income is the monthly flow of realized household income (crop profit, livestock profit, business profit, wages, and remittances). Savings and assets reflect current total levels at each respective endline. Net credit is current debt less any lending to others that the household expects to be paid back. At the first and second endline, we measure consumption as total spending on household expenditures (food, transportation, fuel, airtime, and any irregular expenses, like school, hospital or marriage fees) since the midline plus value of home durables. We combine household expenditures, which are collected as flows, and home durables, which are collected as stocks, together into this single measure of total spending between the midline and the respective endline.[13] At the third endline, we analyze impacts on the flow of weekly consumption separately from the stock of home durables, given

[12] The midline survey, however, is somewhat briefer than other surveys and does not collect updated information on all of the household assets included in the baseline survey. Specifically, we do not update the value of home durables, land, livestock and other agricultural assets from baseline to midline. Tables 3 and 4 depict balance on the most recent pre-intervention measurement of each outcome.

[13] This differentiates household durable spending from spending on *productive* assets, which we include in the investment category because they may lead to positive income returns. Data on durables were not collected at midline, so we simply add the stock of durables at endline to the sum of consumption flows realized between midline and endline. This should lead to no issues with our application of a household budget constraint, as described in Section 5, as long as home durables were balanced at midline, as they were at baseline per Tables 3 and 4.

that we are more concerned with understanding how potential long-run impacts might manifest, rather than detecting the impact of the grant on household budget components.

We also measure land values as estimated by the participant in all three endline waves. In the third endline, we add questions on purchases, sales, and investment (collected separately from total value). As with many peri-urban areas in developing countries, land values in Uganda increased significantly over time (e.g., Wineman and Jayne (2018); Gochberg (2021)). Because there was significant overall appreciation in land, we estimate rates of appreciation by imputing capital gains using *control* households. That is, we calculate the average increase in land values over time using the land values of control households.[14] On average, land values appreciate an estimated 41% over the 18 months between midline and second endline, or 2% per month (see Table A.1 and Appendix A for more detail on capital gains and their calculation).

Land value appreciation may either be a result of general local price increases, average general investment in land, or from spillovers of the experiment itself, i.e., increased demand for land as a result of increased availability of capital due to the lottery. To estimate the extent to which the experiment itself may have impacted land prices, we calculate the percent of the increase in land value that can be attributed to nearby households receiving a grant and purchasing land in Appendix B. We use a two-stage least squares approach that instruments the change in an area's land values with the number of grants disbursed in that area. Table B.1 shows the first stage results, and Table B.2 shows the second stage results. As detailed in Appendix B, we find that land appreciated roughly 20% over the entire 18 month period between the midline and second endline as a result of the grants themselves, or approximately (20%/41%=)49% of the total land appreciation during the period. This price increase will play a pivotal role in interpreting our aggregate simulations, as it implies that the supply of improved land is relatively inelastic.

3.2.1 Sample Balance

We return to midline data to examine sample characteristics and experimental balance between treatment and control. Again, participants self-selected into either the small or large lottery, but the realization of whether they won was random. We check balance across 26 baseline and midline outcomes and demographic characteristics within the sample. Table 3 presents the balance results for those who chose the small lottery, whereas Table 4 presents the balance results for those who chose the large lottery.

Before comparing treatment and control, note some sample characteristics. The average midline income of 362,000 UGX translates to $101, and households average five members. Households are therefore quite poor, and even the small grants are sizable relative to income. Well over 70 percent of households are farmers, and about half are women. Financial intermediation is low with only about one-third of households having loans outstanding, and roughly 10 percent having savings in formal accounts. The overall levels of consumption, income, and savings have implications for the demand for financial services. Though few utilized their zero

[14] Note that the overall increase in land values may not be entirely attributable to capital gains. It may be that, on average, all households in these peri-urban areas of Uganda are investing in their land (thereby increasing the land value). This would over-state the total level of capital gains over the period, but it would not affect our estimates of gains in land value for treatment households *relative* to control households.

interest formal savings accounts provided by the project during the baseline, the data show a substantial underlying level of savings that could indicate a demand for financial services. Specifically, comparing the levels of savings to that of consumption, the average household savings is about 7 weeks of average household consumption. We also find large increases in savings from baseline to midline and substantial demand for credit for investment (see Table C.1).[15]

Comparing treatment and control, balance is quite good. For the 26 outcomes in the two tables, we would expect roughly 1 variable per table to be significant at a 5 percent level based on type I errors, but indeed none are statistically significant at the 5 percent level, and only 1 - 2 per table are significant at the 10 percent level. Households winning small grants tend to consist of a slightly smaller number of adult females, 1.1, as opposed to 1.2 for the small lottery control. They also have a higher level of business durables, 405,000 UGX in non-stock business assets relative to 286,000 UGX in the small lottery control. Among those selecting the large lottery, winners have greater divisible investments, 642,000 UGX relative to 458,000 UGX (significant at the 10 percent level). Thus, balance between the treatment and control group is as expected.

Still there are a few variables in which the differences may be economically significant. In Table 3, the average monthly income is roughly 22,000 UGX less among the small lottery "winners" relative to the control, and savings is 21,000 UGX higher, which are both small relative to the size of the 350,000 UGX grant received but not negligible. Similarly, in Table 4, we see that average monthly income is 45,000 UGX more in the large lottery treatment relative to the risk-loving control and likewise midline savings is 71,000 UGX more, which is small but not negligible compared to the grant size of 1,700,000 UGX. Land values are 2,843,000 UGX larger (or 22% higher) in the large lottery treatment group relative to the high-risk control, though this difference is not statistically significant. This is part of our motivation for controlling for baseline and midline levels in our endline analyses, as well as other economic and demographic characteristics such as midline income and the number of adult males, adult females, and children. We find similarly good balance among those receiving the grant and those not receiving the grant when partitioning by the choice of early or delayed reception.

3.2.2 Attrition from the Sample

From the midline to the first endline, we retain 983 of 1,048 (94%) original respondents. Of those, we retain 867 respondents (83% of the original respondents) through the second endline, which becomes our primary sample of analysis, allowing us to compare outcomes between the first and second endline for the same group. In the third endline, occurring 6 years after grant receipt, we were able to track 838 (80%) of original respondents.

The rate of retention between midline and second endline does vary between treatment (87%) and control

[15] The lack of use of the formal accounts may have several causes: low trust in formal accounts as currently offered, the fact that the accounts are zero interest, or that traditional formal accounts are simply not convenient enough to use, even when offered free of charge. This may be because of the costs associated with transactions like transportation costs, or a mistrust of institutions. Novel approaches like savings groups or cell phone-related savings vehicles may therefore be more appropriate for meeting this underlying demand.

(79%) households, though it does not vary based on choice of small or large lottery (i.e., we retain 87% of both small and large lottery winners). We do check balance on baseline characteristics between the retained and attrited sample, for both those who chose the small lottery and were retained relative to those choosing the small lottery who attrited, and again for those who chose the large lottery and were retained relative to those choosing the large lottery who attrited, in Tables D.1 and D.2. In general, balance is good, and we only find significant differences on age, which we include, along with age^2, as a demographic control in our outcome analyses. The differential rate of attrition between treatment and control, however, may be indicative of unobservable characteristics that are correlated with treatment status and driving the likelihood that a household remains in the sample over time. To address this possibility, we compute Lee Bounds (Lee, 2009) around all of our primary OLS point estimates in Appendix D. Our key results — that large lottery winners differentially invest in indivisible assets and increase their incomes in the long run — are robust to the bounds.

4 Who selects the large lottery?

The model predicts that entrepreneurs who have large, indivisible investment opportunities are more likely to choose a lower expected return large lottery and that these investments may increase their income over time. In this section, we test the extent to which we see this behavior in our participants. We find that participants choosing the large lottery tend to be people with higher income, higher wealth, and whose wealth has increased quickly since the baseline.

4.1 Methods of Predicting Lottery Choice

We examine the significant predictors of the lottery choice in our data. We first run simple OLS regressions to test whether the characteristics that the model predicts matter in the risk decision are in fact correlated with the risk decision. We run the OLS regressions:

$$D_i^m = \beta P_i^m + \gamma X_i^m + \varepsilon_i, \tag{5}$$

where D_i^m is the decision of household i at midline m (e.g., a dummy for the risky choice, a dummy for the impatient choice) and P_i^m are the midline predictors on which we test for significant differences between those choosing the small lottery relative to those choosing the large lottery, as well as the impatient relative to the patient. X_i^m is a vector of household-level demographic controls: household income at midline, female, household head status, age, age^2, number of adult females, number of adult males, number of children, district fixed effects, and patience (when testing for differences in the risk decision). In the OLS specification, we first test whether each predictor P_i^m is statistically significantly correlated with the lottery decision unconditionally, and second whether the predictor is correlated with the lottery decision conditional on the set X_i^m of demographic characteristics. We also use lasso (Tibshirani, 1996) to select which among 160 covariates are most important for predicting the household's lottery choice given a parameter, selected using adaptive lasso, that penalizes additional model complexity.[16] Table 5 presents statistically significant predictors of the large lottery choice in the OLS regression.[17] Predictors also selected by the much higher dimension lasso regression are designated with an asterisk.

4.2 Correlates of Lottery Choice

The risk choice does not appear to be random but reflects true approaches to risk. In particular, we find that the lottery choice is correlated with proxies for underlying risk preference but also economic variables. We discuss each in turn.

4.2.1 Demographics

Demographics are a reasonable proxy for underlying risk preference. Those choosing the large lottery tend to be men, older, heads of household, and come from larger households with more children and adult males.

4.2.2 Income

In the model, those with high-productivity select the large lottery; we find that this is borne out in the data in that those who select the large lottery have higher incomes. They have significantly higher (40 percent) crop income, significantly higher (13 percent) consumption, and significantly larger (14 additional log points) growth in consumption from baseline to midline.[18] Those choosing the large lottery tend to have higher crop income both in absolute terms and as a fraction of their total income, perhaps suggesting that those with higher levels of home production are more willing to take on risk. While crop income and consumption are both higher for those taking the large lottery, recent changes in total monthly income and business income in particular tend to be smaller for those selecting the large lottery over the small lottery, perhaps reflecting their need to invest in order to increase income. Crop income, in absolute level and per adult equivalent, and growth in consumption, business income, and total monthly income are also selected by lasso.[19]

4.2.3 Wealth

We also find suggestive evidence that those selecting the large lottery are wealthier and that they experienced faster increases in their savings and wealth from baseline to midline. Those who choose the large lottery are somewhat wealthier, a per adult equivalent difference of 94,000 UGX ($26) in total wealth (assets plus

[16] A list of the full set of covariates included in the lasso specification is available on request.

[17] The full list of covariates on which we use OLS to test for significant differences between those choosing the small lottery versus the large lottery is in Table C.1 in the Appendix. The point estimates in both Table 5 and Table C.1 are from the unconditional specification of Equation 5, i.e. without X_i^m. The estimates conditional on X_i^m are available by request.

[18] On average, incomes increased significantly between baseline and midline. This may be due to seasonal fluctuations in measured monthly income or seasonal variations in the components of income (crop income was especially high, while business income was lower).

[19] A natural question is whether the financial predictors are ultimately driven by the demographics. For example, if men are both more likely to choose the large lottery and have a higher propensity to invest or accumulate assets, then perhaps the accumulation of assets is no longer predictive after controlling for gender. We analyze this by looking at the same predictions but controlling for household demographics. The findings are largely robust. One exception is the level of savings is no longer a predictor of selecting the large lottery once income is added as a control, though growth in savings from baseline to midline, as well as the level of business assets and wealth remain statistically significantly correlated with lottery choice. Table available on request.

savings), and 100,000 UGX ($28) in net wealth (business assets plus savings minus debt) — approximately 30% of average monthly income. When accounting for an average of 3.4 adult equivalents in the household, these differences are smaller than the size of the small grant (350,000 UGX) and are only marginally significant at a 10 percent level.

Those who choose the large lottery do, however, have 43 percent more business assets and hold a higher fraction (5 percentage points) of their total wealth in business assets. The higher growth in wealth and savings before the midline is even more striking. Between baseline and midline, those selecting the large lottery experience significantly larger increases in total wealth (70 additional log points) and total savings (86 additional log points).[20] Thus, the accumulation of assets, also selected by lasso, seems to be a strong predictor of the choice of the large lottery.

4.2.4 Desire to Invest

Consistent with the model, the choice of the large lottery is associated with a pre-existing interest in investing. A significantly greater fraction (6 percentage points) of the participants who choose the large lottery report that they could increase their income if they had access to credit. Moreover, a significantly larger fraction (4 percentage points) want to invest an amount greater than $100, the size of the small grant. Finally, a significantly larger fraction (7 percentage points) indicate that they would use credit for business investment. These predictors are significant at the 5% level in the OLS regression and all selected by lasso. Thus, it appears that, at least for some, the demand for the large lottery could be driven by a desire to invest.

4.2.5 Baseline Risk Choices

We have also have two *hypothetical* risk decisions involving investment collected at baseline. In contrast to the midline lottery choice, the riskier options involve the risk of absolute losses but with less variance and positive expected gains for the riskier option.[21] That is, neither decision involves actual risk-loving behavior, as the midline choice does. We find higher willingness to take these risks, and the percentage is higher for the expected higher payoff. As with the actual lottery choice, regressing these risk choice measures on demographics and economic states yields similar relationships though with slightly different variables showing up in lasso. Namely, demographics predict risk choice in sensible ways, and those with higher income, wealth, and consumption are more willing to take risks. In all three risk choices, we therefore interpret that willingness to take risk depends on both underlying preferences (proxied by demographics) and by economic conditions. (See Table C.3 in the Online Appendix.) The correlation between baseline and midline choices is low, however, consistent with the stochastically changing economic situations, as in the model.

[20]These changes are large because of the very low base levels of wealth in the sample: 25% of the sample has 0 wealth at baseline. Before taking logs, we set any negative or 0 values equal to the minimum value + 1 Ugandan shilling.

[21]Specifically, the first question asks whether the participant would make a risky investment option that yields either 10,000 UGX or 300,000 UGX with equal probability (expected value of 155,000 UGX) at a cost of 100,000 UGX. A follow up question asks the same payoffs but at a cost of 150,000 UGX.

Though the theory is more ambiguous, we also test for significant predictors of the impatient versus patient, but find few differential characteristics. We control for patience in the remainder of our analyses, but do not interact the lottery outcome with time preference. In sum, those whose wealth increased quickly between baseline and midline and those who expressed a pre-existing interest in investing were more likely to choose the large lottery. Those choosing the large lottery also tended to have higher crop income, both in absolute terms and as a proportion of their overall income. These predictors are robust to the inclusion of demographic controls. The level of crop income, growth in wealth from baseline to midline, desire to invest, and gender are also selected by lasso, underscoring the importance of these attributes for predicting risk-loving behavior. These results support the hypothesis from the model that a pre-existing business investment is important for the choice between lotteries.

5 How are winnings spent and what are the household impacts?

The theory predicts that those who win large lotteries should make large investments with high rates of return which increase their income. Based on the model, we expect to see impacts of the large grant on large assets, where households use the proceeds of the lottery to invest. For small lottery winners, we may expect transitory impacts on savings (or other divisible investments that perhaps mirror savings, such as inventory and small livestock), while households accumulate additional funds to invest in a large asset or for those who simply smooth their consumption of small lottery winnings over time before returning to poverty traps.

To evaluate the effect of winning the lottery, we start with OLS regressions to estimate the impact of the large and small grants, conditional on lottery choice (between the small and large lottery). For each household i in district d, we regress:

$$Y_{id}^{e} = \beta_0 + \beta_1 Win_i^m + \beta_2 Win_i^m * D_i^m + \beta_3 D_i^m + \rho Y_i^b + \gamma X_i^m + \lambda_d + \varepsilon_{id} \tag{6}$$

where b denotes baseline, m denotes midline, and e denotes endline.[22] D_i^m reflects the household's lottery selection, where $D_i^m = 1$ if the household selected the large lottery, $Win_i^m = 1$ if the household won either lottery (small or large), and their interaction, $Win_i^m * D_i^m$, is the additional effect of winning the large lottery. Thus, in this specification, β_1 identifies the (total) effect of winning the small grant, β_2 identifies the additional effect of winning the large grant relative to the small grant, and $\beta_1 + \beta_2$ identifies the total effect of winning the large grant. We conduct F tests on the sum $\beta_1 + \beta_2$. Critically, β_1 and β_2 are estimated conditional on lottery selection, as captured in D_i^m. (In our regression tables, *won lottery* corresponds to Win_i^m, *won large lottery* corresponds to the interaction term $Win_i^m * D_i^m$, where large lottery winners are those who both won their lottery and selected the large lottery, and *risk loving* corresponds to D_i^m.)

In this regression model, λ_d are district fixed effects and X_i^m is a vector of household-level demographic controls: patience, household income at midline, age, age^2, gender, household head status, number of adult

[22] Recall that both baseline and midline take place pre-intervention, as the midline survey concludes with the household's lottery choice. We use e to generally denote the endline survey waves, but results will be reported separately for each endline.

females, number of adult males, and number of children. We winsorize to the 5th and 95th percentiles to ensure that results are not driven by outliers — a concern given the high degree of skewness in the income and asset distributions. We examine impacts on endline levels conditional on baseline levels (as denoted by Y_i^b), consistent with the prescriptions in Bruhn and McKenzie (2009).[23] We apply multiple hypothesis corrections in Appendix E.

5.1 How Lottery Winnings are Spent: Impacts on Investment

We estimate the effect of winning the lottery on small and large agricultural and business assets, as well as land and home durables. We categorize these investments into consumptive assets, productive assets that are relatively divisible, and productive assets that are relatively indivisible: *consumptive assets:* (1) home durables (e.g., a radio); *divisible investments:* (2) small livestock and agricultural tools (e.g., a pig or a spade), (3) business inventory (e.g., items for retail such as soap or salt); *indivisible investments:* (4) large livestock (e.g., cattle) and ploughs,[24] (5) business durables (e.g., a sewing machine or mirror for a salon) and (6) land.[25] Appendix F includes descriptive statistics summarizing the purchases that respondents reported making with the grants.

In our discussion of results, we describe point estimates in levels of Ugandan shillings (UGX), with the percent change relative to the control group following each estimate in brackets, where the small (large) grant control group consists of non-winners who also chose the small (large) lottery. We will start with the treatment effects in the short run (first endline, 4 months after grant receipt) and continue with a discussion of treatment effects in the medium run (second endline, 18 months after grant receipt).

5.1.1 Short-Term Results (First Endline at 4 Months)

In the short run (3-4 months), we find that small grant winners make statistically significant investments in small livestock, large livestock, and business inventory, while large lottery winners make statistically significant investments in large livestock, business inventory, and land (Table 6). Those who win the small grant invest 191,000 UGX [31%] more in divisible goods than the control group ($p < 0.01$). Decomposing this divisible investment effect, we find that small grant winners have 84,000 UGX [31%] greater levels of small livestock and agricultural tools ($p < 0.01$) and 128,000 UGX [45%] greater levels of business inventory ($p < 0.01$) than the control group at first endline. We find no statistically significant effect of the small grant on total indivisible investment, though in decomposing indivisible investments, we see that small

[23]In cases for which pre-intervention levels of the outcome were collected at midline rather than baseline, the ρ term instead controls for the midline level of the outcome (where the midline also took place prior to the intervention). Specifically, business inventory, (non-inventory) durable business assets, and thus the aggregated measures of divisible and indivisible assets, are constructed at midline rather than baseline, since inventory and business durables were not disaggregated at baseline.

[24]The plough is the only large agricultural machine reported by anyone in our sample.

[25]In principle, land is divisible. In practice, we rarely see purchases of land below 500,000 UGX — only about 5% of land transactions made recently, in June 2013 or after, are valued at less than 500,000 UGX — suggesting that land is typically sold in larger units. Small, disbursed, parcels of land are unlikely to be as productive as large, connected plots; as a result potential land buyers must either restrict themselves to purchasing from neighbors or purchasing a large plot on its own. The matching process between buyers and sellers can create inefficiencies due to the thinness of particular land markets as shown by Bryan et al. (2022).

grant winners have 90,000 UGX [44%] higher levels of large livestock and ploughs ($p < 0.10$). We find no statistically significant effect of the small grant on home durables.

Winning the large grant, in contrast, leads to statistically significant effects on both total divisible and indivisible investment. Large grant winners have 319,000 UGX [40%] greater investment in divisible goods ($p < 0.05$) and 4,300,000 UGX [22%] greater investment in indivisible goods ($p < 0.05$), all relative to non-winners who also selected the large lottery. As in the case of small grant winners, we find no statistically significant effect of the large grant on home durables. We find that the divisible investment effect is driven by a 302,000 UGX [94%] increase in business inventory ($p < 0.01$), as we find no effect of the large grant on small livestock. The indivisible investment effect for large grant winners is driven by land, where the large grant leads to a 4,454,000 UGX [26%] increase in land values ($p < 0.05$). Large grant winners also have 215,000 UGX [70%] greater investment in large livestock and ploughs ($p < 0.05$). At the first endline, we find no statistically significant effect of winning the large grant on business durables, the other indivisible investment category.

The divisible investment effect for large winners is 67% larger than the effect for small winners, but the difference is not statistically significantly different. Large lottery winners do differentially increase their investment in indivisible goods relative to small lottery winners ($p < 0.05$). This is driven by land: large lottery winners' investment in land is differentially larger than that of both small lottery winners and the control group ($p < 0.05$), while their investment in large livestock and business durables is not statistically significantly larger than small lottery winners.

5.1.2 Medium-Term Results (Second Endline at 18 Months)

In the medium run (18 months), neither small nor large grant winners sustain statistically significantly higher levels of investment in divisible goods, and only large grant winners sustain a statistically significantly greater level of total indivisible investment, including statistically significant increases in both business durables and land (Table 7). Small grant winners only sustain statistically significant increases in large livestock and ploughs, where their level of investment is 91,000 UGX [50%] higher than that of non-winners who also selected the small lottery ($p < 0.10$). The short-term effect on total divisible investment — small livestock and agricultural tools and business inventory — observed for small lottery winners at first endline is now smaller and statistically indistinguishable from zero. The short-term effects on total divisible investment, and on business inventory in particular, also fade for large lottery winners. Large lottery winners' investment in divisible goods is not statistically significantly different from small lottery winners, in aggregate or in the disaggregated divisible investment categories. Large lottery winners do, however, retain differentially higher levels of indivisible investment, in aggregate ($p < 0.10$) and for land ($p < 0.05$) in particular, relative to small lottery winners at second endline. In total, their indivisible investments are 7,638,000 UGX [31%] higher ($p < 0.05$) at second endline than the non-winners who also chose the large lottery. In decomposing the indivisible investment effect for large lottery winners at second endline, we see that the effect on investment in large livestock and ploughs is nearly zero (not statistically significant), but large lottery winners report 514,000 UGX [56%] greater investment in business durables ($p < 0.10$) and 7,488,000 UGX [32%] higher land values ($p < 0.05$) than non-winners who also selected the large lottery.

In sum, both small and large lottery winners make initial investments in divisible goods, which fade for both groups in the medium run. Only large lottery winners increase total investment in indivisible goods, and they sustain elevated indivisible investments in the medium run. In the short run, large lottery winners make indivisible investments in large livestock and land, while in the medium run, their indivisible investments consist of business durables and land. These results are consistent with the model's predictions, where small and large lottery winners experience short-lived increases in divisible investments that mirror savings (such as business inventory and small livestock). Only large grant winners are able to accumulate sufficient funds to sustain a higher overall level of indivisible investment in the medium run.

We note that the effect of the large grant on indivisible investment, in total and for land in particular, is quite large. At first endline, the effect of the large grant on total indivisible investment and on land values is more than 4,000,000 UGX, which is more than twice the size of the large grant itself. By second endline, the large grant effect on indivisible investment and land values is more than 7,000,000 UGX, or more than four times the size of the large grant itself. This may suggest mis-measurement, co-financing through other wealth or income, joint investments with others not included in the measurements, or differential increases in value for lottery winners. In the next section, we consider impacts on non-investment components of the household budget, which provides estimates on potential sources of co-financing.

5.2 Impact on the Full Household Budget

We now consider the effect of winning the lottery on all components of a household's budget, namely consumption, savings, investment, income, and borrowing. We begin by estimating OLS regressions, following the same specification as laid out in Equation 6.

Our OLS approach, standard in the treatment effects literature, considers each outcome as an independent regression. However, the basic adding up of a household budget implies that the estimating equations are not independent but governed by a common budget constraint. That is, the following simple budget constraint should hold:

$$\Delta C + \Delta S + \Delta K = x * \Delta Y + \Delta B + Grant \tag{7}$$

where C is consumption (including purchases of home durables), S is savings, K is capital (both divisible and indivisible), such that the change in capital reflects investment, Y is income, and B is net credit. The treatment difference, i.e., treatment minus control, is reflected in each Δ term.[26] We use $x \in \{4, 18\}$ to denote the number of months between midline (the time of grant allocation) and the relevant endline, since

[26]This can be derived by our theoretical model by defining $Y_t = e_t + z_t k_t^\alpha - \delta k_t$ and recursively iterating on the budget constraint, Equation 1 from midline to endline. In our empirical setting this yields $\sum_{t=m}^{e} C_t + A_e + K_e = \sum_{t=m}^{e} Y_t + A_m + K_m + Grant$. We further break out net assets into gross savings and gross debt, i.e, $A_e = S_e - B_e$. Then differencing this between treatment (winners) and control (non-winners), and using the fact that $E[A_m + K_m]$ is equal for winners and non-winners because of randomization, yields Equation 7.

income is measured as a monthly flow. We measure all other components of the budget constraint in levels, including consumption, which is unusual, but allows us to combine spending on home durables (a stock) with the flow of consumption, which we aggregate into a total level of spending between midline and each endline.

We complement our OLS analysis with a seemingly unrelated regression (SUR), which has three advantages. First, it allows us to impose a cross-equation restriction on the coefficients associated with the household's budget constraint. Second, it allows us to account for the correlation in error terms across equations that the constraint implies. Both of these improve efficiency, if they hold. Third, the cross-equation restriction yields coefficients that necessarily sum to the household's total available resources, and thus an increase in spending across categories does not exceed the amount of the grant (plus any increase in income or decline in spending in other categories that can be attributed to the grant).

The SUR uses the same basic specification as in Equation 6, with the constraint as a cross-equation restriction. Specifically, we apply this restriction across the coefficients on $Win_{i.m}$:

$$\beta_{1.consumption} + \beta_{1.savings} + \beta_{1.divInvestment} + \beta_{1.indivInvestment} - x\beta_{1.income} - \beta_{1.credit} = 350,000 \quad (8)$$

And this restriction across the coefficients on $Win_{i.m} * D_{i.m}$:

$$\beta_{2.consumption} + \beta_{2.savings} + \beta_{2.divInvestment} + \beta_{2.indivInvestment} - x\beta_{2.income} - \beta_{2.credit} = 1,350,000 \quad (9)$$

where 350,000 UGX is the amount of the small grant, 1,350,000 UGX is the additional amount of the large grant, and $x \in \{4, 18\}$ denotes the number of months between midline and the respective endline, which is applicable to the coefficient on monthly income. All other outcome variables are stocks.[27] Divisible and indivisible investments are constructed as an aggregate of their respective subcategories, as in Section 5.1, but indivisible investments are adjusted downward by the capital gains common to land values in their district, through the process described in Section 3.2 and in greater detail in Appendix A.[28] This is a simple adjustment to reflect real value at the time of purchase, net of any appreciation that may have taken place between the grant allocation and endline surveys, and is necessary if the budget constraint is to hold. Further, assuming that respondents' reported quantities reflect their "true" values, winsorization should also cause the constraint to be rejected. To eliminate the chance that winsorization leads the constraint to be rejected while still estimating the SUR on a sample that is comparable to that in the OLS, we estimate the SUR on a truncated sample: those whose indivisible investments fall within the 5th and 95th percentiles at second endline. Because the application of the budget constraint means that equations are not estimated independently, we choose one outcome on which to truncate our sample, and indivisible investments have the highest degree of skewness.

[27]Recall from Section 3.2 that we construct consumption as a stock of total spending between midline and the respective endline, plus home durables.

[28]Thus, point estimates of the grant effect on divisible investment will be identical between Sections 5.1 and 5.2 but will vary for indivisible investment.

The adding up condition allows us to precisely model the effect of the grant on each budget category: consumption, savings, divisible investment, indivisible investment, and net borrowing. If, for example, self-financing (through own savings, sale of existing assets for purchase of new assets, or a decrease in consumption) enables households to increase the resources available for investment beyond the cash grant, then we should see this reflected in those budget categories, with the cross-equation constraint ensuring that total expenditures do not exceed the available resources.

5.2.1 Short-Term Results (First Endline at 4 Months)

The OLS results indicate that, in the short run, small lottery winners statistically significantly increase their savings and divisible investment, while large lottery winners statistically significantly increase their savings, divisible investment, and indivisible investment (Table 8). We find no significant effect on consumption, income, or borrowing, for small or large lottery winners. The effect of winning the large lottery is statistically indistinguishable from the effect of winning the small lottery in all budget categories except indivisible assets, where large lottery winners differentially invest ($p < 0.05$). Specifically, small lottery winners have 57,000 UGX [22%] higher savings ($p < 0.10$) and 191,000 UGX [31%] higher divisible investment ($p < 0.01$), relative to non-winners who also chose the small lottery. Winning the large lottery increases savings by 165,000 UGX [61%] ($p < 0.01$), divisible investment by 319,000 UGX [40%] ($p < 0.05$), and indivisible investment by 4,295,000 UGX [25%] ($p < 0.05$), relative to non-winners who also chose the large lottery. (Note that the divisible investment results are identical to those discussed in the previous section, and the indivisible investment results change only due to the capital gains adjustment that allows us to analyze land values net of appreciation over time. We include the investment effects again here as an essential component of the household budget constraint.)

Before comparing the SUR and OLS results, we first note that neither the cross-equation constraint on the small nor large grant is rejected in the SUR. This indicates that the constraints fit the data reasonably well. We see that point estimates and precision are qualitatively similar between the OLS and SUR (Table 9), except in the indivisible investment category. The lottery effects on indivisible investment are substantially smaller in the SUR relative to the OLS, for both small and large lottery winners. As in the OLS, the SUR highlights the differential effect of winning the large lottery on indivisible investment. In the short run, the SUR does not reveal an obvious story of co-financing larger purchases through grant-induced changes in other budget categories, such as borrowing, savings, or income. This may indicate measurement error in indivisible investment, and the SUR mechanically reduces the effect on indivisible investment to satisfy the requirement that the budget constraint must hold. Alternatively, this could indicate rapid appreciation in land values even beyond the capital gains calculated in Section 3.2, or joint financing of purchases with friends or family not measured in the household budget. We will return to this issue in Section 5.3.

5.2.2 Medium-Term Results (Second Endline at 18 Months)

Winning the large lottery leads to increases in savings ($p < 0.05$), indivisible investment ($p < 0.05$), and consumption ($p < 0.10$) in the medium run, where the consumption effect only emerges after 18 months (Table 10). The short-run effects of both the small and large lottery on divisible investment fade — now indistinguishable from zero — suggesting that these assets may have been a mechanism for short-term savings. There is no statistically significant effect of winning the small lottery on any budget category, including consumption, savings, divisible and indivisible investment, income, and borrowing, in the medium run. There is no statistically significant effect of winning the large lottery on income or borrowing in the medium run, but large lottery winners do have 681,000 UGX [13%] higher spending on consumption and home durables ($p < 0.10$), 134,000 UGX [48%] higher savings ($p < 0.05$), and 5,276,000 UGX [30%] higher indivisible investment ($p < 0.05$), relative to non-winners who also selected the large lottery.

Comparing the OLS results (Table 10) to the SUR results (Table 11) at second endline, we again see that neither cross-equation constraint is rejected. Like in the short run, the point estimates on indivisible investment are substantially lower in the SUR than in the OLS, and the SUR suggests that only large lottery winners sustain elevated levels of indivisible investment into the medium run ($p < 0.10$). At the medium run, the SUR implies that large lottery winners spent 1,279,000 UGX, or about 75% of the grant, on indivisible investment goods. This result aligns with the model's prediction. Savings also increases for the large lottery winners ($p < 0.05$), with a point estimate of 136,000 (SUR), or approximately 8% of the grant amount. This suggests that there may still be large lottery winners saving for a large investment, or that some winners may be smoothing the windfall in income over time. We do not detect any change in income, for small or large lottery winners, in the medium run. In the longer run, however, we will find substantial income gains for large lottery winners, as depicted in Table 12 and discussed next, in Section 5.2.3.

5.2.3 Long-Term Results (Third Endline at 6 Years)

We returned to survey the participants after 6 years in order to observe the evolution of their investments and incomes. We estimate the effects of the large and small lotteries using OLS.[29] We find a large and statistically significant ($p < 0.05$) increase in monthly income for those winning the large lottery. Their monthly incomes are now 114,000 UGX, or 32%, higher than the large lottery control. Large lottery winners also have 12,700 UGX, or 16%, higher consumption than the control group, though weekly consumption is measured imprecisely ($p = 0.12$). This suggests that about 50% of the increase in income is consumed.

In Figure 3, we use distribution regressions (e.g., Chernozhukov et al. (2013); Goodman-Bacon (2021)) to show how the treatment effect emerges over the income distribution at each endline, for both small and large lottery winners. The vertical dotted lines correspond to the 25^{th}, 50^{th}, and 75^{th} percentiles. At the first endline, large lottery winners are not statistically significantly more likely to have income in the higher (or lower) part of the distribution than the large lottery control group. By the second endline, large lottery

[29] Because of the long time horizon between the lottery and the 6 year follow-up survey, the budget constraint for the SUR is unlikely to hold, given common fluctuation in incomes, and so we estimate the effects for the third endline solely using OLS.

winners are about 5 percentage points more likely than the control to have income above 380,000 UGX (corresponding to the 75$^{\text{th}}$ percentile), but this is imprecisely estimated. Large lottery winners may also be less likely to have income in the middle of the distribution — perhaps indicating that they are now more likely to compose the upper end of the income distribution — but again, these effects on income are still imprecise at the second endline. By the third endline, however, large lottery winners are statistically significantly more likely (specifically, about 12 percentage points more likely) to have monthly income that exceeds 600,000 UGX (corresponding to the 80$^{\text{th}}$ percentile of the distribution). This suggests that large lottery winners disproportionately compose the upper end of the income distribution, as a result of receiving the large grant. While not statistically significant until about 600,000 UGX, the effect of the large grant on the probability of having income greater than X at the third endline is positive for all values of X that exceed 260,000 UGX, which is just over median income. In other words, the large lottery moved its recipients into the upper half of the income distribution, and the distribution regressions at each endline underscore that this effect emerges over time and only for the large lottery winners. At the third endline, small lottery winners do not disproportionately compose any part of the income distribution relative to the control.

We do not detect statistically significantly higher investment levels in the long run. There are several potential explanations for this increase in long-term income without a commensurate long-term increase in business or agricultural assets. Many of the durable investments measured at 18 months may continue to generate income for the participants, but they are likely to have depreciated significantly over 6 years. While the market value of the durable depreciated assets is quite low, the assets may continue to be productive assets in the business. Improvements made to land may have similarly depreciated, increasing long-term productivity while having little impact on overall land values. Temporary improvements made to businesses may have also yielded long-term clients who remain customers and have increased profitability.

5.3 Understanding the Large Effect on Land Values

The effect of the large grant on indivisible investments, driven by very large effects from land, far exceeds the size of the grant itself. This cannot fully be explained by commensurate changes in other aspects of the household budget that might have enabled co-financing — while there is some increase in income, the principal result of the SUR is simply to adjust the point estimates on indivisible investment downward (as opposed to an indication that levels of investment were co-financed by an increase in borrowing, spending down of savings, or sale of older assets due to the grant). These large point estimates on indivisible investment, and on land in particular, could reflect a number of things:

1. Unmeasured transfers from others that enable purchases or investment on existing land that exceed the immediate household's available resources (or unmeasured transfers from own savings or own assets that enable purchases of new land or investment on existing land exceeding the size of the grant)

2. Differential appreciation in land values for large grant winners due to putting land to a more productive use

3. Differential appreciation in land values in the areas where large lottery winners tend to purchase land, beyond the level of appreciation captured in the district's overall capital gains (for which we adjust down land values in Section 5.2)

4. Large grant winners who purchase new land or invest in their land also differentially overestimate their land value, perhaps due to a higher private valuation of the land

5. Large grant winners differentially report biased land values, irrespective of land purchases, perhaps due to the large grant and its potential uses inflating their belief about returns to the household's wealth in general

These explanations differ in their implications for the expansion of financial services. For example, grant winners making already owned plots of land more productive has distinct implications for aggregate growth relative to grant winners simply speculating in land and driving up its price, especially since land is in fixed supply.

Our data do not allow us to entirely differentiate between these explanations. Using the information that we have to partially disentangle these explanations, however, we examine the extent to which large grant winners made new land purchases versus investments in improving land (both of which could increase a household's land value). First, descriptive statistics in which we simply asked respondents directly how they spent the grant reveal that land purchases accounted for the highest fraction of grant spending for 32% of large grant winners, by far the modal expenditure among large grant winners (Table F.1).[30] About 6% of small grant winners also report that purchasing land was their largest expenditure with the grant.[31] 14% of large grant winners and 9% of small grant winners report that land and building improvements accounted for the largest fraction of their grant spending, which could have increased the value of their land as well. In sum, the descriptive statistics suggest that land values likely reflect a combination of new land purchases and land improvements, with land purchases accounting for the modal largest expenditure made with the large grant.

In our long-term (6 year) follow-up survey, we did ask respondents retrospective questions about land purchases, investment, and sales. In Table 13, we show that winning the large lottery differentially increases the likelihood of purchasing land by 15 percentage points ($p < 0.05$) relative to small lottery winners and by 16 percentage points ($p < 0.05$), or 48%, relative to the large lottery control. We find no statistically significant impacts on the likelihood of investing in land or selling land, for either small or large lottery winners. These results increase our confidence that the large increase in land values that we detect in the regions where the experiment takes place are associated with high rates of land purchase (note that even

[30]Table F.1 reports the single item on which a grant recipient spent the largest fraction of their grant funds, such that the categories are mutually exclusive. Many grant recipients, for example, may have purchased both business inventory and business durables, but the category on which they spent the largest fraction of their funds appears in Tables F.1.

[31]Small grant winners also purchasing land is consistent with the model's predictions that some households whose baseline wealth is sufficiently close to the threshold above which they can make the indivisible investment will choose the small lottery, if winning the small lottery provides enough funds to surpass the threshold.

the control means suggest relatively high frequency of land purchase), which could lead to substantial price effects for an asset like land that is not perfectly elastically supplied. We will analyze the policy implications of an inelastically supplied investment good using our calibrated model in the following section.

6 Calibrated Model Results

We now return to our model of Section 2, but we use the income and savings distributions observed in our midline data and the households' choice of lottery to calibrate a model of financially-constrained indivisible investment and savings dynamics. It is common in the macro development literature that links experimental data with macro models to use the experimental data to either calibrate or cross-validate the model. In Appendix G, we do the latter, showing that analogous regressions on model simulated data can reproduce the large coefficients on indivisible investment that we find in Section 5.2. Having done so, we use the model to quantitatively assess the impact of financial intermediation.

6.1 Calibration

Mapping the model to data for aggregate analysis requires adding important elements of persistent heterogeneity in the productivity of labor, $\bar{e}$, and capital, $\bar{z}$, and disciplining the other parameters of the model using data moments.[32] Specifically, we assume $\bar{e}_i$ and $\bar{z}_i$ are (independently) lognormally distributed, so that $\log \bar{e}_i \sim \mathcal{N}(0, \nu_e)$ and $\log \bar{z}_i \sim \mathcal{N}(\mu_z, \nu_e)$, respectively. Here, assuming the mean of the $\log \bar{e}_i$ to be zero is a normalization.

Our calibration results and fit are summarized in Table 14. We start by assigning four parameters. First we set the maximum loan-to-value ratio $\theta = 0$ in the benchmark. We do so for simplicity, but this broadly matches the limited access to credit that we observe. The interest rate r then effectively becomes the interest on savings, which we set to zero, consistent with the fact that our empirical sample all were provided with zero interest savings accounts. A period is a month, and we set the monthly maintenance cost of capital, δ, which is analogous to depreciation in an indivisible capital model, to 0.01. We set the constant survival probability, p, to $1 - 1/480$, implying an average adult life (or career) of 40 years.

We are left with eight parameters to calibrate: the discount factor, β; the parameters disciplining the capital technology, $\underline{k}$ (size of a unit of indivisible capital), α (the capital elasticity in production), μ_z, ν_z, and σ_z (governing the (log) mean productivity, persistent dispersion, and productivity shock dispersion, respectively); and the parameters disciplining the labor income: ν_e and σ_e (disciplining the dispersion of the persistent income difference and productivity shocks, respectively).

Our calibration strategy is to choose these parameters to match the the moments in the data that are most of interest to this study: the observed lottery choices, the distribution and dynamics of income, and the distribution of wealth. For the lotteries, we target the percentage of households who choose each of

[32]We examined alternative models with additional parameters such as non-unitary risk aversion, Epstein-Zin preferences (with separate risk aversion and intertemporal substitution parameters) and both physical and pecuniary fixed costs to adjusting capital, but these extensions do not significantly improve the fit over our parsimonious model.

the four lottery choices. For the distributions of both income and savings, we target the mean as well as five percentiles of the distribution (10th, 25th, 50th, 75th, and 90th), a total of 11 moments given the normalization of median income to one in the model and in the data.[33] Finally, for the dynamics of income, we target transitions across income terciles over the 16 months from baseline to midline. The 3x3 transition matrix constitutes nine additional moments. Together, these targets amount to 22 moments, substantially more than the eight free parameters we calibrate.

Given the parsimony of the model, we cannot match all moments, and instead minimize a weighted average of the sum of percentage squared deviations.[34] Table 14 summarizes the parameter values and model fit. Despite the over-identification, the model fit is reasonably close, especially for our purposes. The model is able to match the fact that a substantial share choose the large lottery (0.20+0.04=0.24 in the model vs. 0.20+0.07=0.27 in the data). The share choosing to delay is somewhat smaller (0.04 vs. 0.07, respectively), but overall the share of those delaying is also comparable (0.04+0.19=0.23 vs. 0.07+0.14=0.21, respectively). The savings distributions are comparable with median levels of savings well below median monthly income (0.13 vs. 0.19, respectively). Both distributions exhibit a leftward skew with the means exceeding the medians, and at least 25% of households in both distributions hold no positive savings. Of course, given the fact that our benchmark simulations have no credit, we cannot match the negative assets for those in the 10th percentile, but recalling Figure 2, this distinction is likely not crucial for our aggregate analysis. Although the right tail is lower in the model than in the data (e.g., 90th percentiles of 1.43 vs. 2.92), the mean is somewhat higher given the lack of debtors in the model.

We see that the income distributions are also broadly comparable. Though the mean income is somewhat higher in the model (1.97 vs. 1.73), due to somewhat higher weight in the tails, both distributions have a leftward skew with mean substantially higher than the median. Looking at the income transition matrix, both the model and data exhibit strong diagonal elements, showing a tendency to stay in one's income tercile, especially in the upper and lower terciles. Conditional on being in the lower income tercile, a household has a high chance of remaining there (67% vs. 63%), which could be evidence of a (stochastic) poverty trap. In the middle tercile, the numbers are lower (43% vs. 48%), reflecting, in the model, the transitional saving dynamics of moving to one of the stable steady states (recall Figure 1).

Looking at the calibrated parameter values, we see that $\underline{k} = 8.0$ implies that the indivisible investment is about 8 months of the median family income, or 40 times larger than the median level of liquid savings. The estimates of $\sigma_\epsilon = 0.53$ and $\sigma_z = 1.13$ indicate considerable uncertainty in labor and capital income. The first creates both variation and churning in the income distribution, while the latter simply creates variation. Finally, we note that the discount factor, $\beta = 0.84$, is quite low, much lower than typically calibrated for macroeconomic studies. Models with financial frictions often yield very low discount factors, however, which is needed to prevent people from simply saving out of the range of financial frictions (e.g., Buera et al.

[33] Savings includes only financial wealth and corresponds to S in the model.

[34] The weights are equal to one, except for the lottery choice moments, which are critical in getting the indivisibility dynamics and so get a higher weight of 20.

(2020)). Note that in this calibration, the presence of high-yield investment opportunities will generate patience among a world of impatient agents rather than impatience among the otherwise patient.

6.2 Counterfactual Assessment of Introduction of Financial Services

We now use the model to evaluate the impacts of introducing wide-scale financial services to the regions of study. We assess four different "policies" relative to our benchmark. For each policy, we assess these policies under two different scenarios about the supply of capital. The first is a scenario where capital is perfectly elastically supplied at a constant price, as is typically assumed in macro models of investment. In this case, only quantities will adjust to an increase in the demand for investment. Such an assumption is surely appropriate when the intervention is small relative to overall supply of capital, and so we label this "PE". The second scenario is one in which capital is in fixed supply. Such a scenario is an extreme scenario but perhaps more appropriate for the case when land is the investment good. In this case, prices will adjust to changes in the demand for capital rather than aggregate quantities, and so we label this "GE". We note, however, the purpose of both scenarios is to use the extreme cases to bracket possible impacts.

Table 15 presents the results for the various policies under both scenarios. We focus on the impacts of these policies on aggregates: income, consumption, net savings, capital, the value (price $\times$ quantity) of capital, the price of capital, and capital income. Given our interest in poverty traps and wealth dynamics, we also report the fraction of the poor in the economy (i.e., the fraction below a threshold defined by the lowest tercile *of wealth* in the benchmark economy) and the probability of staying poor. We report all of the counterfactual results relative to the benchmark values (which are given in the notes of Table 15 but not otherwise of particular interest). We point out that although savings and capital are positive, consumption approximately equals income in the steady state because capital does not depreciate and income is already net of maintenance costs. That is, steady state investment is zero in the economy whether capital is elastically or inelastically supplied. The only difference between consumption and income comes from the small probability of death.

The first "policy" we evaluate is a 'Divisible Capital' case in which capital is perfectly divisible (though still bounded above) enabling a choice of any $k \in [0, k_1]$. This might be a viable policy if indivisibility in land, for example, were driven by the titling of plots or rental markets frictions. (However, our qualitative research suggests that titles are *not* the driving characteristic of land indivisibility.) Alternatively, this exercise can be understood as providing a benchmark comparison for how powerful indivisibility in investment can be in driving economic aggregates and poverty in order to answer the question in the paper's title. Comparing the first and second columns, we see that indivisibility substantially lowers output. In the PE case, output would be more than twice as high without the indivisibility, and capital would be nearly three times as high, since even the poor-but-productive would be able to invest some, and gradually expand their capital over time. The GE column shows large differences in aggregate consumption and income as well, even though the aggregate capital stock is fixed, and these gains come from a redistribution toward households with a higher marginal product of capital on the margin.[35] The consequences are that no one is below the benchmark poverty line in this divisible capital world. In the GE case of divisible capital, the savings rate goes down substantially as the motive to self-finance the indivisible capital is eliminated.

We now turn to three financial policies which we compare to these two benchmarks. The first is an expansion of credit services that enables households to borrow up to (a relatively modest) 25% of the value of their capital, which we model as an increase of the collateral parameter, θ, from 0 to 0.25. The second is an expansion of interest-bearing savings facilities, which we model as an increase in the monthly interest rate, r, from 0 to 0.03, equal to the "delay" interest offered in our empirical experiment. The third is a combination of both, which enables borrowing together with saving but both at a positive interest rate.

The pure credit intervention is quite powerful when the price of investment is fixed. Under this scenario ('Credit' and 'PE' in the table), the 2.30 indicates that the capital stock is 130% larger while the 1.53 indicate that income is 53% larger. Capital income rises slightly more due to a better allocation of capital. The 0.91 indicates that net savings declines, a combination of both credit and decreased savings for self-financing reasons, but by only 9%. The fraction poor declines by 32%, although the chances of staying poor remain the same.

In striking contrast, in the case of credit under a fixed stock of capital, we see absolutely no impact on aggregate income, capital income, or poverty. Indeed, the policy is completely neutral even on the micro level. The change in θ is completely offset by a commensurate change in price, where $P = 1/(1-\theta)$ or 1.33 in this case. Net savings declines as households simply keep their surplus savings above available credit, i.e., $\hat{a} = a' + \theta P k'$, unchanged. Indeed, given our assumptions, one can easily show this neutrality result analytically.[36] The key point is that the power of credit to increase output and reduce poverty is substantially reduced in a world where the increased demand for investment manifests itself more in an increase in prices than through an increase in productive capital.

The results for the pure savings intervention demonstrate that when the investment price is fixed, interest-bearing savings can also be a powerful financial intervention. Under a fixed price of capital, savings responds considerably to the positive return on savings, increasing by 37%, a strong contrast to the impact of the credit policy. However, capital increases by 20%, capital income increases by 23%, and overall income rises by 11%. The impact of savings on poverty is perhaps as dramatic as in the credit intervention, as the fraction poor drops by 18% and the probability of staying poor is 14% lower in the savings distribution. The "poverty

[35] Note that our calibrated elasticity of capital $\alpha = 0.35$ is consistent with capital's share in other quantitative work, but implies an Inada condition, where the marginal products of capital are unbounded as capital approaches zero.

[36] To see this, recall that θ only impacts the household's problem through the borrowing constraint, $a' \geq -\theta P k'$. Define $\hat{a} = a' + \theta P k'$ as surplus savings above the lower bound. Then combining the recursive constraints (2) and (4) to eliminate l, substituting in for $\hat{a}$, and simplifying using $r = 0$ yields the following constraints:

$$c + \hat{a} + P(1-\theta)(k' - k) = e + \hat{a} + zk^{\alpha} - \delta k$$

and

$$\hat{a} \geq 0.$$

It is clear that any change from θ to θ' is simply offset by a general equilibrium change in the price of capital from P to $P' = P(1-\theta)/(1-\theta')$, and no household's problem is affected, except that while $\hat{a}$ remains constant, the 0.38 indicates that a' declines dramatically (by 62%) to offset the change in available credit according to the equation that holds by definition, $\hat{a} = a' + \theta P k'$. The clarity of this analytical neutrality result is further justification for the $r = 0$ assumption.

trap" is therefore weakened.

When we look at the case of capital in fixed supply, although the perfect neutrality result no longer holds, the aggregate impacts are nonetheless tempered. The price of capital increases but by only 6%, showing that the savings intervention doesn't increase the demand for investment quite as much as the credit program. Income rises by only 2%, as does capital income. Here labor income is fixed, but interest becomes an important source of income. Savings rises by 20%, and both higher savings and a positive interest rate lead to interest income.[37] Hence, while the aggregate results are tempered, they are not completely neutral. Moreover, because it affects the accumulation of savings, the program still has important impacts on poverty. The fraction poor drops by 14% even under a fixed supply of land, and poverty is again much less persistent with the probability of staying poor also dropping by 14%.

Lastly, we see that the combination of interest-bearing savings and interest-paying credit can be an even stronger financial intervention when the price of capital is fixed. Indeed, the 74% increase in consumption and 72% in income represents more than half of the distance between the benchmark and the divisible capital case, and the 50% reduction in poverty is midway between the two as well. The persistence of poverty is comparable to the case with only savings, however. In the case of capital in fixed supply, however, even the combined impacts of financial services remain muted. Net savings is actually lower than in the benchmark (although it is higher than the benchmark when the price of capital is fixed). The price of capital is higher when both credit and savings possibilities increase the price of capital, but poverty and its persistence is comparable to the savings only scenario.

In summary, the aggregate simulation results underscore that the indivisibility of capital has strong impacts on aggregate development and poverty. Financial interventions can be powerful forces for development and poverty reduction in this world of indivisible investments, but this hinges critically on the elasticity of the supply of capital. General equilibrium forces can undermine positive aggregate impacts measured in partial equilibrium experiments.

Given the importance of land as an indivisible investment in the empirics, a final question is whether we ought to think about peri-urban land in fixed or elastic supply. One reasonable answer is to simply assert that land captures simple area, and is in therefore in fixed supply. If the increased land value we capture reflects land purchases, so even the small-scale increases in land value among the treated come from the sales of land of the untreated, a quantitatively small but in this case economically important violation of the stable unit treatment value assumption (SUTVA) for our control. An alternative to consider is that land value, especially quality-adjusted land, is potentially elastic, however, reflecting either investments/improvements in land that increase the value and/or a true expansion of utilized land from around the perimeter of a town, for example. Following such an assumption, we can use the exogenous increase in demand of land from our experiment to calculate a back-of-the-envelope estimate of the elasticity of the supply of land. Specifically, using the results in Table 7 we estimate a percentage increase in the quantity of quality-adjusted land

[37] Our neutrality result for credit hinged on zero interest loans. In the case where loans were positive interest there would be distributional consequences as well.

(calculated to be roughly 1% as a fraction of all land, participants and not). Recalling the price effects estimated in Appendix B, which implied an increase in price of 20%, we estimate a very small elasticity of $1\%/20\% = 0.05$, quite close to the inelastic benchmark, indicating the GE results are most relevant.[38]

7 Conclusions

We examine the importance of high-yield, indivisible investments in peri-urban and rural Uganda, where financial services are limited. Empirically, we have shown demand for a large-stakes-but-lower-expected-value lottery, especially among those who have self-financing motives for savings and investment motives for credit, even among a risk-averse population. The risk-loving behavior we observe is consistent with theories of high-yield indivisible investments, which, in principle, can lead to sizable gains to financial intermediation. Winners of these large lotteries invest disproportionately in indivisible assets, land in particular. We find sizable income gains for winners of the large lottery which take time to develop — they are present at 6 years but not at 4 or 18 months (though there is some evidence of consumption increases for large lottery winners at 18 months). Our theory demonstrates that when indivisible investments are inelastically supplied, the impacts of expanding financial services, especially credit, on aggregate outcomes and poverty can be substantially lower. From a policy perspective, the results indicate that interest-bearing savings, perhaps along the lines of Greaney et al. (2016), may be relatively more important when the investment good is in fixed supply.

Substantively, the findings about land elicit questions of their own for future research and highlight the importance of work in peri-urban environments which are growing quickly and often have lagging access to infrastructure. Poverty trap dynamics have been observed for smaller investments such as livestock, which are profitable and more elastically supplied (e.g., Balboni et al. (2022)), but the importance of land merits more consideration. The development literature has focused on the interaction of finance, land titling, and investment, and also the link between land plots, overall farm size, and misallocation (e.g., Foster and Rosenzweig (2022); Gollin and Udry (2021); Acampora et al. (2022)), but the issues we raise are unique. How common are land-driven poverty traps and to what extent does land reallocation increase productivity and income? Finally, our results indicate that, even outside of major urban areas, land may be an important investment for the poor. The lack of clear evidence on whether returns to land result from investment in the land by more productive households or simply as the result of holding a good that offers high capital gains is an important limitation of the findings. More research on these aspects of land markets is therefore encouraged.

[38] The specifics of these calculations are also included in Appendix B.

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Figures

Figure 1: Asset-Dependent Behavior and Poverty Traps

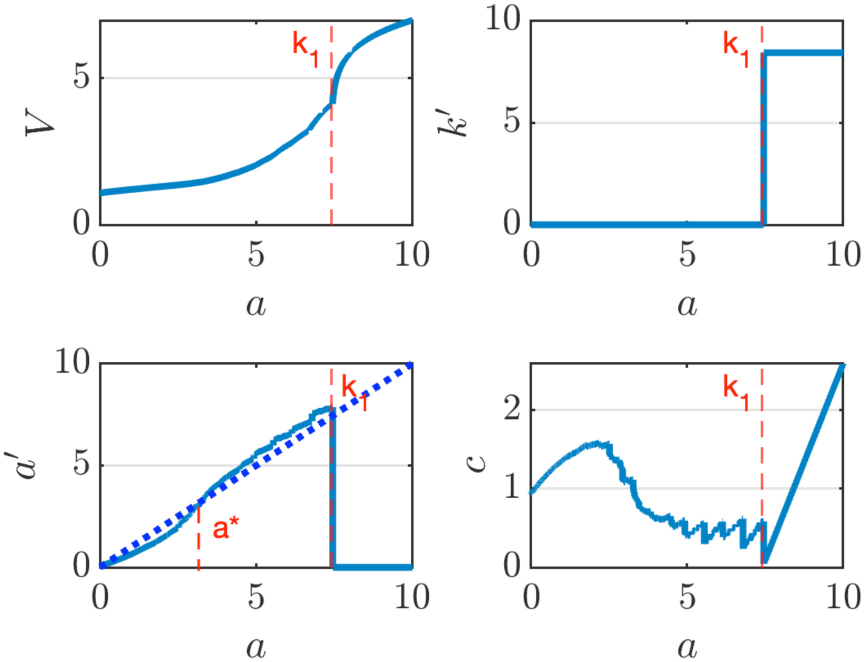


Figure 2: Asset-Dependence of Lottery Choice

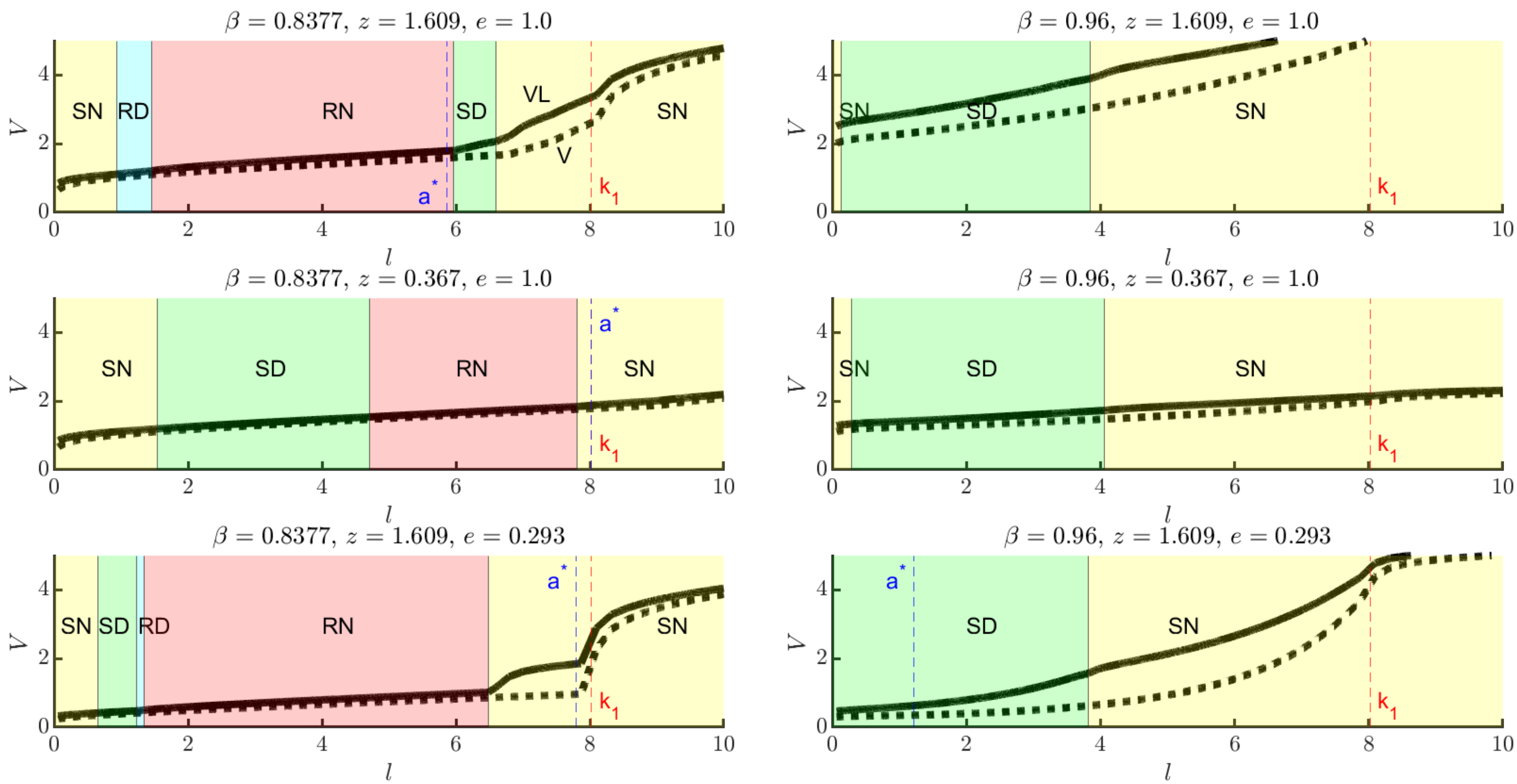
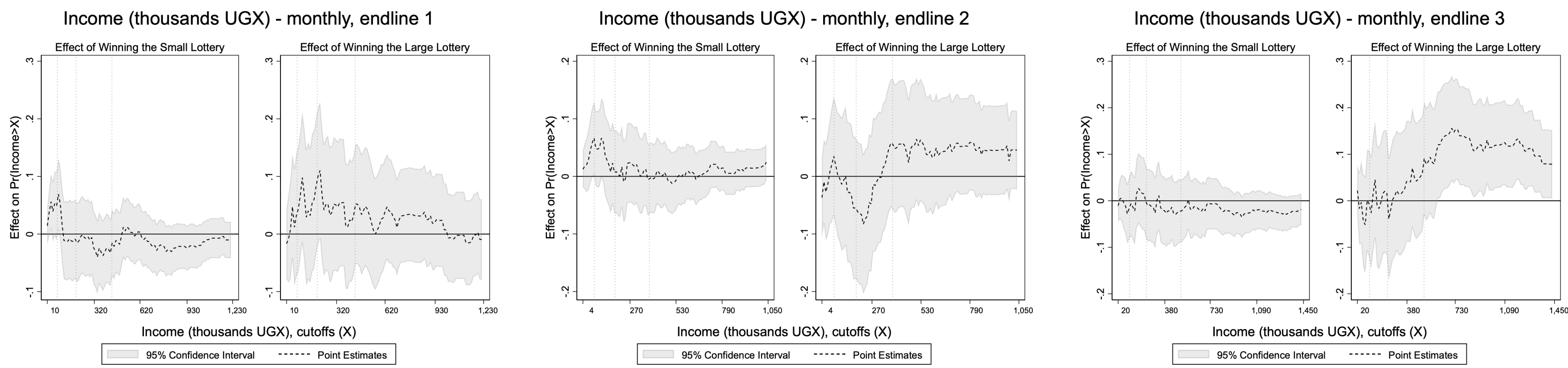


Figure 3: Distribution Regressions: Effect of Winning the Lottery on the Distributions of Income at Each Endline



Notes: Vertical dotted lines correspond to the 25th, 50th, and 75th percentiles of the outcome, respectively.

Tables

Table 1: **Lottery choices**

	Large	Small	Total
Patient	78	144	222
	(7%)	(14%)	(21%)
Impatient	205	621	826
	(20%)	(59%)	(79%)
Total	283	765	1,048
	(27%)	(73%)	(100%)

Table 2: **Lottery winners**

	Large	Small	Total
Patient	19 of 78 = 24%	71 of 144 = 49%	90 of 222 = 40%
Impatient	66 of 205 = 32%	302 of 621 = 49%	368 of 826 = 45%
Total	85 of 283 = 30%	373 of 765 = 49%	458 of 1,048 = 44%

Table 3: **Balance between small lottery winners and non-winners**

	won small lottery	N	did not win small lottery	N	diff	p-value
Household budget components						
mthly income$_m$	362,779	325	385,259	309	-22,480	0.44
wkly consumption$_m$	40,315	325	39,451	309	864	0.70
savings$_m$	289,452	325	268,359	309	21,093	0.51
credit outstanding$_m$	184,105	325	204,933	309	-20,828	0.51
home durable value$_b$	507,805	325	501,452	309	6,353	0.92
Investment categories						
total divisible investments$_m$	409,608	325	342,147	309	67,461	0.16
small livestock and ag. assets$_b$	176,231	325	161,210	309	15,020	0.41
bus inventory$_m$	170,068	325	150,846	309	19,222	0.53
total indivisible investments$_m$	11,184,306	325	11,166,890	309	17,416	0.99
large livestock and ag. assets$_b$	285,815	325	237,133	309	48,683	0.47
land value$_b$	9,920,154	325	10,091,586	309	-171,432	0.87
bus assets, no stock$_m$	405,198	325	286,228	309	118,970*	0.10
Other financial indicators						
operates non-farm business$_m$ (0/1)	.53	325	.55	309	-.021	0.60
farmer$_m$ (0/1)	.75	325	.77	309	-.019	0.57
work hours per week$_m$	77	325	78	309	-.98	0.58
had negative shock since baseline$_m$ (0/1)	.64	325	.68	309	-.037	0.33
has formal savings$_m$ (0/1)	.11	325	.15	309	-.035	0.19
acquired loans since baseline$_m$ (0/1)	.32	325	.33	309	-.007	0.85
Demographic characteristics						
female (0/1)	.47	325	.52	309	-.05	0.20
household head (0/1)	.61	325	.6	309	.0042	0.91
respondent age	35	325	37	309	-1.2	0.18
education beyond primary school (0/1)	.27	325	.28	309	-.011	0.76
num people in household$_b$	5	325	5	309	.041	0.82
num adult females$_b$	1.1	325	1.2	309	-.076*	0.09
num adult males$_b$	1.4	325	1.4	309	.039	0.64
num children$_b$	2.5	325	2.4	309	.078	0.55
Observations	634					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Midline denoted by **m** and baseline denoted by **b**
Sample consists of those retained through the second endline survey (those used in our analysis of treatment effects)
bus is an abbreviation for business; * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table 4: **Balance between large lottery winners and non-winners**

	won large lottery	N	did not win large lottery	N	diff	p-value
Household budget components						
mthly income$_{\mathrm{m}}$	423,464	74	378,105	159	45,359	0.40
wkly consumption$_{\mathrm{m}}$	46,428	74	43,862	159	2,566	0.54
savings$_{\mathrm{m}}$	353,284	74	281,918	159	71,366	0.19
credit outstanding$_{\mathrm{m}}$	169,459	74	204,522	159	-35,063	0.54
home durable value$_{\mathrm{b}}$	676,441	74	743,906	159	-67,465	0.62
Investment categories						
total divisible investments$_{\mathrm{m}}$	642,345	74	458,409	159	183,936*	0.08
small livestock and ag. assets$_{\mathrm{b}}$	199,385	74	197,148	159	2,237	0.95
bus inventory$_{\mathrm{m}}$	301,149	74	201,572	159	99,576	0.13
total indivisible investments$_{\mathrm{m}}$	18,325,135	74	14,950,233	159	3,374,902	0.17
large livestock and ag. assets$_{\mathrm{b}}$	590,811	74	626,132	159	-35,321	0.85
land value$_{\mathrm{b}}$	15,665,270	74	12,821,698	159	2,843,572	0.21
bus assets, no stock$_{\mathrm{m}}$	540,676	74	498,157	159	42,518	0.78
Other financial indicators						
operates non-farm business$_{\mathrm{m}}$ (0/1)	.61	74	.61	159	-.002	0.98
farmer$_{\mathrm{m}}$ (0/1)	.73	74	.71	159	.019	0.77
work hours per week$_{\mathrm{m}}$	77	74	77	159	-.42	0.90
had negative shock since baseline$_{\mathrm{m}}$ (0/1)	.64	74	.62	159	.012	0.86
has formal savings$_{\mathrm{m}}$ (0/1)	.054	74	.094	159	-.04	0.30
acquired loans since baseline$_{\mathrm{m}}$ (0/1)	.23	74	.33	159	-.097	0.13
Demographic characteristics						
female (0/1)	.38	74	.43	159	-.056	0.43
household head (0/1)	.73	74	.63	159	.1	0.13
respondent age	38	74	37	159	1	0.53
education beyond primary school (0/1)	.31	74	.23	159	.078	0.21
num people in household$_{\mathrm{b}}$	5.4	74	5.4	159	-.0097	0.98
num adult females$_{\mathrm{b}}$	1.1	74	1.1	159	.042	0.64
num adult males$_{\mathrm{b}}$	1.6	74	1.4	159	.19	0.26
num children$_{\mathrm{b}}$	2.6	74	2.9	159	-.25	0.34
Observations	233					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Midline denoted by **m** and baseline denoted by **b**
Sample consists of those retained through the second endline survey (those used in our analysis of treatment effects)
bus is an abbreviation for business; * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table 5: **Statistically significant differences between those choosing the large v. small lottery**

	large	N	small	N	diff	p-value
Income and consumption						
Δ ln mthly income$_{\text{m-b}}$*	.71	283	1.2	765	-.44	0.02
mthly crop income$_{\text{m}}$*	100,208	283	71,148	765	29,061	0.00
crop income/total income$_{\text{m}}$	.3	283	.25	765	.05	0.01
mthly crop income/adult equiv$_{\text{m}}$*	30,562	283	22,981	765	7,580	0.00
ln mthly crop income$_{\text{m}}$*	12	283	12	765	.21	0.00
Δ ln mthly bus income$_{\text{m-b}}$*	6.7	283	7.6	765	-.87	0.02
wkly consumption$_{\text{m}}$	44,466	283	39,453	765	5,013	0.01
ln wkly cons$_{\text{m}}$	10	283	10	765	.18	0.01
Δ ln wkly cons$_{\text{m-b}}$*	.38	283	.24	765	.14	0.03
Savings and wealth						
savings$_{\text{m}}$	322,675	283	275,817	765	46,858	0.10
Δ ln savings$_{\text{m-b}}$	2.5	283	1.7	765	.86	0.03
bus assets$_{\text{m}}$	824,954	283	577,814	765	247,140	0.01
bus assets/wealth$_{\text{m}}$	.29	283	.24	765	.053	0.05
bus assets/adult equiv$_{\text{m}}$	295,958	283	218,673	765	77,285	0.07
ln bus assets$_{\text{m}}$	5.3	283	4.3	765	.99	0.03
wealth (sav + bus assets)$_{\text{m}}$	1,245,155	283	920,185	765	324,970	0.01
wealth/adult equiv$_{\text{m}}$	431,561	283	337,778	765	93,784	0.07
ln wealth$_{\text{m}}$	11	283	11	765	.65	0.05
Δ ln wealth$_{\text{m-b}}$*	2.2	283	1.5	765	.7	0.05
net wealth (sav + bus assets - credit)$_{\text{m}}$	1,070,910	283	744,418	765	326,492	0.01
net wealth/adult equiv$_{\text{m}}$	377,813	283	277,547	765	100,265	0.05
ln net wealth$_{\text{m}}$	16	283	16	765	.075	0.06
land value$_{\text{b}}$	13,345,159	283	9,852,680	765	3,492,479	0.00
land value/adult equiv$_{\text{b}}$	3,936,519	283	3,010,483	765	926,036	0.00
ln land value$_{\text{b}}$	13	283	12	765	.91	0.04
Desire to invest						
wants credit to increase income$_{\text{b}}$ (0/1)*	.84	283	.78	765	.062	0.03
would invest >100_{\text{b}}$ (0/1)*	.95	283	.91	765	.038	0.04
would use credit for bus investment$_{\text{b}}$ (0/1)*	.67	283	.59	765	.073	0.03
Demographic characteristics						
female (0/1)*	.42	283	.51	765	-.09	0.01
household head (0/1)	.66	283	.6	765	.058	0.09
respondent age	37	283	35	765	2.3	0.00
num people in household$_{\text{b}}$	5.5	283	5	765	.47	0.00
num adult males$_{\text{b}}$	1.5	283	1.4	765	.14	0.08
num children$_{\text{b}}$*	2.8	283	2.5	765	.34	0.00

*Denotes that variable was also selected by lasso. All quantities in UGX. Outliers top/bottom coded to 95th/5th percentile. Midline denoted by **m** and baseline denoted by **b**; **bus** is an abbreviation for business. Full list of covariates on which we test for differences between those selecting the small versus large lottery is in Table C.1. Complete list of lasso-selected covariates is in Table C.2.

Table 6: **Grant effects on investment - First endline**

		Productive divisible investments			Productive indivisible investments			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Home durables	Tot. div.	Small livestock and ag. tools	Bus. inventory	Tot. indiv.	Large livestock and ploughs	Bus. durables	Land
won lottery (0/1)	91,888	190,956***	84,271***	127,997***	-796,104	90,079*	65,295	-861,540
	(62,914)	(61,827)	(27,645)	(40,916)	(954,012)	(49,229)	(70,324)	(982,476)
won large lottery (0/1)	-67,114	127,754	-76,874	174,088*	5,095,876**	124,565	122,533	5,315,274**
	(130,254)	(151,638)	(63,475)	(102,373)	(2,075,135)	(118,938)	(172,279)	(2,127,186)
risk loving (0/1)	4,945	76,005	55,439	-1,218	-2,438,998**	-41,153	27,890	-1,958,856*
	(78,014)	(75,969)	(34,643)	(49,342)	(1,041,186)	(66,155)	(91,002)	(1,055,963)
$\beta_1 + \beta_2$	24,774	318,710	7,397	302,085	4,299,771	214,644	187,828	4,453,734
P-value: $\beta_1 + \beta_2 = 0$	.83	.02	.9	.0012	.019	.048	.23	.017
Control mean if risk loving = 0	628,817	613,887	275,969	285,471	16,750,624	202,913	537,380	15,675,049
Control mean if risk loving = 1	748,134	787,251	369,204	320,723	19,021,050	308,805	748,535	17,415,000
R^2	.28	.41	.22	.46	.72	.31	.5	.69
Observations	867	867	867	867	867	867	867	867

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses

Controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's

Table 7: **Grant effects on investment - Second endline**

		Productive divisible investments			Productive indivisible investments			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Home durables	Tot. div.	Small livestock and ag. tools	Bus. inventory	Tot. indiv.	Large livestock and ploughs	Bus. durables	Land
won lottery (0/1)	4,120	69,303	33,652	55,353	644,569	91,122*	129,478	319,283
	(71,454)	(60,111)	(27,418)	(42,651)	(1,487,327)	(51,760)	(113,988)	(1,494,017)
won large lottery (0/1)	13,266	-27,480	-20,836	16,520	6,993,895*	-89,363	384,424	7,168,289**
	(151,702)	(138,689)	(62,223)	(101,933)	(3,576,218)	(121,789)	(294,705)	(3,493,766)
risk loving (0/1)	-34,722	86,905	36,522	20,325	-1,514,346	83,579	-14,138	-1,325,532
	(87,422)	(76,456)	(36,753)	(52,175)	(1,743,776)	(77,256)	(140,530)	(1,722,529)
$\beta_1 + \beta_2$	17,386	41,822	12,816	71,873	7,638,464	1,759	513,902	7,487,571
P-value: $\beta_1 + \beta_2 = 0$	.9	.74	.82	.43	.019	.99	.057	.018
Control mean if risk loving = 0	725,261	596,244	280,831	286,676	21,386,603	181,553	703,200	20,327,217
Control mean if risk loving = 1	819,181	776,076	344,160	361,808	24,606,028	398,129	918,528	22,733,019
R^2	.26	.32	.13	.37	.52	.2	.36	.5
Observations	867	867	867	867	867	867	867	867

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses

Controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's

Table 8: **Grant effects on components of the household budget constraint - First endline**

	(1) consum. (stock) wkly cons + home dur.	(2) savings	(3) div. investment	(4) indiv. investment*	(5) mthly income	(6) net credit
won lottery (0/1)	121,277	57,204*	190,956***	-721,095	-8,344	-7,054
	(90,290)	(30,408)	(61,827)	(906,426)	(20,200)	(18,092)
won large lottery (0/1)	-18,497	107,836	127,754	5,016,354**	38,551	-23,513
	(176,415)	(69,336)	(151,638)	(1,965,752)	(44,173)	(40,044)
risk loving (0/1)	110,406	12,933	76,005	-2,326,259**	-4,074	-788
	(109,121)	(35,395)	(75,969)	(966,582)	(25,967)	(22,591)
$\beta_1 + \beta_2$	102,781	165,040	318,710	4,295,259	30,207	-30,567
P-value: $\beta_1 + \beta_2 = 0$	.5	.0082	.02	.013	.44	.39
Control mean if risk loving = 0	1,608,566	259,468	613,887	15,232,971	327,076	73,180
Control mean if risk loving = 1	1,798,491	271,428	787,251	17,160,718	321,271	80,220
R^2	.29	.3	.41	.71	.42	.093
Observations	867	867	867	867	867	867

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses

*Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time

Controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's

Table 9: **SUR with household budget constraint - First endline**

	consum. (stock) wkly cons + home dur.	savings	div. investment	indiv. investment*	mthly income	net credit
won lottery (0/1)	83,017	54,390*	177,950***	-78,531	-26,015	-9,112
	(93,281)	(32,223)	(66,585)	(132,562)	(23,304)	(19,249)
won large lottery (0/1)	-32,121	139,176**	92,247	1,247,456***	29,663	-21,893
	(195,226)	(67,492)	(139,403)	(277,484)	(48,801)	(40,313)
risk loving (0/1)	201,784*	1,438	145,056*	669,053	-4,107	-6,831
	(118,592)	(40,557)	(84,223)	(1,189,239)	(29,304)	(24,071)
district fe's	Yes	Yes	Yes	Yes	Yes	Yes
demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Within-equation tests:						
$\beta_1 + \beta_2$	50,897	193,566	270,197	1,168,925	3,647	-31,004
P-value: $\beta_1 + \beta_2 = 0$	.77	.00	.03	.00	.93	.38
Cross-equation tests:						
P-value: Sm grant constraint	.95					
P-value: Lg grant constraint	.65					
Control mean if risk loving = 0	1,573,710	256,157	591,676	15,431,617	318,218	77,590
Control mean if risk loving = 1	1,839,073	265,070	818,792	17,691,141	328,638	70,739
R^2	.2	.25	.35	.42	.28	.073
Observations	783					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Estimated with cross-equation budget constraint

Demographic controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children

Table 10: **Grant effects on components of the household budget constraint - Second endline**

	(1) consum. (stock) wkly cons + home dur.	(2) savings	(3) div. investment	(4) indiv. investment*	(5) mthly income	(6) net credit
won lottery (0/1)	294,543	48,839	69,303	506,277	16,240	-20,703
	(249,593)	(33,020)	(60,111)	(1,050,417)	(18,897)	(23,852)
won large lottery (0/1)	386,636	84,891	-27,480	4,770,034*	7,896	8,687
	(472,079)	(70,157)	(138,689)	(2,493,362)	(41,709)	(51,953)
risk loving (0/1)	157,957	3,760	86,905	-1,002,692	27,946	-44,824
	(294,962)	(38,289)	(76,456)	(1,220,197)	(24,040)	(30,255)
$\beta_1 + \beta_2$	681,180	133,730	41,822	5,276,311	24,136	-12,016
P-value: $\beta_1 + \beta_2 = 0$	.091	.033	.74	.02	.51	.79
Control mean if risk loving = 0	4,603,540	273,166	596,244	15,040,343	264,233	119,272
Control mean if risk loving = 1	5,036,368	279,987	776,076	17,326,575	289,215	76,352
R^2	.28	.23	.32	.51	.29	.069
Observations	867	867	867	867	867	867

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses

*Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time

Controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's

Table 11: **SUR with household budget constraint - Second endline**

	consum. (stock) wkly cons + home dur.	savings	div. investment	indiv. investment*	mthly income	net credit
won lottery (0/1)	21,291	46,674	24,199	333,714	4,314	-1,781
	(255,323)	(32,975)	(63,451)	(384,449)	(20,405)	(24,813)
won large lottery (0/1)	342,344	89,967	-68,503	945,661	-824	-25,699
	(534,416)	(69,069)	(132,841)	(804,880)	(42,729)	(51,965)
risk loving (0/1)	235,648	7,752	143,697*	2,265,515	34,987	-22,269
	(328,117)	(41,662)	(80,082)	(1,545,600)	(25,483)	(31,021)
district fe's	Yes	Yes	Yes	Yes	Yes	Yes
demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Within-equation tests:						
$\beta_1 + \beta_2$	363,635	136,641	-44,305	1,279,375	3,490	-27,480
P-value: $\beta_1 + \beta_2 = 0$	.44	.02	.70	.07	.93	.55
Cross-equation tests:						
P-value: Sm grant constraint	.52					
P-value: Lg grant constraint	.53					
Control mean if risk loving = 0	4,597,112	253,897	597,332	18,669,532	250,716	108,971
Control mean if risk loving = 1	5,049,384	274,655	822,299	22,488,440	293,904	83,239
R^2	.2	.2	.28	.29	.2	.058
Observations	783					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Estimated with cross-equation budget constraint

Demographic controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children

Table 12: **Grant effects on components of the household budget constraint - Third endline**

	(1) weekly consumption	(2) home durables	(3) savings	(4) div. investment	(5) indiv. investment*	(6) mthly income
won lottery (0/1)	-818	-2,455	19,243	15,687	570,089	-15,468
	(4,387)	(113,772)	(54,942)	(117,392)	(1,080,048)	(28,595)
won large lottery (0/1)	13,470	-80,403	32,624	16,592	-563,232	129,367**
	(9,130)	(224,349)	(138,951)	(257,404)	(2,357,928)	(62,467)
risk loving (0/1)	4,318	14,317	175,644**	95,343	2,127,393	-34,305
	(5,536)	(141,031)	(76,641)	(147,478)	(1,391,724)	(32,407)
$\beta_1 + \beta_2$	12,652	-82,858	51,867	32,280	6,857	113,900
P-value: $\beta_1 + \beta_2 = 0$	.12	.67	.69	.89	1	.042
Control mean if risk loving = 0	74,243	1,176,056	452,420	1,064,878	14,388,904	388,771
Control mean if risk loving = 1	81,032	1,304,103	633,123	1,258,952	18,360,600	355,319
R^2	.13	.18	.12	.18	.33	.18
Observations	838	838	838	838	838	838

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses

*Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time

Controls include: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, and district FE's

Table 13: **Effect of winning the grant on likelihood of purchasing, improving, and selling land**

	(1) purchased land between midline and endline3 = 1	(2) made improvements to land between midline and endline3 = 1	(3) sold land between midline and endline3 = 1
won lottery (0/1)	.011	.032	-.021
	(.038)	(.039)	(.031)
won large lottery (0/1)	.15**	-.026	-.04
	(.078)	(.081)	(.065)
risk loving (0/1)	-.033	.045	.039
	(.047)	(.048)	(.04)
$\beta_1 + \beta_2$	.16	.0057	-.061
P-value: $\beta_1 + \beta_2 = 0$	.017	.94	.29
Control mean if risk loving = 0	.37	.36	.18
Control mean if risk loving = 1	.33	.41	.22
R^2	.08	.043	.031
Observations	838	838	838

Heteroskedasticity-robust standard errors in parantheses; Controls include: pre-treatment land value, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's

Table 14: **Calibration Parameters and Moments**

A. Assigned Parameters

r	interest rate	0.00
θ	borrowing limit	0.00
δ	depreciation rate	0.01
p	survival probability	1 - 1/480

B. Calibrated Parameters

β	discount factor	0.84
$\underline{k}$	size of capital unit	8.02
α	capital elasticity in production	0.35
μ_z	mean productivity	0.96
ν_z	persistent productivity dispersion	0.35
σ_z	productivity shock dispersion	1.13
ν_e	income dispersion	0.43
σ_e	income productivity shock dispersion	0.53

C. Moments

	Model	Data
Income Distributions		
P10	0.39	0.15
P25	0.60	0.41
P50	1.00	1.00
P75	1.88	2.04
P90	4.18	3.72
Mean	1.98	1.73
Savings Distributions		
P10	0.00	-1.85
P25	0.00	0.00
P50	0.13	0.19
P75	0.47	1.16
P90	1.43	2.92
Mean	0.80	0.56
Lottery Choice		
Choose Risky Now	0.20	0.20
Choose Safe Now	0.56	0.59
Choose Risky Delay	0.04	0.07
Choose Safe Delay	0.19	0.14

Income Tercile Transition Probabilities

		Current	
		Model	
Future†	Low	Medium	High
Low	0.53	0.36	0.11
Medium	0.35	0.43	0.22
Hih	0.12	0.22	0.67
		Data	
	Low	Medium	High
Low	0.63	0.24	0.13
Medium	0.28	0.48	0.25
High	0.09	0.28	0.63

† Future measurements are taken after 16 months

Table 15: **Counterfactual Aggregate Impacts of Financial Interventions**

	Benchmark ($\theta = 0, r = 0$)	Divisible Capital		Credit ($\theta = 0.25, r = 0$)		Savings ($\theta = 0, r = 0.03$)		Combined ($\theta = 0.25, r = 0.03$)	
		PE	GE	PE	GE	PE	GE	PE	GE
Agg. Consumption	1.00	2.15	1.64	1.53	1.00	1.11	1.02	1.74	1.03
Agg. Income	1.00	2.15	1.64	1.53	1.00	1.11	1.02	1.72	1.02
Agg. Net Savings	1.00	1.57	0.19	0.91	0.38	1.37	1.20	1.44	0.58
Agg. Capital	1.00	2.98	*1.00*	2.30	*1.00*	1.20	*1.00*	2.76	*1.00*
Value of Capital	1.00	2.98	2.97	2.30	1.33	1.20	1.06	2.76	1.39
Price of Capital	1.00	*1.00*	2.95	*1.00*	1.33	*1.00*	1.06	*1.00*	1.39
Capital Income	1.00	4.26	3.09	2.32	1.00	1.23	1.02	2.75	1.03
Fraction Poor	1.00	0	0	0.68	1.00	0.82	0.86	0.50	0.86
Probability of Staying Poor	1.00	0	0	1.00	1.00	0.86	0.86	0.88	0.86

Notes: Values are reported relative to the benchmark, which has been normalized to one. Initial benchmark values are aggregate consumption = 2.10, aggregate income = 2.11, aggregate net savings = 0.86, aggregate capital = 1.59, price of capital = 1.00, capital income = 0.85, fraction poor = 0.33, and probability of staying poor = 0.42. Those people whose wealth is below the initial 33.33% of the wealth distribution are considered poor, and the probability of staying poor is calculated if they are poor 16 months later, conditional on being poor initially. Divisible capital allows households to purchase any value of $k \in [0, k_1]$. PE fixes the price of capital to 1. GE fixes the aggregate quantity of capital to that in the benchmark. In both cases, these values that are constant by construction are indicated by italics.

A Data Appendix – For Online Publication Only

The baseline and all three endline surveys contained detailed questions on household consumption, savings, income, assets, borrowing and lending (mapping to the components of the household budget constraint, which we use to structure our empirical analysis). The midline survey, intended to be somewhat briefer as it took place immediately preceding the lottery, consisted of questions on consumption, savings, income, business assets (but not home durables, land, livestock, or other agricultural assets), and borrowing. We detail the measurement of key outcomes below.

In the first and second endline, we prime respondents with the consumption, savings, income, or asset level that they reported at baseline or midline, and we ask whether that level has increased, decreased, or stayed the same, to prevent drastically different interpretations of the same question across survey waves. If the level has changed, we then ask for the new level. In the third endline, we do not prime respondents with their earlier responses as six years have passed and earlier responses may not be a useful benchmark.

A.1 Consumption

Consumption is constructed from detailed questions on subcategories of regular spending over the period of a week plus questions on the frequency and amount of less regular expenses. Specifically, we ask about regular weekly spending on:

- Staple grains, beans, other (non-meat, non-fish) food that is prepared at home, and cooking supplies
- Meat
- Fish
- Milk
- Non-milk beverages, including tea, beer, liquor, coffee, soda, and juice
- Transportation, including fuel for transportation
- Airtime
- Electricity, gas, firewood, and charcoal

We ask whether the respondent has incurred any of these less regular expenses in the past year and, if so, then we follow-up with questions about how much:

- Visits to hospitals, doctors, or other healers, and medicine
- School fees
- Expenses associated with marriage and marital ceremonies

We combine spending on all of these categories and standardize the frequency of incurred expenses to generate a measure of weekly consumption.

A.2 Home Durables

To collect the value of home durables, which we group with consumption in our analyses, we first ask about ownership of home assets (lamps, radios, stoves, generators, cell phones, televisions, refrigerators, carpets, sofas, tables, bicycles, motorbikes, and any other household asset that we might have missed). If a respondent reports to own a particular asset, then we ask how many they own, and we ask for the average value of one unit. We then sum values across all home assets that a respondent owns to obtain our measure of home durables.

A.3 Savings

For savings, we first ask the respondent for an estimate of their total savings. We then ask where they hold their savings (formal bank, microfinance institution, a savings cooperative known as a SACCO, any other savings group, with another person, in a secret place, or in a mobile money account). For each place where they tell us they hold savings, we ask how much they hold in that place. We then sum these values over all of the respondent's recorded savings places and ask the respondent whether they believe that the aggregate sum they provided initially or this sum of components better represents their total savings. Their preferred measure becomes our measure of savings.

A.4 Income

We collect "typical monthly income" through detailed questions on subcategories of income: crop income, livestock income, non-farm business income, wage/salary income, and remittances. Like savings, we start by asking the respondent for their best guess of their typical monthly income, and we then follow-up with detailed questions on each income component and produce our own calculation of total monthly income. Finally, we ask the respondent which measure they believe is more accurate, their initial aggregate estimate or our calculation from components.

To collect crop income, we ask the respondent which crops they harvest and how frequently. For each crop, we ask for the typical quantity that they produce with each harvest, how much they consume, and how much they sell. For the sold quantity, we ask the average price per unit sold, and we then calculate revenue per crop. We separately ask for the typical costs incurred to harvest all crops over the course of a year (including labor, fertilizer, and pesticides). We then construct crop income as revenue across all crops less costs across all crops.

To collect livestock income, we ask the respondent which animals the household has owned in the past 12 months. For each one that the household has owned, we ask how many they have sold in the past year and their earnings from these sales. We then ask which types of expenses they incur to maintain livestock (animal feed, labor, veterinary services, or other expenses) and the cost of each. We produce profit per animal and sum across all animals to construct total income from livestock.

To collect (non-farm) business income, we ask the respondent whether they own any businesses and how many. For each business, we ask about the number of months per year that the business operates, the typical sales per month, what types of expenses are incurred (inventory, labor, and any other costs), and the cost of each per month. From these questions, we construct monthly profit for each business. We ask the respondent whether our monthly calculation seems accurate, and if not, then we give them the opportunity to provide a corrected measure of monthly business profit.

We ask the respondent if they or any other household members earn income from wage or salaried jobs. If so, then we collect the typical monthly amount earned by the respondent and, separately, by other household members. Finally, we ask the respondent if they receive remittances from family within Uganda or abroad and if so, then we follow-up with questions about the typical monthly value of remittances.

A.5 Agricultural Assets

Agricultural assets include livestock as well as durables (pangas, axes, hammers, spades, sickles, and ploughs). For each animal or durable that a household owns, we ask how many they own and the average value of one unit. We collect livestock at an aggregate level (current total value of livestock) and through disaggregated categories for each animal, with a follow-up question about which measure of total livestock value is better.

A.6 Business Assets

To construct business assets, we separately ask about the current level of business inventory and other non-inventory business assets (machines or equipment, non-home buildings or land that are primarily for business use, and other capital assets) used in each non-farm business. We sum across all enterprises owned by the household to construct total business assets.

A.7 Land

We ask respondents to report the value of their land, including any dwellings on the land. As with prior categories, we prime the respondent with their previously reported land value and ask whether their land has since increased, decreased, or stayed the same in value. If it has changed, we ask the new value. At the third endline survey only, we add questions to separately capture land purchases, land sales, and land investment, including retrospectively over the entire experimental period.

As discussed in Section 3.2, we find substantial appreciation in land values over time (i.e., across survey waves). To derive the total capital gain in land value over time, we sum land values across all control households in each district d at endline over the sum of the same set of control households' land values at baseline. We allow capital gains (ϕ) to vary by district. We do this for both the first and second endline and adjust the ratios to reflect appreciation solely between midline and each respective endline. Specifically, for control households in a given d district:

$$\phi_d = \left(\frac{\sum_i land_i^e}{\sum_i land_i^b} \right)^{\frac{x}{y}} \tag{10}$$

where $d \in \{Ntungamo, Ibanda, Kagadi\}$, i denotes household, x denotes time in months between midline and the relevant endline, y denotes time in months between baseline and the relevant endline, b specifies baseline, and e specifies the relevant endline (either the first or second). The calculated capital gains rates are listed in Table A.1. We find that land values appreciated at a rate of approximately 2% per month.

Table A.1: **Estimated capital gains by region**

	midline to endline 1 (4 months)	midline to endline 2 (18 months)	average monthly (baseline to endline 2)
Ntungamo	1.084	1.36	1.017
Ibanda	1.079	1.47	1.022
Kagadi	1.078	1.42	1.020
Overall	1.081	1.41	1.019

We then apply these capital gains rates to adjust land values downward, i.e., net of appreciation, such that we can measure the effect of the grants on real land values and such that the cross-equation budget constraint used in the SUR will hold. We construct new capital gains-adjusted land* values for all households in each district d at each endline:

$$land^*_{id} = \left(\frac{1}{\phi_d}\right) land_{id} \tag{11}$$

A.8 Net Credit

For credit, we ask the respondent if they have any loans outstanding and, if so, then the current amount owed. We also ask the same set of questions for loans that the respondent has made to others. We construct net credit as the current outstanding amount that the household owes to others less the current amount others owe to the household. Thus, a positive value of net credit reflects that the respondent owes money on net and a negative value reflects that others owe money to the respondent on net.

B Evidence of GE Effects for Land – For Online Publication Only

The model in Section 2 indicated that risk-loving behavior can be linked to large, indivisible investments, and Section 6 showed that if the investment good is not elastically supplied, the aggregate impacts of financial services can be limited through general equilibrium forces. Given that the empirical results in Section 5 demonstrated that winners of a large lottery have a large propensity to invest winnings in land, and that land price appreciation (2 percent per month) is sizable (Section 3.2), a natural question is whether general equilibrium forces are important for land. That is, does demand for land investment increase the prices of land?

Given the high propensity to purchase land out of large lottery winnings, our randomized experiment generated exogenous variation in the demand for land. We therefore test the impact of the local grant winnings on land values by estimating the impact of more grants being awarded within close proximity to a participant household, using 0.5 and 1 mile radii around the household as measures of proximity. That is, we run the following two-stage least squares model:

$$\Delta LocalLandValue_{id} = \beta_0 + \beta_1 GrantsWithinRadius_i + \gamma X_i + \lambda_d + \varepsilon_{id} \qquad (12)$$

$$HouseholdOwnLandValue_{id} = \beta_0 + \beta_1 \Delta Local\widehat{Land}Value_i + \gamma X_i + \lambda_d + \varepsilon_{id} \qquad (13)$$

Where X_i controls for the (sample) number of households within the radius of interest (0.5 miles or 1 mile), the number of households choosing the large lottery within the radius, whether the household won a grant itself (*won lottery*), whether the household itself chose the large lottery (*risk loving*), the household's own land value at baseline, and the same set of demographic controls included in our main estimating equation (Equation 6). We also include λ_d, district fixed effects, as in our main estimating equation. In this specification, the independent variation in winning a grant is the result of the realization of random draws within the area. The number of grants disbursed within a given radius vary at the household-level, and include only those grants which were given to *surrounding* households within the given radius. We cluster standard errors by the 141 geographic "neighborhoods" used in our census survey (with an average of 7 households per neighborhood).

Table B.1 presents the impact of local grants on local land values. At the first endline, we find that each additional grant within 0.5 miles increases local land values by approximately 6%. The effect is even larger in a 1 mile radius — each additional grant increases values by 7%.[39] While the first stage is a bit weak in the 0.5 mile radius specification with an F-statistic of 3.5, the F-statistic for the one mile specification is 17 (reported in Table B.2). Point estimates are similar at the second endline, and again the F-statistic is stronger in the one mile specification.

[39] The effects are large, but if one unit of land is sold above the status quo price, the values of *all* land may increase correspondingly. Indeed, this indirect impact is precisely our interest. Note also that the impact may also include any increase in local growth from people investing in their businesses.

Table B.1: **Effect of grants disbursed nearby on others' land values nearby (first stage)**

	(1) Ln sum of others' land values within 0.5 mi_{e1}	(2) Ln sum of others' land values within 0.5 mi_{e2}	(3) Ln sum of others' land values within 1 mi_{e1}	(4) Ln sum of others' land values within 1 mi_{e2}
num grants within 0.5 mi	.063*	.066**		
	(.034)	(.031)		
num grants within 1 mi			.072***	.063***
			(.018)	(.017)
num risk lovers within 0.5 mi	.00076	-.023		
	(.04)	(.034)		
num houses within 0.5 mi	.1***	.097***		
	(.024)	(.022)		
num risk lovers within 1 mi			.0077	.0071
			(.022)	(.02)
num houses within 1 mi			.041***	.044***
			(.012)	(.011)
won lottery (0/1)	-.02	-.02	.017	-.019
	(.065)	(.057)	(.048)	(.049)
risk loving (0/1)	-.18**	-.16**	-.045	-.064
	(.078)	(.07)	(.057)	(.058)
district fe's	Yes	Yes	Yes	Yes
demographic controls	Yes	Yes	Yes	Yes
R^2	.45	.47	.55	.55
Control mean (level)	108,967,724	146,208,633	198,887,799	267,238,782
Observations	740	774	764	801

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Standard errors clustered at the neighborhood
Sample size changes due to restriction that land values must be positive, the likelihood of which does not vary by treatment
Conrols include: pre-intervention levels of own land value, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children

In the second stage (Table B.2), we find that a 1% increase in neighboring land values leads to a 0.42% increase in the household's own land values at the first endline and 0.47% increase at the second endline (using the 1 mi radius specification). Given an average of 6.67 grants disbursed within a mile of each house, a household's own land value is 19.7%(=6.67 grants*6.3% increase in local land values per grant*0.47% increase in own land value per 1% increase in local land values) higher at the second endline due to grants disbursed by the experiment, as reported in Section 3.2.

Table B.2: **Effect of others' land values nearby on own land value (second stage)**

	(1) Ln $land_{e1}$	(2) Ln $land_{e2}$	(3) Ln $land_{e1}$	(4) Ln $land_{e2}$
Ln sum of others' land values within 0.5 mi_{e1}	.24			
	(.42)			
Ln sum of others' land values within 0.5 mi_{e2}		.28		
		(.39)		
Ln sum of others' land values within 1 mi_{e1}			.42	
			(.26)	
Ln sum of others' land values within 1 mi_{e2}				.47*
				(.28)
num risk lovers within 0.5 mi	-.019	-.046		
	(.029)	(.034)		
num houses within 0.5 mi	-.035	-.032		
	(.06)	(.055)		
num risk lovers within 1 mi			-.019	-.035*
			(.02)	(.019)
num houses within 1 mi			-.027	-.025
			(.022)	(.023)
won lottery (0/1)	.034	.14**	.0045	.12*
	(.059)	(.058)	(.059)	(.061)
risk loving (0/1)	.057	.18*	.043	.16**
	(.11)	(.094)	(.073)	(.074)
district fe's	Yes	Yes	Yes	Yes
demographic controls	Yes	Yes	Yes	Yes
First stage F-stat	3.5	4.5	17	14
Control mean (level)	18,174,911	17,141,538	18,656,827	22,678,972
Observations	740	774	764	801

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Standard errors clustered at the neighborhood; Sample size changes due to restriction that land values must be positive, the likelihood of which does not vary by treatment; Conrols include: pre-intervention levels of own land value, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children

Hence, we have direct evidence of price increases resulting from the demand for land, indicating that land is not perfectly elastically supplied even in the underbanked, peri- and semi-urban small cities that we study. In the context of our model, this limits the impacts that financial services can have in promoting development and the escape from poverty. Moreover, the emphasis on land as an investment good disproportionately favors savings services relative to credit services toward these ends, since credit had no impact when the investment capital was in fixed supply.

Assuming increases in demand are purely partial equilibrium and so induce true increases in land (i.e., land is not in absolutely fixed supply), we use the estimates in Table 7 to estimate the increase in quantity demanded. We can use this to yield the back-of-the-envelope calculation of an elasticity of the supply of land of 0.05 in the paper. Specifically, we calculate a percentage increase in demand, where the total increase in demand for land is the product of the number of participants (1048), their lottery-choice probabilities (0.27 for the large lottery and 0.73 for the small lottery), the respective probabilities of winning (0.3 and 0.49, respectively), and the increase in land demand as a result of winning, per Column 8 of Table 7 (7.5 million and 300 thousand UGX, respectively). This yields an increase in demand for land of roughly 750 million UGX. Total land demand is the number of households in our original census (3734) times average land holdings in the control of our sample (roughly 21 million UGX), which yields a baseline demand of land of 78 billion. The percentage increase in land demand is therefore close to 1 percent. Dividing this 1% increase in land demand by the 20% yields the reported elasticity of 0.05.

C Predicting Lottery Choice – For Online Publication Only

The following table presents the full set of covariates on which we test for differences between those selecting the large lottery and those selecting the small lottery:

Table C.1: **Characteristics of those choosing the large v. small lottery**

	large	N	small	N	diff	p-value
Income and consumption						
mthly income$_m$	398,608	283	371,090	765	27,518	0.29
mthly income/adult equiv$_m$	122,872	283	126,665	765	-3,793	0.68
total income per hour worked	911	283	910	765	.94	0.99
ln mthly income$_m$	12	283	12	765	-.043	0.73
Δ ln mthly income$_{m\text{-}b}$	.71	283	1.2	765	-.44**	0.02
mthly crop income$_m$	100,208	283	71,148	765	29,061***	0.00
crop income/total income$_m$	.3	283	.25	765	.05***	0.01
mthly crop income/adult equiv$_m$	30,562	283	22,981	765	7,580***	0.00
crop income per hour worked	860	283	696	765	164	0.14
ln mthly crop income$_m$	12	283	12	765	.21***	0.00
Δ ln mthly crop income$_{m\text{-}b}$	-1.5	283	-1.4	765	-.051	0.50
mthly bus income$_m$	125,247	283	119,725	765	5,523	0.68
bus income/total income$_m$	.28	283	.29	765	-.0087	0.79
mthly bus income/adult equiv$_m$	41,641	283	41,745	765	-103	0.98
bus income per hour worked	916	283	1,092	765	-176	0.49
ln mthly bus income$_m$	12	283	12	765	.033	0.54
Δ ln mthly bus income$_{m\text{-}b}$	6.7	283	7.6	765	-.87**	0.02
wkly consumption$_m$	44,466	283	39,453	765	5,013**	0.01
wkly cons/adult equiv$_m$	14,034	283	13,798	765	236	0.77
ln wkly cons$_m$	10	283	10	765	.18**	0.01
Δ ln wkly cons$_{m\text{-}b}$	.38	283	.24	765	.14**	0.03
Savings and wealth						
savings$_m$	322,675	283	275,817	765	46,858*	0.10
savings/adult equiv$_m$	103,375	283	96,393	765	6,982	0.51
ln savings$_m$	10	283	9.8	765	.31	0.35
Δ ln savings$_{m\text{-}b}$	2.5	283	1.7	765	.86**	0.03
bus assets$_m$	824,954	283	577,814	765	247,140**	0.01
bus assets/wealth$_m$	.29	283	.24	765	.053**	0.05
bus assets/adult equiv$_m$	295,958	283	218,673	765	77,285*	0.07
ln bus assets$_m$	5.3	283	4.3	765	.99**	0.03
Δ ln bus assets$_{m\text{-}b}$	.6	283	.23	765	.37	0.22
wealth (sav + bus assets)$_m$	1,245,155	283	920,185	765	324,970***	0.01
wealth/adult equiv$_m$	431,561	283	337,778	765	93,784*	0.07
ln wealth$_m$	11	283	11	765	.65**	0.05
Δ ln wealth$_{m\text{-}b}$	2.2	283	1.5	765	.7**	0.05
net wealth (sav + bus assets - credit)$_m$	1,070,910	283	744,418	765	326,492***	0.01
net wealth/adult equiv$_m$	377,813	283	277,547	765	100,265**	0.05
ln net wealth$_m$	16	283	16	765	.075*	0.06
Δ ln net wealth$_{m\text{-}b}$	-.22	283	-.25	765	.029	0.57
land value$_b$	13,345,159	283	9,852,680	765	3,492,479***	0.00
land value/adult equiv$_b$	3,936,519	283	3,010,483	765	926,036***	0.00
ln land value$_b$	13	283	12	765	.91**	0.04

Other financial indicators						
operates non-farm business$_{\mathrm{m}}$ (0/1)	.59	283	.54	765	.049	0.15
farmer$_{\mathrm{m}}$ (0/1)	.71	283	.75	765	-.041	0.18
work hours per week$_{\mathrm{m}}$	78	283	77	765	.52	0.74
had negative shock since baseline$_{\mathrm{m}}$ (0/1)	.63	283	.67	765	-.046	0.16
has formal savings$_{\mathrm{m}}$ (0/1)	.088	283	.12	765	-.035	0.12
acquired loans since baseline$_{\mathrm{m}}$ (0/1)	.29	283	.32	765	-.035	0.27
credit outstanding$_{\mathrm{m}}$	193,779	283	192,949	765	830	0.98
Desire to invest						
wants credit to increase income$_{\mathrm{b}}$ (0/1)	.84	283	.78	765	.062**	0.03
would invest >100_{\mathrm{b}}$ (0/1)	.95	283	.91	765	.038**	0.04
would use credit for bus investment$_{\mathrm{b}}$ (0/1)	.67	283	.59	765	.073**	0.03
would use credit for ag investment$_{\mathrm{b}}$ (0/1)	.053	283	.08	765	-.027	0.14
Hypothetical preferences						
would invest for 53% exp gain$_{\mathrm{b}}$ (0/1)	.67	283	.64	765	.032	0.33
would invest for 105% exp gain$_{\mathrm{b}}$ (0/1)	.7	283	.67	765	.031	0.34
would invest for 1% mthly interest$_{\mathrm{b}}$ (0/1)	.24	283	.23	765	.0054	0.86
desired mthly interest to invest now$_{\mathrm{b}}$	16	283	16	765	.22	0.88
Demographic characteristics						
female (0/1)	.42	283	.51	765	-.09***	0.01
household head (0/1)	.66	283	.6	765	.058*	0.09
respondent age	37	283	35	765	2.3***	0.00
education beyond primary school (0/1)	.26	283	.29	765	-.026	0.40
num people in household$_{\mathrm{b}}$	5.5	283	5	765	.47***	0.00
num adult females$_{\mathrm{b}}$	1.1	283	1.1	765	-.0095	0.82
num adult males$_{\mathrm{b}}$	1.5	283	1.4	765	.14*	0.08
num children$_{\mathrm{b}}$	2.8	283	2.5	765	.34***	0.00
Observations	1048					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Midline denoted by **m** and baseline denoted by **b**
bus is an abbreviation for business; * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

In table C.2, we analyze the predictors of lottery choice using lasso. Among 160 baseline and midline covariates, the following are selected:

Table C.2: **Predicting those who chose the large lottery: Lasso-selected covariates**

	Penalized coeffient:
total income per hour worked	-.0000192
mthly crop income$_{\mathrm{m}}$	3.59e-07
bus income per hour worked	-3.15e-06
monthly livestock income$_{\mathrm{m}}$	2.16e-08
monthly livestock income$_{\mathrm{b}}$	2.39e-06
mthly wage income$_{\mathrm{m}}$	-5.37e-08
wealth$_{\mathrm{b}}$	1.46e-09
net savings$_{\mathrm{b}}$	-6.09e-08
bus assets$_{\mathrm{b}}$	4.06e-08
wkly consumption$_{\mathrm{b}}$	1.18e-06
farm assets$_{\mathrm{b}}$	2.63e-07
ag assets$_{\mathrm{b}}$	4.37e-08

ln mthly income$_{\text{m}}$	-.0189
ln mthly crop income$_{\text{m}}$	.0255
ln savings$_{\text{b}}$	-.005
Δ ln mthly income$_{\text{m-b}}$	-.00199
Δ ln mthly bus income$_{\text{m-b}}$	-.00236
Δ ln wkly cons$_{\text{m-b}}$	.0387
Δ ln wealth$_{\text{m-b}}$	.00288
mthly crop income/adult equiv$_{\text{b}}$	2.35e-08
farmer$_{\text{m}}$ (0/1)	-.0522
experienced bad event$_{\text{b}}$ (0/1)	-.0534
has formal savings$_{\text{m}}$ (0/1)	-.11
acquired loans since baseline$_{\text{m}}$ (0/1)	-.0311
wants credit to increase income$_{\text{b}}$ (0/1)	.0775
would invest >\$100$_{\text{b}}$ (0/1)	.0787
would use credit for bus investment$_{\text{b}}$ (0/1)	.0169
would use credit for ag investment$_{\text{b}}$ (0/1)	-.0654
female (0/1)	-.0339
respondent age^2	.0000217
num children$_{\text{b}}$	.0146
crop: Irish Potato (0/1)	-.0545
crop: Sweet Potato (0/1)	-.0644
crop: Yam (0/1)	-.451
new crops since baseline$_{\text{m}}$ (0/1)	-.0295
savings place: SACCO (0/1)	-.058
savings place: ROSCA or other cooperative/ community group (0/1)	.104
savings place: In a secret place (0/1)	.0434
bad event: Loss of crop due to disease, etc (0/1)	-.061
bad event: Assets damaged or destroyed (0/1)	.253
bad event: Sickness or injury to family member (0/1)	-.0456
opened a new business since baseline$_{\text{m}}$ (0/1)	-.0294
Observations	1048

The table depicts the unstandardized penalized coefficients of those covariates which were selected from among 160 baseline and midline variables given to lasso. We set the penalty parameter using adaptive lasso. All quantities in UGX. Outliers top/bottom coded to 95th/5th percentile. Midline denoted by **m** and baseline denoted by **b**; **bus** is an abbreviation for business. Full list of covariates which we give to lasso is available on request.

Looking only at demographic characteristics and those financial outcomes which are collected at both baseline and midline, we can compare the variables selected by lasso when predicting midline lottery choice relative to baseline (hypothetical) risk preferences:

Table C.3: **Lasso-selected predictors of midline lottery choice and baseline hypotheticals**

	Midline lottery choice	Baseline: Greater risk preference	Baseline: Moderate risk preference
mthly crop income	3.76e-07		
mthly livestock income	6.82e-07		
mthly wage income	-1.06e-07		
net wealth (sav + bus assets - credit)	6.61e-09		
ln mthly income	-.0245	.00852	.0102
ln mthly crop income	.0227	.000845	

ln wkly consumption$_{\mathrm{m}}$	.019		
ln bus assets$_{\mathrm{b}}$	.00311		
recent negative shock (0/1)	-.0348		
respondent age^2	.00003		-4.03e-06
num children$_{\mathrm{b}}$	.0162		
gender	-.0428	-.0561	-.0779
net savings		3.61e-08	
savings		1.09e-07	1.35e-07
ln savings$_{\mathrm{m}}$		.000706	
mthly income/adult equiv		1.23e-09	
wkly consumption/adult equiv		2.25e-06	5.54e-07
num adult females$_{\mathrm{b}}$		-.00643	
Observations	1048	1048	1048

The table depicts the unstandardized penalized coefficients of those covariates which were selected by lasso from among 39 demographic characteristics and financial outcomes collected at both midline and baseline. We set the penalty parameter using adaptive lasso. All quantities in UGX. Outliers top/bottom coded to 95th/5th percentile. Midline denoted by **m** and baseline denoted by **b**; **bus** is an abbreviation for business. Full list of covariates which we give to lasso is available on request.

D Attrition – For Online Publication Only

We first compare balance on observable characteristics between the retained and attrited sample. We then compute Lee Bounds.

D.1 Balance Between Retained and Attrited Sample

Tables D.1 and D.2 show that observable characteristics are, in general, balanced between the retained versus attrited sample, suggesting that attrition was idiosyncratic.

Table D.1: **Balance between retained and attrited, among those choosing the small lottery**

	chose small retained	N	chose small attrited	N	diff	p-value
Household budget components						
mthly income$_{\mathrm{m}}$	373,736	634	358,289	131	-15,446	0.66
wkly consumption$_{\mathrm{m}}$	39,894	634	37,321	131	-2,573	0.33
savings$_{\mathrm{m}}$	279,172	634	259,580	131	-19,592	0.61
credit outstanding$_{\mathrm{m}}$	194,256	634	186,626	131	-7,630	0.84
home durable value$_{\mathrm{b}}$	504,709	634	583,386	131	78,678	0.32
Investment categories						
total divisible investments$_{\mathrm{m}}$	376,729	634	388,587	131	11,858	0.84
small livestock and ag. assets$_{\mathrm{b}}$	168,910	634	156,534	131	-12,377	0.58
bus inventory$_{\mathrm{m}}$	160,700	634	173,702	131	13,003	0.73
total indivisible investments$_{\mathrm{m}}$	11,175,818	634	10,075,985	131	-1,099,833	0.44
large livestock and ag. assets$_{\mathrm{b}}$	262,088	634	241,527	131	-20,562	0.80
land value$_{\mathrm{b}}$	10,003,707	634	9,121,756	131	-881,951	0.50
bus assets, no stock$_{\mathrm{m}}$	347,215	634	389,267	131	42,053	0.63
Other financial indicators						
operates non-farm business$_{\mathrm{m}}$ (0/1)	.54	634	.53	131	-.013	0.79
farmer$_{\mathrm{m}}$ (0/1)	.76	634	.73	131	-.032	0.44
work hours per week$_{\mathrm{m}}$	77	634	77	131	-.063	0.98
had negative shock since baseline$_{\mathrm{m}}$ (0/1)	.66	634	.73	131	.064	0.15
has formal savings$_{\mathrm{m}}$ (0/1)	.13	634	.099	131	-.029	0.37
acquired loans since baseline$_{\mathrm{m}}$ (0/1)	.33	634	.3	131	-.029	0.52
Demographic characteristics						
female (0/1)	.5	634	.55	131	.051	0.29
household head (0/1)	.6	634	.6	131	-.0087	0.85
respondent age	36	634	32	131	-4.5***	0.00
education beyond primary school (0/1)	.28	634	.33	131	.049	0.26
num people in household$_{\mathrm{b}}$	5	634	4.9	131	-.11	0.63
num adult females$_{\mathrm{b}}$	1.1	634	1.2	131	.029	0.59
num adult males$_{\mathrm{b}}$	1.4	634	1.3	131	-.13	0.20
num children$_{\mathrm{b}}$	2.5	634	2.5	131	-.00072	1.00
Observations	765					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Midline denoted by **m** and baseline denoted by **b** **bus** is an abbreviation for business; * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table D.2: **Balance between retained and attrited, among those choosing the large lottery**

	chose large retained	N	chose large attrited	N	diff	p-value
Household budget components						
mthly income$_{m}$	392,511	233	427,022	50	34,511	0.56
wkly consumption$_{m}$	44,677	233	43,485	50	-1,192	0.80
savings$_{m}$	304,584	233	406,980	50	102,396	0.11
credit outstanding$_{m}$	193,386	233	195,612	50	2,226	0.97
home durable value$_{b}$	722,479	233	564,394	50	-158,085	0.28
Investment categories						
total divisible investments$_{m}$	516,826	233	486,620	50	-30,206	0.79
small livestock and ag. assets$_{b}$	197,858	233	161,140	50	-36,718	0.36
bus inventory$_{m}$	233,197	233	234,000	50	803	0.99
total indivisible investments$_{m}$	16,022,090	233	13,242,000	50	-2,780,090	0.30
large livestock and ag. assets$_{b}$	614,914	233	537,000	50	-77,914	0.71
land value$_{b}$	13,724,807	233	11,576,000	50	-2,148,807	0.38
bus assets, no stock$_{m}$	511,661	233	502,800	50	-8,861	0.96
Other financial indicators						
operates non-farm business$_{m}$ (0/1)	.61	233	.48	50	-.13*	0.09
farmer$_{m}$ (0/1)	.72	233	.68	50	-.037	0.60
work hours per week$_{m}$	77	233	80	50	2.9	0.44
had negative shock since baseline$_{m}$ (0/1)	.63	233	.62	50	-.0066	0.93
has formal savings$_{m}$ (0/1)	.082	233	.12	50	.038	0.39
acquired loans since baseline$_{m}$ (0/1)	.3	233	.24	50	-.056	0.43
Demographic characteristics						
female (0/1)	.42	233	.42	50	.0037	0.96
household head (0/1)	.66	233	.66	50	-.00094	0.99
respondent age	38	233	36	50	-1.4	0.45
education beyond primary school (0/1)	.26	233	.28	50	.022	0.74
num people in household$_{b}$	5.4	233	5.6	50	.23	0.56
num adult females$_{b}$	1.1	233	1.2	50	.08	0.42
num adult males$_{b}$	1.5	233	1.6	50	.12	0.53
num children$_{b}$	2.8	233	2.8	50	.03	0.92
Observations	283					

All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Midline denoted by **m** and baseline denoted by **b** **bus** is an abbreviation for business; * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

D.2 Lee Bounds

We compute Lee Bounds (Lee, 2009) around the estimates in Tables 8, 10, and 12 (which also include the aggregate investment categories from Tables 6 and 7).

Table D.3: **Grant effects on components of the household budget constraint - First endline - Lee Bounds**

	(1) consum. (stock) wkly cons + home dur.	(2) savings	(3) div. investment	(4) indiv. investment*	(5) mthly income	(6) net credit
Lower bound:						
won lottery (0/1)	-148,151*	-54,110**	3,195	-2,375,215***	-62,680***	-70,405***
	(79,287)	(24,149)	(52,218)	(827,145)	(18,032)	(14,329)
won large lottery (0/1)	47,319	141,160**	187,413	5,111,855***	33,697	-19,604
	(154,848)	(61,070)	(138,772)	(1,811,346)	(35,939)	(32,414)
risk loving (0/1)	115,939	6,530	90,432	-1,886,169*	-3,501	2,400
	(108,737)	(35,059)	(76,377)	(963,842)	(26,011)	(22,577)
$\beta_1 + \beta_2$	-100,832	87,050	190,607	2,736,640	-28,983	-90,009
P-value: $\beta_1 + \beta_2 = 0$	0.45	0.12	0.14	0.08	0.35	0.00
Observations	830	830	830	830	830	830
Upper bound:						
won lottery (0/1)	209,641**	79,795**	253,603***	-483,214	6,398	24,335
	(93,427)	(31,801)	(63,307)	(942,183)	(20,738)	(18,058)
won large lottery (0/1)	-31,805	109,859	117,423	5,270,092**	46,522	-28,324
	(183,444)	(72,806)	(158,359)	(2,072,590)	(45,486)	(39,899)
risk loving (0/1)	112,830	12,760	79,779	-2,284,135**	-4,461	-1,839
	(109,195)	(35,447)	(75,989)	(967,924)	(25,969)	(22,542)
$\beta_1 + \beta_2$	177,836	189,654	371,026	4,786,878	52,920	-3,989
P-value: $\beta_1 + \beta_2 = 0$	0.26	0.00	0.01	0.01	0.19	0.91
Observations	830	830	830	830	830	830
Control mean if risk loving = 0	1,608,566	259,468	613,887	15,232,971	327,076	73,180
Control mean if risk loving = 1	1,798,491	271,428	787,251	17,160,718	321,271	80,220

This table constructs Lee Bounds around the point estimates reported in Table 8. All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses. *Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time. All specifications include the following controls: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's. * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table D.4: **Grant effects on components of the household budget constraint - Second endline - Lee Bounds**

	(1) consum. (stock) wkly cons + home dur.	(2) savings	(3) div. investment	(4) indiv. investment*	(5) mthly income	(6) net credit
Lower bound:						
won lottery (0/1)	-407,772*	-67,797***	-117,762**	-2,562,868***	-45,320***	-102,605***
	(223,057)	(25,823)	(50,527)	(890,014)	(16,049)	(19,489)
won large lottery (0/1)	602,600	117,276*	57,066	5,285,826**	32,263	22,405
	(428,585)	(61,291)	(133,424)	(2,190,759)	(38,779)	(42,613)
risk loving (0/1)	192,877	2,274	98,264	-531,663	24,512	-43,127
	(294,575)	(38,317)	(76,822)	(1,218,042)	(23,907)	(30,008)
$\beta_1 + \beta_2$	194,827	49,479	-60,696	2,722,958	-13,057	-80,200
P-value: $\beta_1 + \beta_2 = 0$	0.59	0.38	0.62	0.17	0.71	0.03
Observations	830	830	830	830	830	830
Upper bound:						
won lottery (0/1)	572,033**	76,330**	113,912*	1,041,810	30,941	13,321
	(257,861)	(34,248)	(62,345)	(1,097,676)	(19,623)	(24,035)
won large lottery (0/1)	356,270	72,817	-12,360	4,969,695*	15,901	12,530
	(489,459)	(73,488)	(144,195)	(2,642,252)	(43,465)	(52,184)
risk loving (0/1)	161,890	2,165	88,106	-910,770	27,702	-45,812
	(295,049)	(38,354)	(76,570)	(1,221,176)	(24,130)	(30,347)
$\beta_1 + \beta_2$	928,303	149,147	101,551	6,011,505	46,842	25,852
P-value: $\beta_1 + \beta_2 = 0$	0.03	0.02	0.43	0.01	0.22	0.58
Observations	830	830	830	830	830	830
Control mean if risk loving = 0	4,603,540	273,166	596,244	15,040,343	264,233	119,272
Control mean if risk loving = 1	5,036,368	279,987	776,076	17,326,575	289,215	76,352

This table constructs Lee Bounds around the point estimates reported in Table 10. All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses. *Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time. All specifications include the following controls: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's. * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table D.5: **Grant effects on components of the household budget constraint - Third endline - Lee Bounds**

	(1) weekly consumption	(2) home durables	(3) savings	(4) div. investment	(5) indiv. investment*	(6) mthly income
Lower bound:						
won lottery (0/1)	-12,834***	-337,951***	-165,523***	-296,537***	-2,954,864***	-100,943***
	(3,851)	(103,943)	(43,192)	(100,895)	(924,806)	(25,422)
won large lottery (0/1)	16,089**	-52,630	24,113	-23,768	156,257	129,368**
	(8,164)	(204,292)	(116,581)	(228,185)	(1,979,303)	(56,376)
risk loving (0/1)	5,015	61,534	182,096**	170,976	3,100,868**	-38,952
	(5,493)	(151,073)	(75,649)	(157,704)	(1,478,582)	(33,238)
$\beta_1 + \beta_2$	3,255	-390,581	-141,410	-320,305	-2,798,607	28,425
P-value: $\beta_1 + \beta_2 = 0$	0.65	0.03	0.20	0.12	0.11	0.57
Observations	807	807	807	807	807	807
Upper bound:						
won lottery (0/1)	4,093	66,252	56,236	130,791	1,270,593	-2,419
	(4,467)	(122,693)	(58,217)	(126,066)	(1,186,374)	(29,730)
won large lottery (0/1)	16,250*	-91,180	44,394	88,252	771,684	150,179**
	(9,022)	(242,751)	(144,561)	(287,047)	(2,556,211)	(66,362)
risk loving (0/1)	4,294	88,558	172,680**	186,672	2,974,328**	-32,484
	(5,539)	(151,965)	(76,191)	(157,743)	(1,488,632)	(33,246)
$\beta_1 + \beta_2$	20,343	-24,929	100,630	219,042	2,042,277	147,760
P-value: $\beta_1 + \beta_2 = 0$	0.01	0.91	0.45	0.40	0.37	0.01
Observations	807	807	807	807	807	807
Control mean if risk loving = 0	74,243	1,176,056	452,420	1,064,878	14,388,904	388,771
Control mean if risk loving = 1	81,032	1,304,103	633,123	1,258,952	18,360,600	355,319

This table constructs Lee Bounds around the point estimates reported in Table 12. All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses. *Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time. All specifications include the following controls: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's. * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

E Multiple Hypothesis Corrections – For Online Publication Only

We apply multiple hypothesis corrections to the estimates in Tables 8, 10, and 12 (which also include the aggregate investment categories from Tables 6 and 7). Specifically, we estimate False Discovery Rate (FDR) sharpened q-values, per Anderson (2008), and apply one penalty at each endline across the six household budget categories on which we test for an effect of the small and large lottery. We separately penalize the set of hypotheses concerning the effect of winning the small lottery and the effect of the large lottery.

Table E.1: **Grant effects on components of the household budget constraint - First endline - Multiple hypothesis corrections**

	(1) consum. (stock) wkly cons + home dur.	(2) savings	(3) div. investment	(4) indiv. investment*	(5) mthly income	(6) net credit
won lottery (0/1)	121,277	57,204*	190,956***	-721,095	-8,344	-7,054
	(0.18)	(0.06)	(0.00)	(0.43)	(0.68)	(0.70)
	[0.32]	[0.18]	[0.00]	[0.56]	[0.56]	[0.70]
won large lottery (0/1)	-18,497	107,836	127,754	5,016,354**	38,551	-23,513
	(0.92)	(0.12)	(0.40)	(0.01)	(0.38)	(0.56)
risk loving (0/1)	110,406	12,933	76,005	-2,326,259**	-4,074	-788
	(0.31)	(0.71)	(0.32)	(0.02)	(0.88)	(0.97)
$\beta_1 + \beta_2$	102,781	165,040	318,710	4,295,259	30,207	-30,567
P-value: $\beta_1 + \beta_2 = 0$	.5	.0082	.02	.013	.44	.39
FDR sharpened q-value: $\beta_1 + \beta_2 = 0$	.33	.041	.041	.041	.33	.33
Control mean if risk loving = 0	1,608,566	259,468	613,887	15,232,971	327,076	73,180
Control mean if risk loving = 1	1,798,491	271,428	787,251	17,160,718	321,271	80,220
R^2	.29	.3	.41	.71	.42	.093
Observations	867	867	867	867	867	867

This table includes p-values in parentheses and FDR sharpened q-values in square brackets, corresponding to the point estimates in Table 8. All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses. *Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time. All specifications include the following controls: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's. * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table E.2: **Grant effects on components of the household budget constraint - Second endline - Multiple hypothesis corrections**

	(1) consum. (stock) wkly cons + home dur.	(2) savings	(3) div. investment	(4) indiv. investment*	(5) mthly income	(6) net credit
won lottery (0/1)	294,543	48,839	69,303	506,277	16,240	-20,703
	(0.24)	(0.14)	(0.25)	(0.63)	(0.39)	(0.39)
	[.88]	[.88]	[.88]	[.88]	[.88]	[.88]
won large lottery (0/1)	386,636	84,891	-27,480	4,770,034*	7,896	8,687
	(0.41)	(0.23)	(0.84)	(0.06)	(0.85)	(0.87)
risk loving (0/1)	157,957	3,760	86,905	-1,002,692	27,946	-44,824
	(0.59)	(0.92)	(0.26)	(0.41)	(0.25)	(0.14)
$\beta_1 + \beta_2$	681,180	133,730	41,822	5,276,311	24,136	-12,016
P-value: $\beta_1 + \beta_2 = 0$	.091	.033	.74	.02	.51	.79
FDR sharpened q-value: $\beta_1 + \beta_2 = 0$	.14	.11	.65	.11	.62	.65
Control mean if risk loving = 0	4,603,540	273,166	596,244	15,040,343	264,233	119,272
Control mean if risk loving = 1	5,036,368	279,987	776,076	17,326,575	289,215	76,352
R^2	.28	.23	.32	.51	.29	.069
Observations	867	867	867	867	867	867

This table includes p-values in parentheses and FDR sharpened q-values in square brackets, corresponding to the point estimates in Table 10. All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses. *Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time. All specifications include the following controls: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's. * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

Table E.3: **Grant effects on components of the household budget constraint - Third endline - Multiple hypothesis corrections**

	(1) weekly consumption	(2) home durables	(3) savings	(4) div. investment	(5) indiv. investment*	(6) mthly income
won lottery (0/1)	-818	-2,455	19,243	15,687	570,089	-15,468
	(0.85)	(0.98)	(0.73)	(0.89)	(0.60)	(0.59)
	[1]	[1]	[1]	[1]	[1]	[1]
won large lottery (0/1)	13,470	-80,403	32,624	16,592	-563,232	129,367**
	(0.14)	(0.72)	(0.81)	(0.95)	(0.81)	(0.04)
risk loving (0/1)	4,318	14,317	175,644**	95,343	2,127,393	-34,305
	(0.44)	(0.92)	(0.02)	(0.52)	(0.13)	(0.29)
$\beta_1 + \beta_2$	12,652	-82,858	51,867	32,280	6,857	113,900
P-value: $\beta_1 + \beta_2 = 0$	.12	.67	.69	.89	1	.042
FDR sharpened q-value: $\beta_1 + \beta_2 = 0$	.43	1	1	1	1	.34
Control mean if risk loving = 0	74,243	1,176,056	452,420	1,064,878	14,388,904	388,771
Control mean if risk loving = 1	81,032	1,304,103	633,123	1,258,952	18,360,600	355,319
R^2	.13	.18	.12	.18	.33	.18
Observations	838	838	838	838	838	838

This table includes p-values in parentheses and FDR sharpened q-values in square brackets, corresponding to the point estimates in Table 12. All quantities in UGX; Outliers top/bottom coded to 95th/5th percentile; Heteroskedasticity-robust standard errors in parantheses. *Total indivisible investment includes real land values, adjusted down to exclude appreciation in land values over time. All specifications include the following controls: pre-treatment levels of outcome, hh income, patience, gender, hh head, age, age^2, num ad females, num ad males, num children, district FE's. * $p < 0.1$, ** $p < .05$, *** $p < 0.01$

F Description of Grant Purchases – For Online Publication Only

The following table combines first and second endline data to report grant use for as many respondents as we were able to re-survey: when respondents were surveyed at both endlines, we take the grant use reported at second endline, allowing for the most recent update on spending. Many respondents purchased multiple different items with the grants, but these tables reflect mutually exclusive categories, where we depict the single item on which they spent the greatest fraction of their grant funds:

Table F.1: **Lottery winner grant uses**

	Percent among large lottery recipients	Percent among small lottery recipients
Purchased land	32	6
Business inventory	18	20
Land/building improvements (includes irrigation, solar, and iron roofs)	14	9
Business durables (includes vehicles for business use)	10	6
Small livestock	5	21
Cattle	5	2
School fees	4	9
Household durables (non-vehicle)	4	4
Savings	3	2
Hospital or funeral fees	3	2
Paid down debt	1	2
Farming inputs	1	6
Hired labor	1	0
Farming equipment	0	4
Regular consumption (food, transportation, precautionary health)	0	2
Rented land	0	2
Lost/stolen/did not receive	0	1
Vehicle (not for business)	0	1
Lended out	0	0
Total:	100	100

Besides land purchases, some commonly cited specific examples of purchases made with the grants (both large and small) include:

- Goats, pigs, and chickens
- Coffee seedlings / coffee plants
- Water tank / irrigation drum (for collecting rainwater)
- Iron sheets (as a roof material)
- Solar panels and batteries
- Motorcycle or bicycle, often for delivery
- Inventory for retail, such as soap, salt, and coffee

G Model Validation Regressions – For Online Publication Only

In this Appendix, we evaluate the model's ability to rationalize and reproduce our key empirical finding on the impact of lottery winnings. Specifically, we ask whether, first, the model replicates the fact that winners of the large lottery make large, indivisible investments and even in excess of their winnings. Furthermore, we ask whether our use of the SUR cross-equation budget constraints can be justified through the lens of the model.

Clearly, there are other empirical findings along which the parsimonious model is limited. We note two important examples of limitations. First, with only one investment good, the indivisible good which we will interpret as land, the model cannot replicate the investment in agricultural and business assets that small lottery winnings yield. Second, in the data capital gains appear to be an important return to investment in land, but in the model the returns to the indivisible investment are through realized income. Realized income leads to higher levels of both savings and consumption. Hence, we focus on capital investment in the model and compare it to land investment in the data.

To do so, we generate 500 samples of individual simulations from the ergodic distribution in model. These samples are identical in size to our empirical sample, 867 agents, and we have the full series of simulated monthly data for consumption, savings, income, and capital investment, with 16 months between baseline and midline. At midline, we simulate lotteries with lottery choice proportions and lottery winning proportions matching the field experiment via construction. We then simulate 4 months between midline and first endline, and 18 months between midline and second endline to again match the empirics.

Using these simulated data, we run Monte Carlo regressions analagous to those in Equation 6, with slight necessary modifications given the model. First, with only one capital good, we have only a single investment outcome (rather than agricultural investment, business investment, and land as separate outcomes). We focus on land investment as the empirical comparison, since business investment and agricultural investment are less discrete.[40] Second, we have no demographic controls other than age and age^2, and no geographic controls. Third, in the application of the cross-equation restriction (Equation 7, for our SUR regressions with cross-equation restrictions), we omit borrowing, which is zero by assumption.

Finally, in constructing our income and consumption outcomes, we distinguish between the true measure in the budget constraint (which we call "True Values"), an approach that more closely mirrors our empirics ("Empirical Proxy"), and an approach which introduces true measurement bias into the data used ("Biased Measurement"). "True Values" constructs income and consumption as sums of the full series between midline and (first) endline. "Empirical Proxy" constructs them as we do in the empirics, using the endline value multiplied by the number of months between midline and endline.[41] The point of "Empirical Proxy" is that

[40]Other work has emphasized the indivisibility or minimum scale of livestock that can lead to poverty traps, e.g., Balboni et al. (2022); Barrett et al. (2019).

[41]For consumption, we multiply endline values times the number of months *minus one* and then add consumption from the month directly after the midline. The empirics combines the past week's consumption with durable purchases since midline. Since these durables are likely purchased upon receiving winnings, we choose this as the closest analog because immediate consumption after winnings is generally highest.

our measurement at a point in time automatically introduces some deviation from the budget constraint.

Lastly, we account for two features of the empirical data not present in the model. First, the model has only one value for capital (land) investment and so, the precision of the estimates is quite high. In the empirical data, land purchases are of varied size and also likely reflect considerable measurement error. Second, expenditures may suffer not only from classical measurement error but actual bias. To mimic this, we consider multiplicative measurement error, multiplying land realizations in the simulated data by the random variable, $X = \tilde{X}\mu_e$, where $\tilde{X}$ is a log-normally distributed random variable with mean of one and log variance of ν_e^2. Here $\nu_e = 1.95$ is calibrated to match the average standard error on the coefficient for winning the large lottery to our empirical standard error. The coefficient $\mu_e = 2.2$ captures the bias in measurement and its value is calibrated to equal the average ratio of expenditures to income in the pre-experimental data, much of which may reflect overstatement of land values as discussed in Section 5.3. We call this alternative set of simulated data "Measurement Error".

Table G.1 presents a summary of the results of these regressions on simulated data focusing on the investment outcome and comparing those to the empirical estimates for indivisible investment in Column (4) of Table 8. The top panel presents results for the estimates of the impacts of winning the (small) lottery. In the first two columns, we see that across all estimation techniques the mean coefficients average small positive numbers, but the mean standard errors dwarf the mean coefficients. Using the Measurement Error data, standard errors on the OLS coefficient is comparable to that in the empirics (847,510 vs. 906,426). Looking at the SUR budget constraint, we see that the mean p-value for rejecting the constraint on winning the small lottery are high, and it is rejected in roughly 5% of the samples.

The lower panel shows results for the incremental impacts of winning the large lottery on indivisible investment, which are of greater interest. The model is able to generate the surprisingly large coefficients on winning the large lottery that (based on point estimates) indicate that the additional expenditures on indivisible investment actually exceed the incremental grant winnings of 1,350,000 UGX. Using the True Values, the estimated coefficients average roughly 2,000,000 with very small standard errors (11,837).[42] These values are actually somewhat above the confidence bands of the SUR estimate in Table 9 of 1,247,456 (standard error: 277,484). Moreover, the SUR estimation for the True Values yields high average p-values and the budget constraint is rarely rejected. Using the SUR on the Empirical Proxy, the average coefficient is virtually identical.[43] However, the average p-value of the SUR budget constraint is 0.16 for those winning the large lottery, and the constraint is rejected in 54% of the regressions. Finally, we turn to the Measurement Error regressions. By construction, the average OLS standard error in the estimates equals the empirical value of roughly 1,950,000. The estimated coefficients are much larger with the biased measurement error, averaging roughly 4,100,000 in the simulations, which compares well with the roughly 5,000,000 in the empirics, especially given the large standard errors. Focusing now on the SUR estimates for the Measurement Error data,

[42]For all estimations and simulated data, the realized 95% confidence intervals for the distributions of the estimated coefficients closely reflect those expected by the standard errors of the coefficients.

[43]We omit OLS for the Empirical Proxy, since it only changes consumption.

we see that applying the SUR budget constraint yields coefficients close to the true coefficient in the model of just over 2,100,000 and with a much smaller average standard error of roughly 210,000. These patterns mimic those in the actual data. Indeed, this coefficient in the empirics is statistically indistinguishable, roughly 1,200,000 with a standard error of about 300,000. The p-values on the large constraint average 0.29, but the constraint is again rejected more often (in 13% of the samples).

Together, these estimates show the usefulness of the SUR in a situation where biased measurement error can lead to unreasonably large estimates. As argued in the empirics, the SUR returns reasonable estimates (true to the actual estimates) and smaller standard errors.

Table G.1: **Model-Simulated Monte Carlo Regressions**

	Won Small Lottery			
			SUR Budget Constraint	
Simulated Data, Estimation	Mean Investment Coefficient	Mean Standard Error	Mean p-Value	Rejected at 5%
True Values, OLS	3,591	5,478	.	.
True Values, SUR	3,578	5,651	0.56	0.04
Empirical Proxy,† SUR	3,617	5,639	0.50	0.05
Measurement Error,†† OLS	391,660	898,616	.	.
Measurement Error,†† SUR	-2,836	97,935	0.48	0.04
	Won Large Lottery			
True Values, OLS	2,030,588	11,837	.	.
True Values, SUR	2,030,840	12,208	0.73	0.01
Empirical Proxy,† SUR	2,030,997	12,185	0.16	0.54
Measurement Error,†† OLS	4,073,000	*1,944,900*	.	.
Measurement Error,†† SUR	2,100,600	211,784	0.29	0.13

The natural empirical analogs are the estimates from indivisible investment equation in Tables 8 (OLS) and 9 (SUR). The coefficients coefficients for winning the (small) lottery are -721,095 (standard error: 906,426) and -78,531 (132,562) for the OLS and SUR estimations, respectively. The coefficients for additionally winning the large lottery are 5,016,354 (1,965,752) and 1,247,456 (277,484) for the OLS and SUR estimations, respectively.

† Empirical Proxy data constructs total consumption between endline and midline by multiplying the value of endline consumption times the number of months minus one and adding consumption from the month directly after the midline as we do to construct consumption in the empirics. OLS estimates are omitted since, for investment, they are identical to True Values, OLS.

†† Measurement Error data multiplies simulated land realizations by the random variable, $X = \tilde{X}\mu_e$, where $\tilde{X}$ is a log-normally distributed random variable with mean of one and log variance of ν_e^2. Here $\nu_e = 1.95$ is calibrated to match the average standard error on the coefficient for winning the large lottery to our empirical standard error in Table 8 (i.e., 1,965,752). This matching value is italicized. The coefficient $mu_e = 2.2$ captures the bias in measurement and its value is calibrated to equal the average ratio of expenditures to income in the pre-experimental data.