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Investment Behavior of Ugandan Smallholder Farmers: An Experimental Analysis

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Abstract

In this study, we experimentally analyze the investment behavior of smallholder farmers in Uganda. We consider a problem of optimal stopping, stylizing an option to invest in a project. We ascertain whether, and to what extent, the real options approach and the classical investment theory can predict farmers' investment behaviors. We also examine differences in the investment behavior with respect to the presence of a price floor, which is often used to stimulate investments. Furthermore, we look at learning effects. Our results show that both theories do not exactly explain the observed investment behavior. However, our results suggest that real options models better predict the decision behavior of farmers than the classical investment theory. The presence of a price floor and learning from personal experience during the experiment do not significantly affect the investment behavior. However, we find that specific socio-demographic and socio-economic characteristics affect the investment behavior of farmers.

Keywords: experimental economics, investment, price floors, real options, Uganda

JEL codes: C91, D03, D81, D92

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1. Introduction

Investment decisions affect a household's income and consumption patterns in the long term, particularly poor farm households in developing countries (Hill, 2010a). Almost every important economic farm decision is constrained by uncertainty over future returns stemming from the risks associated with price fluctuations, crop and livestock diseases, or adverse weather conditions. In this regard, it can be observed that decision makers are often reluctant to invest. Examples of such inertia have been reported in the literature and include the adoption of new technologies (Kabunga et al., 2012), selection of perennial crop varieties (Hill, 2010a), investment in conservation intervention (Winter-Nelson and Amegbeto, 1998), and crop insurance markets (Hill and Viceisza, 2012).

In order to stimulate investments, agricultural policies frequently use price floors, which ensure a price above a certain limit (Foltz, 2004; Kim et al., 1992; Sckokai and Moro, 2009). Price floors have also been used in the agricultural sector to assure supply security for certain commodities. For example, Holt (1994), Holt and Johnson (1989), and Shonkwiler and Maddala (1985) find that price floors have contributed to stabilizing prices for agricultural commodities and raising farm income. However, there are some studies that doubt the effectiveness of a minimum price (e.g., Dixit and Pindyck, 1994). In some cases, it can be observed that price floors do not have a stimulating effect on investment (Maart-Noelck et al., 2012; Patlolla et al., 2012).

In the extant literature, several reasons have been offered to explain farmers' slow response to changed framework conditions, including economic and sociological factors, such as financial constraints (Moser and Barrett, 2006), risk aversion (Knight et al., 2003), and non-monetary goals of the decision maker (Musshoff and Hirschauer, 2008). The real options approach (ROA) - also known as the new investment theory - has been discussed as a possible alternative or an additional explanation for economic inertia (Abel and Eberly, 1994; Dixit and Pindyck, 1994; Purvis et al., 1995). The ROA evaluates uncertainty, temporal flexibility, and irreversibility in investment decision making and generates results that can be different from the classical investment theory. The ROA states that an investor may increase profits by deferring an irreversible investment decision rather than realizing the investment immediately, even if the expected net present value (NPV) is positive. The main idea is that an investment decision can be treated as the exercising of an option. That means that an investor has the option to invest now or defer the decision to a later date after more information is known about uncertain future prospects. The option to postpone a decision in order to adapt to changing conditions becomes quite valuable for an investor, especially when future returns of an investment are uncertain. The existence of option values may be one explanatory factor of reluctance often observed in investment decisions.

Specifically, this study focuses on smallholder coffee farmers in rural Uganda, a setting in which the importance of uncertainty in influencing economic behavior of poor households has been documented. For example, Hill (2010a) empirically examines the investment and abandonment behavior of poor rural households using field data. The author considers the decision of Ugandan coffee-farming households to invest in or to abandon coffee trees, a high risk but high return activity due to price volatility and the trees' susceptibility to disease. Hill (2010b) notes the possibility that by affording some minimum price guarantee, price insurance would encourage coffee farmers to invest more household resources in coffee production.

Our study is inspired by previous and current research on normative and econometric analyses of investment problems using the ROA. Normative applications of the real options theory to agricultural investment decisions include among others Khanna et al. (2000) and Luong and Tauer (2006). However, these applications merely indicate the explanatory potential of the ROA for observed economic inertia. Some studies provide empirical evidence for the validity of the ROA using econometric approaches based on field data, such as Hill (2010a), Richards and Green (2003), and Wossink and Gardebroek (2006). Unfortunately, an econometric validation of theoretical models explaining investment behavior, such as the ROA, is difficult for several reasons. For instance, the results of the ROA usually refer to investment triggers, which are not directly observable. Furthermore, besides options effects, risk aversion or financial constraints may cause farmers' reluctance to invest and the various effects are difficult to disentangle. Experimental methods are a natural way to overcome these difficulties. A fundamental difference of experimental methods to econometrical analyses based on field data is that investigators can observe individuals' actual decision behavior in a controlled environment. Experimental methods allow them to study the question of interest more precisely by controlling extraneous factors which may affect individual behavior, and thus improves internal validity (Harrison and List, 2004; Roe and Just, 2009).

The use of experimental methods in investigating the ROA is growing. Rauchs and Willinger (1996) were among the first in testing the irreversibility effect of real options in an experimental setting with students. They investigate how increased expected information affects participants' investment choices and show that decision makers choose a more flexible current option when anticipating more information. Yavas and Sirmans (2005) carry out a laboratory experiment with students and find that participants invest earlier than predicted by the ROA and thus fail to recognize the benefit of the option to wait. However, their willingness to pay for an investment included an option value when they had to compete with other investors. Another real options investment experiment with students was conducted by Oprea et al. (2009) who focused on learning effects of participants. Their research revealed that participants can learn from personal experience to closely approximate optimal exercise of wait options. The study closest to ours is Maart-Noelck and Musshoff (2013) who experimentally examine the decision behavior of German farmers in an agricultural and non-agricultural investment situation, but the study does not focus on policy impact analysis. They find that the timing of investments is not exactly predictable with the ROA or with the NPV but lies between both benchmarks. All of these studies consider investment decisions of decision makers, including convenience groups (e.g., students) and real decision makers (e.g., farmers) in developed countries but no real decision makers in a developing country. However, this is of particular interest because it is not possible to simply apply the results of experiments investigating the investment behavior of individuals in developed countries to individuals in developing countries, given the complexity of the ROA and the different level of education in developing countries.

The main objective of this paper is to experimentally investigate the investment behavior of smallholder farmers while trying to determine the underlying models of investment consistent with actual decision behavior. First, we ascertain whether, and to what extent, the real options theory and the NPV criterion can predict farmers' investment behavior. Second, we investigate whether the presence of a price floor has an effect on farmers' investment behavior. Third, we examine the effect of personal experience during the experiment and specific socio-demographic and socio-economic characteristics on farmers' decision behavior. In addition, we carry out a lottery-choice experiment based on Holt and Laury (2002) to elicit farmers' risk attitudes, as an individuals' risk attitude is of great relevance for decision making under uncertainty (Koundouri et al. 2006; Liu and Huang, 2013). To achieve these objectives we combine data generated from investment and lottery-choice experiments with comprehensive household survey data which were collected in Uganda from July to August 2012. By examining the investment behavior of smallholder farmers in Uganda, we gain some understanding of the dynamics of how uncertainty affects economic behavior in the context of a developing country.

This paper contributes to the extant literature by addressing the following three aspects: First, to the best of our knowledge, it is the first experimental contribution using models of irreversible investment under uncertainty to analyze the investment behavior of farmers in a developing country. This allows us to observe the effects of uncertainty, irreversibility, and the option to wait on an individual's investment decision under controlled conditions compared to an econometric analysis of field data. Second, the effect of a price floor on investment behavior has not yet been analyzed experimentally in a developing country. This understanding might be valuable to support and tailor agricultural policies aimed at inducing changes in investment conditions as one can observe investment decisions with and without a price floor. Third, individual risk propensity of farmers in a developing country is measured to determine the normative benchmark for the investment decision. Therefore, we adapt the method used in Holt and Laury (2002) to measure risk attitudes of people with a limited level of education. From a policy maker's perspective, it is imperative to understand farmers' investment behavior in order to gain insight into the dynamics of how uncertainty affects decision behavior and to predict this behavior in the future in order to design policies that will enable poor smallholder farmers to improve their incomes and welfare.

The remainder of this paper is structured as follows: Section 2 presents the relevant literature from which the research hypotheses are derived. In section 3, we explain the design of the experiments. The sampling procedure, incentive design, and the experimental implementation are described in detail in section 4. In section 5, we describe the calculation of the normative benchmarks and the approach to data analysis. We present and discuss our results in section 6, and lastly, section 7 concludes this paper.

2. Theory and hypotheses

In accordance with the classical investment theory, a decision maker should realize an investment if the investment costs are covered by the present value of the investment returns, that is, if its NPV is positive (Jorgenson, 1963; Tobin, 1969). In contrast to the NPV, the ROA does not imply an 'either now-or-never' investment decision and argues that it might not be optimal to invest immediately even if the NPV is positive. In reality, many investment decisions are characterized by uncertainty regarding future returns, temporal flexibility, and some degree of irreversibility. The ROA addresses these aspects of an investment decision by valuing the option to invest now compared with investing at a later stage. The value of an investment option is called 'option value' and consists of the intrinsic value and the value of waiting (Trigeorgis, 1996, p. 124). According to the ROA, the expected investment returns do not only have to cover the investment costs but also the opportunity costs or the profit that could be realized if the investment is postponed; that is, the investment trigger is shifted upwards (Abel and Eberly, 1994; Dixit and Pindyck, 1994; Pindyck, 1991).

In the following, we describe the investment decision as a simple optimal stopping problem and assume a risk-neutral decision maker. We choose a discrete time framework. The investment can be implemented once, either immediately or it can be postponed up to one period. The investment cost I = 10,000 needs to be paid immediately when one decides to invest. The present value of investment returns in period 0 is V_0 = 10,000. The future development of the present values of the investment returns, which is paid out one period after implementation, is uncertain and follows a binomial arithmetic Brownian motion (Dixit and Pindyck, 1994, p. 68), i.e. starting from V_0 in period 0, the present value in period 1 will either increase by a value h = 2,000 with probability p = 0.5 or decrease by h with probability $1 - p$. In period 2 the present value can take the values $V_0 + 2 \cdot h$ with probability p^2; $V_0 - 2 \cdot h$ with probability $(1 - p)^2$; and V_0 with probability $2 \cdot p \cdot (1 - p)$. According to the NPV the value of the investment $\hat{F}$ equals:

$$\hat{F} = max\left[\hat{E}(NPV_0); 0\right], \tag{1}$$

where

$$\hat{E}(NPV_0) = \Big(\big(p \cdot (V_0 + h) + \ (1 - p) \cdot (V_0 - h)\big) \cdot q^{-1}\Big) - I$$

Herein, $q^{-1} = 1/1 + r$ is a discount factor, and r denotes the risk-free interest rate (e.g. 10% per period). By equating the expected present value of the investment returns defined in equation (1) and the investment cost I we receive the investment trigger $\hat{V}_0$:

$$\hat{V}_0 = h - 2 \cdot p \cdot h + I \cdot q \tag{2}$$

In our example, the investment trigger $\hat{V}_0$ according to the NPV equals 11,000.

The decision can be deferred which has the potential advantage that it allows the decision maker to take into account new information about the expected present value of the investment returns that arrives in the subsequent period. A rational decision maker would only realize an investment immediately if the actual expected NPV is higher than the discounted expected NPV of investing one period later. According to the ROA, the value of the investment $\tilde{F}$ is:

$$\tilde{F} = max\left[\hat{E}(NPV_0); \tilde{E}(NPV_1)q^{-1}\right], \quad (3)$$

where

$$\tilde{E}(NPV_1) = \left[p \cdot \left[\left(p \cdot (V_0 + 2 \cdot h) + (1-p) \cdot (V_0 + h - h)\right)q^{-1} - I\right] + (1-p) \cdot 0\right] \cdot q^{-1}$$

By equating (1) and (3) we receive the investment trigger $\tilde{V}_0$:

$$\tilde{V}_0 = \frac{q \cdot h - 2 \cdot p \cdot q \cdot h + I \cdot q^2 + 2 \cdot p^2 h - p \cdot I \cdot q}{q - p} \quad (4)$$

In our example, the investment trigger $\tilde{V}_0$ according to the ROA equals 12,667. The investment trigger following the NPV differs from the investment trigger following the ROA. The difference is expressed as follows:

$$\tilde{V}_0 - \hat{V}_0 = \frac{p \cdot h}{q - p} \quad (5)$$

Apparently, $\hat{V}_0$ is smaller than $\tilde{V}_0$ as long as $p > 0$; that is, the higher investment trigger according to the ROA leads to a later investment in comparison to the predictions of the NPV. Against this background, we formulate the following hypothesis:

H1 'ROA superiority to NPV': The ROA outperforms the NPV in explaining the investment behavior of farmers.

Price floors are a common instrument for market intervention to stimulate investments. Governments often seek to assist farmers by setting price floors in agricultural markets, which ensure a price above a certain limit. There are a number of studies which focus on price floor effects on investment behavior, but these studies offer conflicting results. For example, Sckokai and Moro (2009) use empirical farm data and show that an increase in intervention price would significantly stimulate farm investment, mainly through reduced price volatility. Chavas and Kim (2004) present an econometric analysis of the effects of price floors on price dynamics and price volatility in a multimarket framework and provide evidence that the price support program reduces price volatility significantly, although this effect disappears in the long term. Chavas (1994) develops a theoretical model for price floors and examines how sunk cost and temporal risk affect the rental value of capital as well as investment and entry-exit decisions. The author argues that because of sunk costs, it may be socially optimal for government-provided price floors to reduce the uncertainty of the investment. However, Dixit and Pindyck (1994) doubt the effectiveness of a minimum price and argue that the long-run effect of the price floor policy may be harmful even to those it is intended to help. They emphasize the importance of the actual level of the price floor. Patlolla et al. (2012) focus on price floors in India's sugar processing industry and investigate the extent to which the government's price floor policy reduces factories' incentives to improve their sugar recovery rates. They argue that the price floor policy creates a disincentive for private and public firms to be technically efficient in converting sugar cane to refined sugar and find empirical evidence. Maart-Noelck et al. (2012) use an experimental approach to examine the effect of a price floor on the investment behavior of students. They focus on the behavior of participants in a farmland investment situation and conclude that the price floor does not have a significant impact on the decision behavior.

With respect to the decision problem described in *H1*, we introduce a price floor V_{min} = 10,000 equal to the investment cost I. The equations (1) and (3) have to be modified for the price floor case. The value of the investment with price floor according to the NPV $\hat{F}^{WPF}$ can be calculated as follows:

$$\hat{F}^{WPF} = max\left[\hat{E}(NPV_0)^{WPF}; 0\right], \tag{6}$$

where

$$\hat{E}(NPV_0)^{WPF} = \Big(\big(p\, max(V_{min}; V_0 + h) + (1-p) max(V_{min}; V_0 - h)\big) \cdot q^{-1}\Big) - I$$

The value of the investment with price floor according to the ROA $\tilde{F}^{WPF}$ is:

$$\tilde{F}^{WPF} = max\left[\hat{E}(NPV_0)^{WPF}; \tilde{E}(NPV_1)^{WPF} q^{-1}\right], \tag{7}$$

where

$$\begin{aligned}\tilde{E}(NPV_1)^{WPF} = p \max\Big(0;\ \Big(\big(p\, max(V_{min};\ V_0 + 2 \cdot h) \\ + (1-p)\, max\, (V_{min}; V_0 + h - h)\big) \cdot q^{-1} - I\Big)\Big) \\ + (1-p)\, max\Big(0\, \Big(\big(p\, max(V_{min}; V_0 - h + h) \\ + (1-p) max(V_{min}; V_0 - 2 \cdot h)\big) \cdot q^{-1} - I\Big)\Big)\end{aligned} \tag{8}$$

The investment triggers can be derived analogously to the procedures described in *H1*. In our example, the investment trigger $\hat{V}_0^{WPF}$ according to the NPV equals 10,000, while the investment trigger $\tilde{V}_0^{WPF}$ according to the ROA equals 13,143. Due to a higher expected value of the investment returns, the NPV trigger is substantially lower in the WPF treatment compared to the NPF treatment. The ROA trigger in the WPF treatment lies above the trigger in the NPF treatment, which can be explained by the occurrence of an ambiguous effect. Reduced uncertainty due to a guaranteed price and higher opportunity costs caused by higher expected values of future investment returns outweigh each other to a certain extent in the WPF treatment. We derive the following hypothesis:

H2 'Price floor effect': Price floors do not stimulate significantly farmers' willingness to invest.

In reality, decision makers are repeatedly faced with similar decision situations. Moreover, previous decisions can influence the decision making process and potential future decisions. Essentially, this means that the decision behavior is influenced by previous experiences. It stands to reason that a decision maker tends to avoid repeating past mistakes, and in the case that something positive results from a decision, the individual is more likely to reach their decision in a comparable way, given a similar situation. This phenomenon is referred to as the 'learning effect'. A series of studies has shown that learning can affect the behavior of decision-makers in various decision situations. Baerenklau (2005) and Cameron (1999) find that farmers' technology adoption decisions are substantially influenced by learning over time using econometric approaches based on field data. The study by Brennan (1998) applies a normative approach and focuses on the role of learning in dynamic portfolio decisions. He analyzed the effect of uncertainty about returns on the risky asset of the portfolio decisions of an investor who has a long investment horizon and observed a learning effect over time with regard to optimal portfolio allocation. Oprea et al. (2009) carried out a laboratory experiment with students who faced multiple investment opportunities and found that subjects respond to *ex-post* errors. They tended to exercise the wait option prematurely, but over time their average investment behavior converged close to optimum. Loewenstein (1999) points out that 'stationary replication' in an experiment can be a useful tool to observe how people learn in repetitive situations at different complexity levels. Furthermore, people usually have several opportunities for learning in real life. These opportunities are then recreated, to some extent, in laboratories with replications of the task. With regard to our experiment, participants are engaged in repeated choice tasks in which they have to choose when to take an ongoing investment opportunity. We construct the following hypotheses:

H3 'learning effect': Farmers approximate optimal exercise of the ROA if they are given a chance to learn from personal experience in investment decisions.

3. Experiment design

In the following, we describe the experiment's design. Our experiment consists of three parts. In the first part, we use a lottery-choice experiment adapted from Holt and Laury (2002) to elicit the risk attitudes of farmers. The second and third parts of the experiment include two randomized investment treatments. These two treatments stylize a NPF (i.e. no price floor) and a WPF (i.e. with price floor) option to invest in a project. A complete set of instructions for the experiment is included in Appendix 1. The experiment was preceded by a household survey that collected information on household demographics and economic characteristics.

3.1 Lottery-choice experiment design

The lottery-choice experiment proposed by Holt and Laury (2002) is a widely used method for the elicitation of subjective risk attitudes. In the Holt and Laury lottery (HL lottery), participants make 10 choices between two systematically varied options, namely option A (the safe option) or option B (the risky option). In our design, option A offered the chance to either win 6,000 UGX or 4,800 UGX with a certain probability, while option B offered the chance to win 11,550 UGX or 300 UGX with the same probability (see Table 1). The payoffs in the safe option have a lower range than those in the risky option. We use the rate of 1:3,000 to get the equivalent payoffs in Ugandan shillings compared to the original task. The earnings are held constant across the choice tasks, whereas the probabilities of the earnings vary in 10% intervals between the choice tasks.

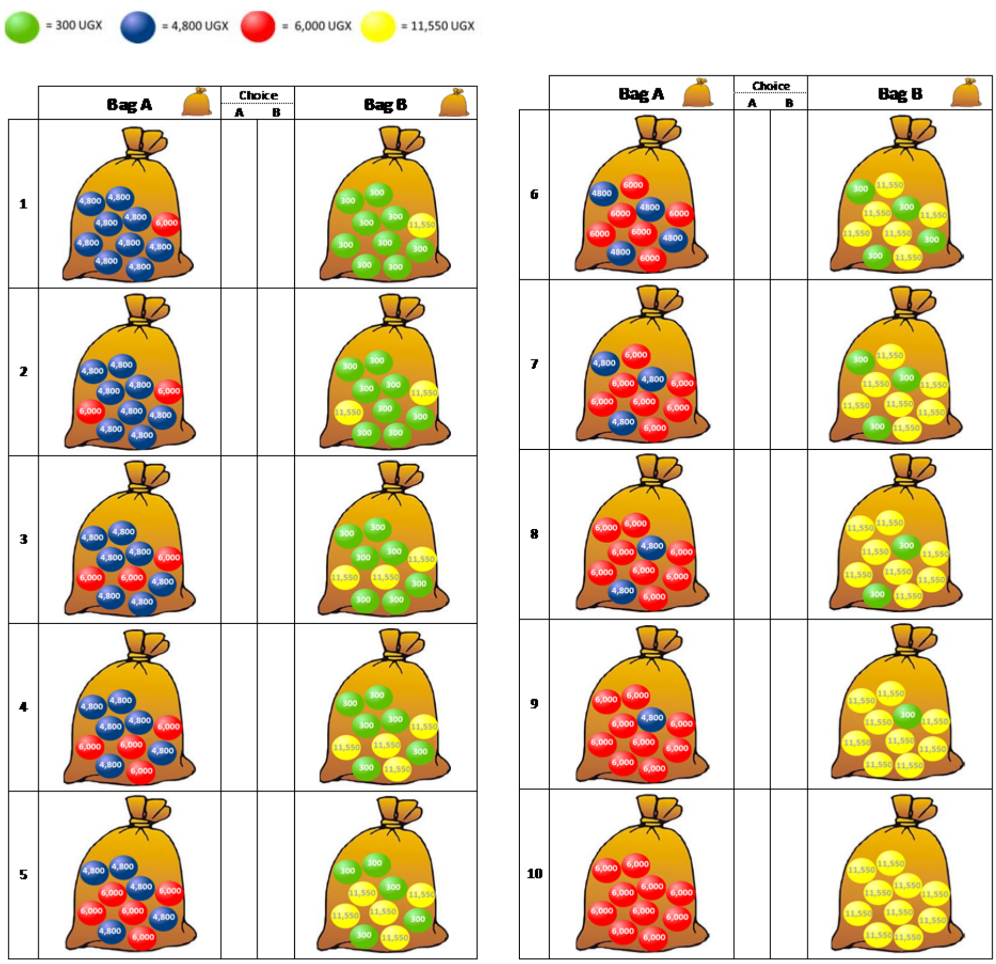
The expected values of the options change as participants move from one to the next choice task. Up to the fourth choice task, the expected value of the safe option A is higher than the expected value of the risky option B. From the fifth task, the expected value of option B exceeded the expected value of option A. Participants were asked to make 10 choices of either option A or option B, one for each choice task. The switching point from the safe to the risky option allows us to determine their individual risk attitude. A risk seeking participant would switch to option B in the first three decision rows, while a risk averse participant would switch to option B between the decision rows five to nine. In turn, a risk neutral participant would always decide in favor of the option with the higher expected value. Therefore, the person would switch from choosing option A to option B in row five. A HL lottery value (= number of safe choices) between one and three expressed risk preference, a HL lottery value of four implied risk neutrality, and a HL lottery value between five and 10 expressed risk aversion of the participant.

Table 1
Payoff matrix of the Holt and Laury lottery.

Task	Option A	Option B	EV^A	EV^B	CRRA ranges[a]	Risk aversion class[b]
1	With 10% prize of 6,000 With 90% prize of 4,800	With 10% prize of 11,550 With 90% prize of 300	4,920	1,425	r < -1.71	Extremely RL
2	With 20% prize of 6,000 With 80% prize of 4,800	With 20% prize of 11,550 With 80% prize of 300	5,040	2,550	-1.71 < r < -0.95	Highly RL
3	With 30% prize of 6,000 With 70% prize of 4,800	With 30% prize of 11,550 With 70% prize of 300	5,160	3,675	-0.95 < r < -0.49	Very RL
4	With 40% prize of 6,000 With 60% prize of 4,800	With 40% prize of 11,550 With 60% prize of 300	5,280	4,800	-0.49 < r < -0.14	RL
5	With 50% prize of 6,000 With 50% prize of 4,800	With 50% prize of 11,550 With 50% prize of 300	5,400	5,925	-0.14 < r < 0.15	RN
6	With 60% prize of 6,000 With 40% prize of 4,800	With 60% prize of 11,550 With 40% prize of 300	5,520	7,050	0.15 < r < 0.41	Slightly RA
7	With 70% prize of 6,000 With 30% prize of 4,800	With 70% prize of 11,550 With 30% prize of 300	5,640	8,175	0.41 < r < 0.68	RA
8	With 80% prize of 6,000 With 20% prize of 4,800	With 80% prize of 11,550 With 20% prize of 300	5,760	9,300	0.68 < r < 0.97	Very RA
9	With 90% prize of 6,000 With 10% prize of 4,800	With 90% prize of 11,550 With 10% prize of 300	5,880	10,425	0.97 < r < 1.37	Highly RA
10	With 100% prize of 6,000 With 0% prize of 4,800	With 100% prize of 11,550 With 0% prize of 300	6,000	11,550	1.37 < r	Extremely RA

Notes: Prizes are displayed in Ugandan shillings (UGX). At the time of the experiments, the exchange rate was approximately 1 € to 3,000 UGX, so prizes range from approximately 0.1 € to 3.85 €. The fourth and fifth column shows the expected values (EV) of the respective option.
[a] Constant relative risk aversion coefficient assuming a power risk utility function.
[b] RL, RN, and RA respectively for risk lover, neutral, and averse.
Source: Author's own illustration according to Holt and Laury (2002).

Pretests have shown that conducting a standard HL lottery with individuals in a rural developing country setting like Uganda might not be appropriate; thus we incorporated some modifications. The standard HL lottery is modified in this experimental design by replacing monetary values with images of bags of colored balls (green, blue, red, and yellow) representing probabilities of different payoffs (300 UGX, 4,800 UGX, 6,000 UGX, and 11,550 UGX). Each payoff is a ball of a particular color. The choice tasks were presented all at once to the participants. Fig. 1 shows the 10 choice tasks the participants faced in this lottery.

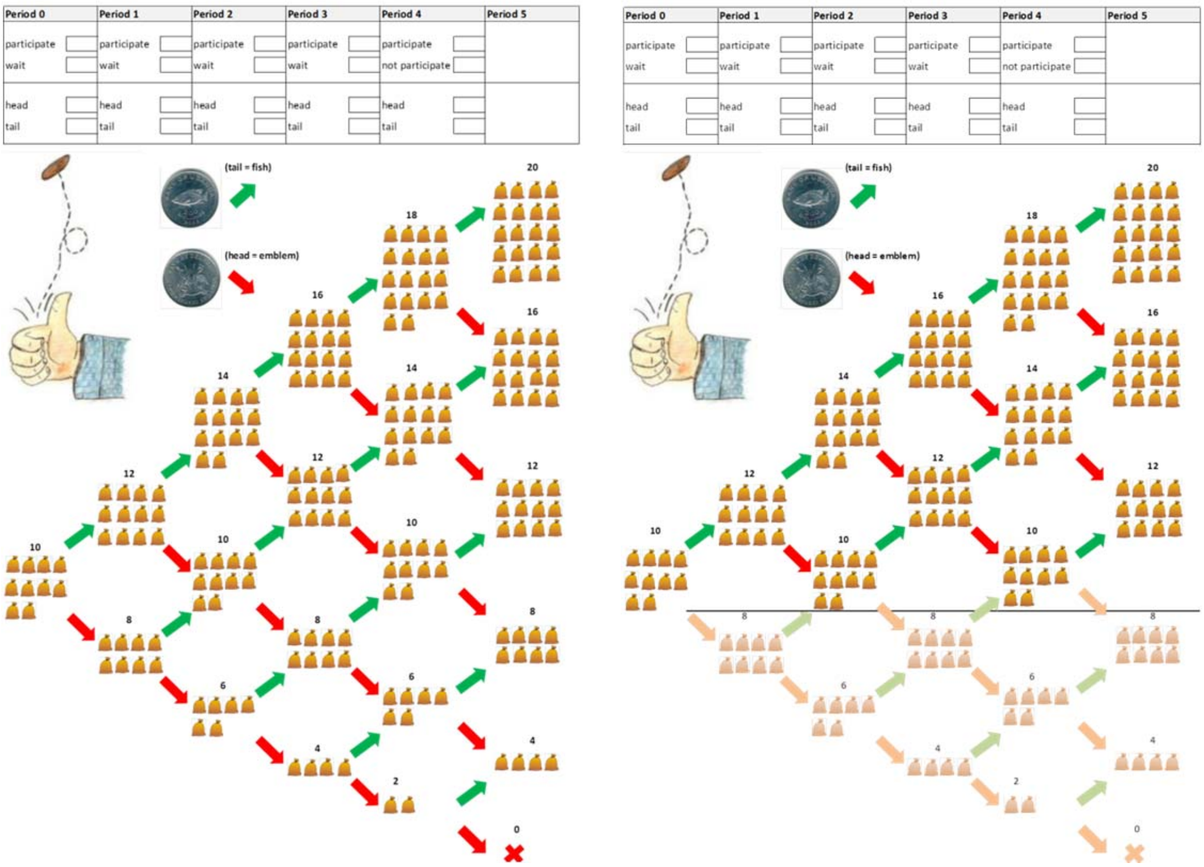


Source: Author's own illustration.

Fig. 1. Graphical display of the modified Holt and Laury lottery (in Ugandan shillings).

3.2 Investment experiment design

The design of the real options experiment was used to develop the model outlined in the previous section. In the NPF and WPF treatment, participants were given the hypothetical possibility to purchase the right to participate in a coin tossing game. Apart from the price floor, both treatments are absolutely identical. The order in which participants were faced with the two treatments was randomly determined. Each participant repeats the NPF and WPF treatment 10 times, having the option to invest 20 times in total. Within each repetition of the respective treatment, participants could decide to take or to postpone an ongoing investment opportunity in one of five possible periods. Every participant started the experiment with a deposit of 10,000 points for each repetition. The initial investment outlay was also 10,000 points. For simplicity reasons, the risk-free interest rate was fixed at 10% per period. The return in period 0 was always 10,000 points. The returns evolved stochastically and followed an arithmetic Brownian motion with no drift and a standard deviation of 2,000 points over five periods. According to a state- and time-discrete approximation of an arithmetic Brownian motion (Dixit and Pindyck, 1994, p. 68), the returns in period 1 either increase to 12,000 points with a probability of 50% or decrease to 8,000 points with a probability of 50% depending on a coin that has been tossed, i.e. upper amount if tail (fish) appears or lower amount if head (emblem) appears. The binomial tree of potential returns which was shown to the participants in the NPF and WPF treatment is illustrated in Fig. 2. The price floor is illustrated in the right part of Fig. 2 by the line which truncates the investment returns below 10,000 points.



Source: Author’s own illustration.

Fig. 2. Graphical display of the binomial tree of potential investment returns (in thousand points) in the NPF (left) and WPF treatment (right).

Each participant had three options: First, a participant could invest immediately, i.e. he/she pays the initial outlay of 10,000 points in period 0 and receives 12,000 points or 8,000 points with a probability of 50% in period 1. Second, a participant could decide to postpone the investment decision and could invest at any time between periods 1 to 4. In case a participant decided not to invest in period 0, he/she would again be faced with the investment decision in period 1. By tossing a coin, it was randomly determined if the return in period 1 increased or decreased starting from the value of period 0. Third, a participant could choose not to invest at any point throughout the 5 periods, i.e. he/she saves the initial outlay of 10,000 points. The deposit and the returns minus the initial outlay realized before period 5 increased by the risk-free interest rate of 10% for every period left in the decision tree.

In the WPF treatment, a minimum investment return is guaranteed. The minimum return is equal to the initial investment outlay of 10,000 points. More precisely, the return develops in accordance with the state- and time-discrete approximation of an arithmetic Brownian motion as described above. Only if a participant decided to exercise the investment option and indeed observed a return less than 10,000 points in the following period would a fictional authority compensate for the difference to reach 10,000 points. In this case, the participant would only loose the interest payment of one period on the investment cost compared to a situation in which the participant does not implement the investment.

3.3 Variables used in analysis

Individuals' socio-demographic and socio-economic characteristics naturally vary and may also have an impact on the investment time in our experiment. Therefore, in addition to the investment and lottery-choice experiments, participants attended a household survey during which they completed a comprehensive questionnaire capturing information on household demographics and economic characteristics. The main variables collected through the survey were age, gender, education, household size, district, per capita household expenditure as a proxy variable for wealth, total land owned, access to a savings account, access to credit, and membership in a farmer group. The selected variables are known in the extant literature to possibly have an influence on the investment behavior and are, therefore, considered in our analysis: age (e.g., Gardebroek and Oude Lansink, 2004), gender (e.g., Jianakoplos and Bernasek, 1998), education (e.g., Hill, 2010a), household size (e.g., Lewellen et al., 1977), geographic region (e.g., Baerenklau, 2005), wealth (e.g., Hill and Viceisza, 2012), farm size (e.g., Savastano and Scandizzo, 2009), access to a savings account (e.g., Dupas and Robinson, 2013), access to credit (e.g., Fafchamps and Pender, 1997), and membership in farmers' organizations (e.g., De Souza Filho et al., 1999).

A participant's ability to reason with numbers and probabilities may affect the understanding and decision making in the experiments and hence the opportunity to obtain an accurate measurement of their investment behaviors and risk attitudes (Cole et al., 2011; Dave et al., 2010). Therefore, we included three additional tasks, adapted from Viceisza (2011) and Charness and Viceisza (2011), to assess farmers' ability to process percentage and probabilistic information and to explore the relationship between their decision behavior and the test score in the quiz: (i) “Imagine, we toss a coin and ‘head’ comes up. What comes up if we toss the coin again?” Participants were faced with three possible answers: head, tail, one cannot predict exactly. (ii) “If the chance of winning a prize is 10%, how many people out of 100 would be expected to get the prize?” (iii) “When you draw the red ball, you win! Look at the two boxes and mark the correct sentence.” One box contains two red and two blue balls, while the other box contains four red and four blue balls. Participants have to decide whether the chance of winning is higher if they choose the first box, the second box, or the chance of winning is equal regardless of which box they choose.

4. Data collection

In the following subsections, we describe the sampling procedure, the incentive design, and the implementation of the experiment that was conducted.

4.1 Study location and sampling procedure

Data used in this study was obtained from experiments and a household survey of 332 smallholder coffee farmers randomly selected from two districts of Masaka and Luwero in Uganda from July to August 2012. These two districts, located in the Central Region, have been broadly classified as having similar agro-climatic conditions and farming systems. The data was collected in collaboration with various local administrative institutions and three non-governmental organizations (NGOs), and conditions were purposively selected based on the project areas of our partners in Uganda. Since the experiments were connected to another project on linking smallholder coffee farmers to certified markets, we had access to complete lists of farmers that we obtained from three NGOs that are involved with farmer groups in these regions. To select farmers, we used a stratified random sampling based on complete lists of participating farmers in activities conducted by the three NGOs. In a first step, we randomly selected parishes and villages. In a second step, we randomly chose farmers at the village level. The farmers were then recruited via the local extension service to participate in a household survey and an experiment. The invitation to attend our experiment was provided orally by the recruiters and contained the date, time, and place of the study, a brief and general purpose of the study, and the type of compensation that could be expected. The household survey took place one day prior to the actual experiments. Our participants were either the household head or the spouse because they are those most likely to be faced with important economic decisions.

4.2 Experiment implementation

The 332 smallholder coffee farmers were allocated randomly to groups for the experimental sessions. In total, we conducted 56 sessions during the course of 30 days. On one day, two sessions were held. Each session involved a group of six farmers[1]. In the experiment, choices made by participants were not time constrained. On average the complete session lasted approximately three hours. The experimental sessions were held in several villages and conducted in classrooms of local schools or in a meeting room at the main gathering place of a farmer's group or association. All of the sessions were held in locations which were familiar to the farmers and usually within walking distance or accessible by bicycle. The rooms were equipped with tables and chairs and were spaced out to prevent conferring among the participants. A team of seven enumerators conducted all of the experimental sessions. One of the enumerators served as the experimenter, and the author served as the assistant experimenter. The other enumerators were placed next to the participants to record their choices in case participants were illiterate. Each participant had their own enumerator. All sessions were conducted in Luganda, one of the main indigenous Bantu languages in south central Uganda. Prior to the first session, the enumerators were trained on the experiment protocol and to carefully avoid giving specific instructions about how to answer.

Each experiment session consisted of registration, instruction, practice, decision making, and payment. In the beginning of each experiment, the participant received a personal number, which randomly determined his/her seat that remained the individual's location throughout the session. The experiment instructions were read aloud to all participants as a group by the experimenter and supported by posters and graphical examples displayed on a large board at the front of the room to improve the understanding. During the presentation of the instructions, participants were encouraged to ask questions about any unclear issues. With regard to the lottery-choice experiment, we used real bags of colored balls representing probabilities of the different payoffs to further facilitate comprehension. Each choice task in the experiment was conducted in the following way: The assistant experimenter placed the appropriate balls in the bags, while the experimenter explained the values attached to each ball. The participants then considered their decision and made their choice by pointing to the preferred bag on the sheet in front of them, and their enumerator recorded the choice.

[1] However, four farmers were excluded from the analysis. One farmer left before completing all tasks, and three farmers participated in the household survey but were not able to undertake (or arrived too late to participate) the experiment.

Before the investment experiment started, the participants had to answer some control questions to ensure that they entirely understood the instructions. After completing the control questions, participants also played a trial round to become familiar with the experiment. In the entire experiment, participants were not provided with the optimal investment strategy according to the NPV and ROA; rather, they decided on an intuitive basis. Both investment treatments were chosen in a randomly determined order and applied to the whole group. Each repetition of the respective treatment in the investment experiment was conducted in the following way. Each participant considers their decision, i.e. to either invest immediately and to participate in the coin tossing game or to postpone the decision and first see the development of the decision tree. The enumerator records the decision by marking the appropriate box on the decision sheet in front of them. Once the enumerator has marked the decision for the period, the participant can no longer change the decision. When all six participants have made their decisions, the experimenter tosses a coin. The enumerator records the result of the coin tossing by marking the appropriate box on the decision sheet, i.e. whether head (emblem) or tail (fish) appears. The experiment then continues with the next period. If a participant had chosen to wait in period 0, he/she makes a decision whether to participate or to wait in period 1 after having observed the outcome of the previous period. If a participant had chosen to participate in the coin tossing game in period 0, the game is over for him/her and he/she has to wait for the next repetition of the game. Nevertheless, the experimenter tosses the coin for each period in this repetition. The second repetition of the experiment starts in period 0 with again the opportunity to invest in 1 of 5 time periods. This procedure is repeated 10 times for each treatment.

Overall, our impression was that the formulation of the instructions was well understood by the participants because of the various interview techniques applied such as visual, oral, and written explanations as well as the practical implementation with real bags and colored balls. Further support of respondents’ comprehension of the instructions is seen, for example, in the unproblematic answering of the control questions during the experiment.

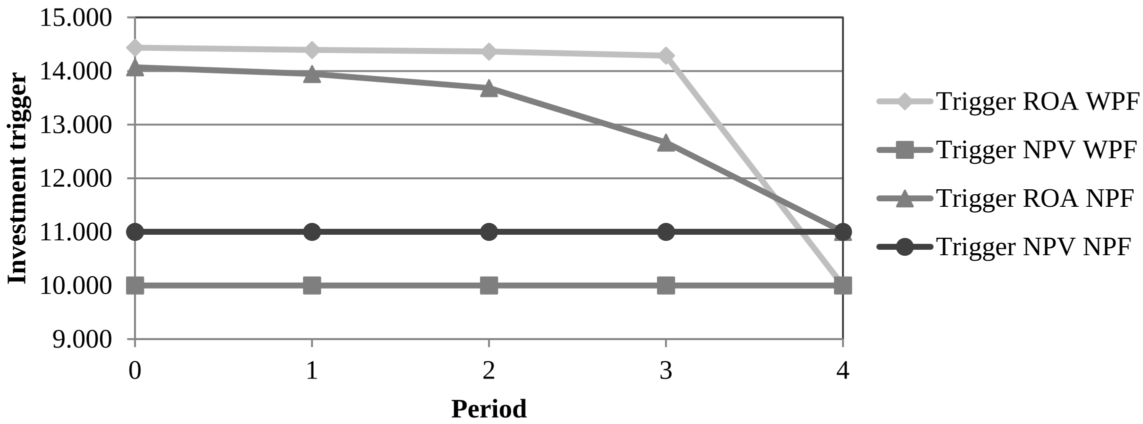
4.3 Incentive design

The decisions in the experiments were related to real earnings to ensure incentive compatibility and to motivate participants to take the tasks more seriously. Participants were informed at the beginning of the experiment that when they have completed all decision tasks in the experiment, one repetition of the NPF and WPF treatment and one decision task from the HL lottery would be selected at random and played out for real money. This random lottery incentive system is commonly used in lottery-choice risk experiments (Humphrey and Verschoor, 2004). Nevertheless, there is an ongoing controversial debate on the use of monetary incentives as rewards for participants in experiments and the practice of paying only some participants for only some of their decisions. Camerer and Hogarth (1999) and Smith and Walker (1993) find that using high financial incentives for a fraction of participants rather than providing small incentives for each of the participants often improves participants' performance during the experiment because participants often overweigh their chances of being selected. We chose one participant at random for payment for each of the experimental parts of our payment design; hence we had three winners per session. The earnings of two participants for the NPF and WPF treatment in the investment experiment were based on their individual scores attained on one randomly chosen repetition of the respective treatment. Each repetition had exactly the same probability to be drawn. The potential earnings varied between 6,800 UGX and 24,000 UGX for the NPF treatment and between 1,400 UGX and 24,000 UGX for the WPF treatment. The average payoffs in the investment experiment were 15,287 UGX (approximately 5.1 €) in the NPF treatment and 14,956 UGX (approximately 5.0 €) in the WPF treatment. The earning of the participant from the lottery-choice experiment was based on his/her preference expressed between various mutually exclusive alternatives in the lottery. Each decision task had exactly the same probability to be drawn. The potential earning varied between 300 UGX and 11,550 UGX. The average payoff in the lottery-choice experiment was 6,674 UGX (approximately 2.2 €). All participants received a show-up fee of 5,000 UGX as a compensation for their time. This compares to one day of casual farm labor wage in this area. Participants were paid in cash by the assistant experimenter at the end of the experiment.

The payment in the experiment was conducted in the following way: In both treatments of the investment experiment, farmers were informed that one participant of the group and one repetition of the game would be randomly selected for payment. The winner was then determined by drawing a number between one and six out of a bag. The holder of the number that was picked from the bag was the winner and received the payment. The repetition relevant for payment was determined by drawing a number between one and 10 out of a bag. The number that was picked from the bag was the choice that counts for payment. In the lottery-choice experiment, farmers were informed that one participant of the group would be randomly selected and would receive a prize between 300 UGX and 11,550 UGX depending on his/her decision. Choosing the winner and the decision task relevant for payment was conducted in the same way as in the investment experiment by drawing a number out of a bag. A third draw decided whether the low or high prize of ‘Bag A’ or ‘Bag B’ would be realized. In case the participant chose ‘Bag A’, he/she had to draw a ball out of this bag and would have the chance to win 4,800 UGX or 6,000 UGX with the respective probability. If the participant chose ‘Bag B’, he/she had to draw a ball out of this bag and would have the chance to win either 300 UGX or 11,550 UGX with the respective probability.

5. Normative benchmarks

To evaluate the actual investment behavior that farmers show in the experiment, we derive normative benchmarks which reflect the NPV and the ROA, respectively. The determined normative benchmarks mark the threshold levels on which it becomes optimal to invest according to the NPV and ROA, the so-called investment triggers. The investment triggers following the NPV can be directly determined via annualizing the investment costs. In contrast, the investment triggers of the ROA have to be calculated by dynamic stochastic programming (Trigeorgis, 1996, p. 312). Fig. 3 illustrates the normative benchmarks of the investment according to the NPV and the ROA for a risk-neutral decision maker for both the NPF and WPF investment treatment. The investment triggers of the ROA decrease exponentially reflecting the diminishing time value of the investment option. The trigger value of the ROA starts in period 0 at 14,070 points in the NPF treatment and at 14,436 points in the WPF treatment. The triggers of the ROA of both treatments equal the triggers of the NPV in period 4, when the option to invest expires and it is not possible to postpone the decision.



Source: Author’s own illustration.

Fig. 3. Investment triggers for a risk-neutral decision maker.

For the determination of the normative benchmarks we do not assume that the decision makers are risk neutral, rather we take into account the individual risk attitude participants show in the HL lottery. On the basis of these results, we determine the respective risk-adjusted discount rates. Following Holt and Laury (2002), we assume a power risk utility function, which implies decreasing absolute risk aversion (DARA) and constant relative risk aversion (CRRA):

$$U(V) = V^{1-\theta} \tag{9}$$

Here U denotes utility, V describes the present value of the investment returns, and θ is the risk aversion coefficient. Based on equation (9) we can derive θ for each individual from his/her choices in the HL lottery. Thus, the certainty equivalent (CE) of a risky prospect can be calculated as follows:

$$CE = V\left(E\big(U(V)\big)\right) = E\big(U(V)\big)^{\frac{1}{1-\theta}} = E(V) - RP \tag{10}$$

where $E(V)$ is the expected present value of the investment returns and RP is a risk premium. The present value of the certainty equivalent CE_0 of an uncertain payment V_T at time T can be defined as follows:

$$CE_0 = CE_T \cdot (1+r)^{-T} = (E(V_T) - RP_T) \cdot (1+r)^{-T} \tag{11}$$

where r is the risk-free interest rate. An equivalent risk-adjusted discount rate $r^* = r + v$ can be derived from equation (11) using the following equation:

$$(E(V_T) - RP_T) \cdot (1+r)^{-T} = E(V_T) \cdot (1+r+v)^{-T} \tag{12}$$

$$\rightarrow v = (1+r) \cdot \left(\left(\frac{E(V_T)}{E(V_T) - RP_T}\right)^{1/T} - 1\right)$$

The risk loading v, and thus the risk-adjusted discount rate $r + v$ depend on the risk premium RP as well as on the length of the discounting period T.

Applying dynamic programming to the binominal tree displayed in figure 1 using risk-adjusted discount rates from equation (12) is problematic because the certainty equivalent of the up and down movements, and thus the risk-adjusted discount rates are not constant over time. This leads to a non-recombining binomial tree for the stochastic variable, in which the number of potential states increases exponentially with the number of periods (Longstaff and Schwartz, 2001). Therefore, we first fix the level of the returns at its initial value. Second, we fix T at one period in equation (12). We derive 9 discount rates per treatment representing different risk attitudes for each treatment. In the NPF treatment, the risk-adjusted discount rates vary between 9.28% (HL lottery value = 0) and 10.62% (HL lottery value = 9) and in the WPF treatment between 7.77% (HL lottery value = 0) and 8.05% (HL lottery value = 9).

6. Experimental results

In the following subsections, we present the descriptive statistics and test the validity of our hypotheses derived in Section 2.

6.1 Descriptive statistics

Table 2 presents some descriptive statistics on the individuals who participated in the experiment as well as an overview of the normatively expected and observed investment decision behavior exhibited during the experiment. As can be seen from the table below, on average, the participants were slightly risk averse (HL lottery value = 5.20). Although 77.11% of the participants revealed risk aversion, 9.34% of them were risk neutral, and 13.55% of them were risk seeking. The average age of participants is 50.21 years and ranges from 18 to 90 years. About 39% of the participants are female. The education of the household head is on average 6.67 years of schooling. The average household size is 6.56. About 43% of the participants live in the Luwero district, while 57% of them live in the Masaka district. In order to assess whether farmers have a basic comprehension of probabilities, we conducted a short quiz composed of three simple questions before the experimental sessions started. On average, each farmer answered two out of the three questions correctly. The average annual per capita household expenditure on non-food items is approximately 516,855 UGX. The mean farm size for each farmer is about 5.73 acres, ranging between 1 acre and 42 acres. About 28% of the farmers indicated that they have access to a savings account, while 43% claimed that they are able to access financial credit for agricultural activities whenever they need it. The majority of farmers, about 80%, are members of a farmer group organization.

The actual investment period chosen by participants in the experiment is on average period 2.49 in the NPF treatment and period 2.45 in the WPF treatment. These figures do not take into account repetitions with non-investment. In 40.27% and 38.49% of the repetitions, participants chose not to invest, respectively. The optimal investment period predicted by the NPV is 1.39 in the NPF treatment and 0.00 in the WPF treatment. The share of repetitions of non-investments is 36.81% and 0.00%, respectively. The optimal investment period predicted by the ROA is 2.66 in the NPF treatment and 2.99 in the WPF treatment. The share of repetitions of non-investments is 59.04% and 0.00%, respectively. This is already an initial indication for the validity of *H1*. Participants invested on average much earlier than predicted by the NPV and closer to the predictions of the ROA in both treatments.

Table 2
Descriptive statistics of respondents' characteristics (N = 332).

Parameter	NPF treatment with 3,320 decisions	WPF treatment with 3,320 decisions
Socio-demographic characteristics		
Risk attitude (HL lottery value)[a]	5.20 (1.96)	
Age (years)	50.21 (14.28)	
Gender (dummy = 1 if female, 0 otherwise)	0.39 (0.49)	
Education (years)	6.67 (3.60)	
Household size (number)	6.56 (3.10)	
District (dummy = 1 if from Masaka, 0 = if from Luwero)	0.57 (0.50)	
Quiz test score (number of questions correctly answered)[b]	2.05 (0.78)	
Socio-economic characteristics		
Annual per capita household expenditure (UGX)[c]	516,855 (392,949)	
Total land owned (acres)[d]	5.73 (4.53)	
Access to a savings account (dummy = 1 if yes, 0 otherwise)	0.28 (0.45)	
Access to credit (dummy = 1 if yes, 0 otherwise)	0.43 (0.50)	
Member of farmer group (dummy = 1 if yes, 0 otherwise)	0.80 (0.40)	
Investment behavior		
Actual investment period without repetitions of non-investment	2.49 (1.45)	2.45(1.46)
Actual share of repetitions with non-investment (%)	40.27	38.49
Normative investment period following NPV without repetitions of non-investment	1.39 (0.79)	0.00 (0.00)
Normative share of repetitions with non-investment following NPV (%)	36.81	0.00
Normative investment period following ROA without repetitions of non-investment	2.66 (0.94)	2.99 (0.10)
Normative share of repetitions with non-investment following ROA (%)	59.04	0.00

Notes: Standard deviations are indicated in parentheses in column two and three.
[a] A HL lottery-value between 0 and 3 expresses risk preference, a HL lottery value of 4 implies risk neutrality, and a HL lottery value between 5 and 9 expresses risk aversion.
[b] The quiz contains three questions, in total. About 76%, 92% and 37% of the participants correctly answered question one, two and three, respectively.
[c] At the time of the experiments, the exchange rate was approximately 3,000 UGX per €.
[d] 1 acre = 0.40 hectare.
Source: Survey data.

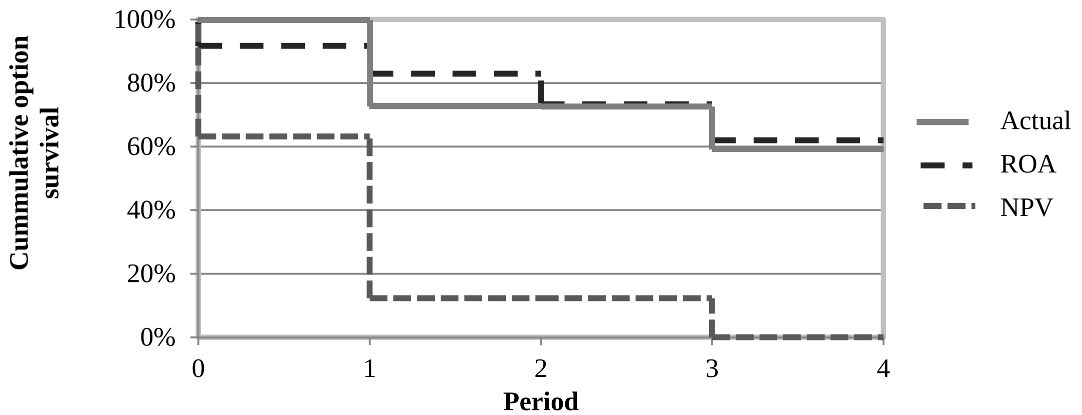
6.2 Validity test of hypotheses

To verify *H1 'ROA superiority to NPV'* and *H3 'Learning effect'*, the data set of the NPF and WPF treatment is pooled, whereas we analyze the data set separately to test *H2 'Price floor effect'*.

Test of H1 'ROA superiority to NPV'

To test *H1*, we compare the actual investment behavior with the benchmark prediction according to the NPV and the ROA. We apply the Kaplan-Meier survival estimator, also referred to as the product limit estimator (Kaplan and Meier, 1958), as modified by Kiefer (1988) to deal with censored data. In our experiment, in 40.27% in the NPF treatment and in 38.49% in the WPF treatment of the total 6,640 cases, participants decided not to invest, which means that a defined investment period was not observed. In this case, data is right-censored as durations end after the time frame of observation.

Fig. 4 shows the survival functions of the Kaplan-Meier estimation of the actual and the optimal investment behavior according to the NPV and ROA. The staircase-shaped curves illustrate the cumulative option exercise over the years. It indicates the percentage of investments realized per year. Declines in the survival curve occur whenever participants decide to invest. A log-rank test of the equality of the survival functions shows that there is a statistically significant difference between the actual investment behavior and the normative benchmarks according to the NPV and the ROA (*p*-value = 0.000). An additional analysis that examined both treatments separately generates similar results. Based on this finding, we conclude that neither the NPV nor the ROA provides an accurate prediction of the experimentally observed investment behavior of farmers.



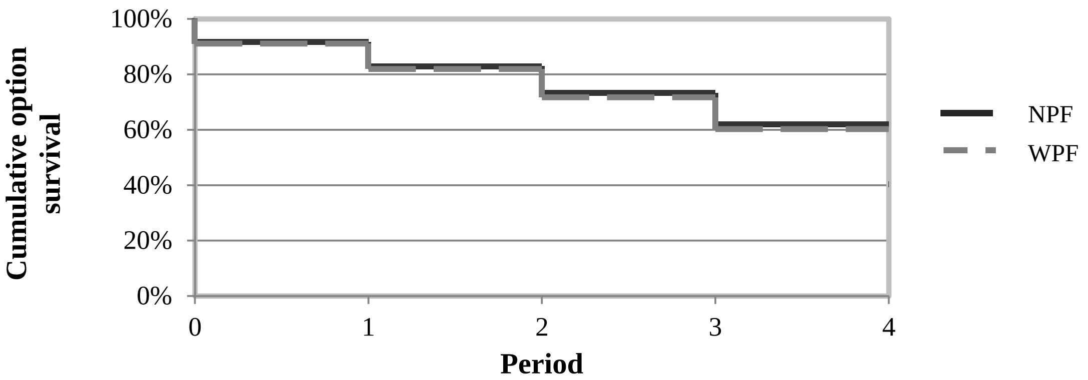
Source: Author’s own illustration.

Fig. 4. Survival functions of actual and optimal investment behavior according to NPV and ROA.

In Fig. 4, the curve of the actual investment behavior is below that of the optimal decision behavior according to the ROA and above the curve of the optimal decision behavior according to the NPV. That means that farmers invest later than predicted by the NPV but earlier than suggested by the ROA. However, the curve of the observed decision behavior seems to be closer to the optimal decision behavior according to the ROA, meaning that farmers invest more in accordance with the ROA. Against this background, we fail to reject *H1 'ROA superiority to NPV'*. Our results show that the ROA is able to predict actual investment decisions better than the NPV. These findings are consistent with previous investigations (Maart-Noelck and Musshoff, 2013; Oprea et al., 2009).

Test of H2 'Price floor effect'

To test *H2*, we compare the participants' actual investment behavior in the NPF and WPF treatment and find that it does not differ significantly. Fig. 5 illustrates the survival functions for both treatments. The log-rank test shows a *p*-value of 0.094 and thus gives statistical evidence for the equality of the survival functions. This result shows that the price floor does not have a statistically significant effect on Ugandan smallholder farmers' investment behavior. Thus, we fail to reject *H2 'Price floor effect'*. In accordance to the theoretical predictions of the ROA, price floors do not stimulate investments in our experiment.



Source: Author's own illustration.

Fig. 5. Comparison of the survival functions for the NPF and WPF treatment.

Test of H3 'Learning effect'

To test *H3* and to analyze the impact of further variables on the investment time, we run a Tobit regression. The dependent variable in the regression model is the individual investment period of farmers. Table 3 presents the results of the Tobit regression model. In our experiment, farmers were faced with repeated investment opportunities. Each farmer repeated the NPF and WPF treatment 10 times so that in each case they had 10 times the option to invest. The estimated coefficient of repetition is not statistically significant, which is surprising because previous findings of Oprea et al. (2009) reveal that participants consider the value of waiting in investment decisions over time if they are given a chance to learn from personal experience. On this basis, we reject *H3 'Learning effect'*.

Table 3
Results of the Tobit regression of the individual investment period (N = 6,640).

Variable	Coefficient	Standard error	*p*-value	
Repetition	0.009	0.011	0.398	
Order of experiment *(0 = NPF-WPF, 1 = WPF-NPF)*	0.330	0.065	<0.000	**
Treatment *(0 = NPF, 1 = WPF)*	-0.115	0.063	0.069	
Risk attitude	0.173	0.017	<0.000	**
Age *(years)*	-0.000	0.002	0.863	
Gender *(1= female)*	0.116	0.069	0.091	
Education *(years)*	0.022	0.011	0.035	*
Household size *(number)*	0.043	0.012	0.000	**
District *(0 = Luwero, 1 = Masaka)*	-0.820	0.070	<0.000	**
Quiz test score *(number)*	0.024	0.044	0.576	
Per capita household expenditure *(UGX)*	8.196	0.000	0.485	
Total land owned *(acres)*	0.024	0.008	0.002	**
Access to a savings account *(dummy)*	0.237	0.079	0.003	**
Access to credit *(dummy)*	0.099	0.068	0.145	
Member of a farmer group *(dummy)*	-0.448	0.088	<0.000	**
Constant	2.798	0.234	<0.000	**
Log-likelihood		-11376,50		
Chi^2		440.012		

Notes: *p < 0.05, **p < 0.01.
Source: Survey data.

In the experiment, farmers were faced with both treatments in a different order so that some were at first faced with the NPF treatment and then with the WPF treatment or with both treatments in a reverse order. According to Day et al. (2012) and Scheufele and Bennett (2013), repeated choice tasks may influence outcomes through order effects. We examined the presence of an 'order effect', meaning that we tested whether farmers show different investment behaviors when faced with the treatments in a different order. The coefficient order is positive and statistically significant. This result shows that farmers demonstrate significantly different investment behaviors dependent on the order in which they are faced with the two treatments. Participants who are first faced with the WPF treatment and second with the NPF treatment invest later or more inert than participants who are faced with the treatments in reverse order. This result shows that the abolishment of price floors causes pronounced increases in inertia. However, it may also indicate a 'learning effect', meaning that farmers acquire routines for repetitive decisions at the beginning of the experiment and apply them to later decisions even if they are related to another treatment. The non-significant coefficient of the variable treatment reinforces the results of the *H2 'Price floor effect'* analysis. It indicates that participants do not invest significantly different in the WPF treatment compared to the NPF treatment, i.e. price floors do not stimulate investments in our experiment.

The coefficients of the variables risk attitude, education, household size, total land owned, and access to a savings account are positive and statistically significant. Our findings that participants who are more risk averse, have a higher education level and a larger household size, and own more land invest later confirm results in other studies (Viscusi et al. (2011) for risk; Hill (2010a) for education; Lewellen et al. (1977) for household size; Savastano and Scandizzo (2009) for farm size). Also, participants who have access to a savings account invest later, which does not support the results of Dupas and Robinson (2013). They find that savings accounts improve investment levels of individuals; thus we expect that participants who have access to a savings account invest earlier. The coefficient of the variable district is negative and significant and indicates that participants from the Masaka district invest earlier than participants from the Luwero district. This result is surprising due to the fact that farmers in Masaka are more enterprising compared to those in Luwero. Baerenklau (2005) supports the result by implying that investment behaviors of individuals may differ across regions. The coefficient of the variable member of a farmers group is also negative and significant and implies that participants who are members of a farmer group invest earlier, confirming results in other studies (e.g., De Souza Filho et al., 1999). There is no significant effect of age, gender, per capita household expenditure, access to credit, and quiz test score, although some other studies find an effect (Jianakoplos and Bernasek (1998) for age; Gardebroek and Oude Lansink (2004) for gender; Hill and Viceisza (2012) for wealth; Fafchamps and Pender (1997) for credit; Cole et al. (2011) for math literacy).

7. Conclusions

A better understanding of farmers' decision to invest in a project under uncertainty is crucial for gaining insights into the dynamics of how uncertainty affects their investment behavior, interpreting agricultural outcomes, and designing policies that effectively assist farmers. Many investment options faced by smallholder farmers in developing countries are characterized by uncertain returns and especially poorer farmers may be impacted by such uncertainty. Therefore, this study examines the investment behavior of Ugandan smallholder farmers under flexibility, uncertainty, and irreversibility, while trying to determine the underlying models of investment consistent with actual decision behavior during an experiment and to analyze the effect of a price floor. The investment decisions are modeled as rights to invest in a project under consideration of the value of flexibility. The observed investment decisions are contrasted with normative benchmarks, which are derived from the NPV and ROA.

Our findings are first that neither the NPV nor the ROA provides an exact prediction of farmers' investment behavior observed in the experiment. Ugandan farmers invest later than predicted by the NPV but earlier than suggested by the ROA. However, the results suggest that the ROA can predict actual investment decisions better than the NPV. Second, the actual investment behavior does not differ significantly with respect to the presence of a price floor, which coincides with the theoretical predictions of the ROA. Third, we do not find evidence for a learning effect, meaning that Ugandan farmers do not learn from personal experience during the experiment and approximate the predictions of the ROA over time. However, we find that specific socio-demographic and socio-economic variables such as risk attitude, education, household size, total land owned, access to a savings account, and membership of a farmer group affect the investment behavior of farmers.

When interpreting the results, it is important to take into account that our experimental design is abstracted from reality and is considerably simpler than investment situations that would occur in an actual business setting. Participants may act differently in the experimental situation than they do in a similar situation in the real world. A common criticism of experiments has to do with whether experimental results are likely to provide reliable inferences outside the laboratory and can be extrapolated to the real world (Levitt and List, 2009; Roe and Just, 2009). This lack of external validity is considered to be the major weakness of laboratory experiments (Loewenstein, 1999). The general implication from this experimental analysis is that flexibility, uncertainty, and irreversibility play a role in farmers' decision making process to invest in a project. This is extremely relevant from a policy maker's perspective. Policies that allow farmers to be more certain of future returns or practices that can reduce the uncertainty might encourage a more responsive investment strategy, regardless of the decision makers' risk attitude. Furthermore, it is a challenge for policy makers to take the effects of certain socio-demographic and socio-economic variables on investment behavior into account in designing future policies for the agricultural sector.

Several opportunities present themselves for future research. First, it is possible that potential drivers of psychological inertia also play a role when explaining investment behavior. A behavioral phenomenon that might influence the intuitive choice of investment triggers towards postponement of this decision is the escalation of commitment effect (Denison, 2009; Staw, 1981). This effect describes the phenomenon that it is difficult to dissuade someone from a course that the person had previously adopted. That would mean that decision makers have the tendency to persist on a failing course of action. With regard to our investment experiment, participants are faced with repeated decision situations in which object returns may fall x-times in a row. Then, participants have the choice either to invest or to continue waiting in the hopes that returns increase. Here, the question arises, whether or not participants follow specific rules of thumb in their decision-making process. It would be interesting to reveal the heuristics, which participants apply to make investment decisions. Second, more research is needed to examine whether the actual price floor level has an effect on the investment behavior. Here, it would be interesting to test different price floor levels. Third, to increase the validity of our results it would be useful to investigate whether farmers in developing countries show a similar investment behavior in different framing situations, e.g., investment in agricultural technology. Fourth, the finding that farmers' investment behaviors differ across regions shows that it is not possible to infer from our results to other developing countries; instead it highlights the importance to conduct further investment experiments in other developing countries. Another interesting path to be taken would be to examine the disinvestment behavior of farmers. To the best of our knowledge, there are no experimental studies that consider farmers' behavior under uncertainty with regard to long-term disinvestment decisions in developing countries. The experimental investigation of real options settings in developing countries is still in its early stages. Therefore, in this regard further research is required to better understand what exactly drives individuals' decision making in investment situations and to predict this behavior in the future.

Appendix A. Experimental instructions

Outline

The experiment session comprises:

1. Sign-in (location and arrival)
2. Introduction and agenda (an introduction of the experimenter, enumerators, assistant experimenter, and the project)
3. Quiz
4. Instructions, practice, and decision making (coin tossing games are randomized)
   4.1 Lottery game
   4.2 Coin tossing game (no price floor)
   4.3 Coin tossing game (with price floor)
5. Payment

1. Sign-in (location and arrival)

- Each participant will present his/her photo ID before he/she will be signed in. The participant will then draw a number out of a bag. This number (personal number of the respondent) randomly determines his/her seat, which is the individual's location throughout the experiment session.
- The experiment will be conducted in sessions of six participants in classrooms in local schools or in a meeting room at the main gathering place of a farmer's group or association.
- Each participant will have his/her own enumerator.
- The typical layout of the room will be as follows:

Front of room (experimenter, and white board)	
Seat 1	Seat 2
Seat 3	Seat 4
Seat 5	Seat 6
Back of room (assistant experimenter/cashier)	

Notes:

- *Text in italics is not part of the participant instructions.*
- *The instructions are explained orally by the experimenter in the local language.*
- *Once all the participants are seated, the explanation will start.*

2. Introduction and agenda

- Hello and welcome. Thank you for coming to our workshop today.
- *The experimenter introduces himself, the enumerators, and the assistant experimenter. The experimenter introduces the institution and the project, typically as follows:*
  - In Uganda, we are conducting a research project on farmers' decision behavior in investment situations.
  - We have been holding discussions with farmers across many parts of Uganda. In particular, we have talked to farmers in …, but we have not been here before.
  - We are very grateful that we can do the workshop in this area today and that you find some time to participate. Thank you very much for that.
  - For the upcoming tasks, you will receive cash payments for the decisions you make. We provide these payments for two purposes:
    1. Because you came here today and you are spending your time with us. This is time in which you could be doing something else, so we would like to remunerate this.
    2. Also, we would like you to take this decision seriously, so that it represents your decision making behavior of normal real life decisions.
- Today's workshop will include the following steps:
  - First, we explain the instructions of the different tasks on decision making.
  - Then, we will do a practice run together to show how it works. Then, you will make your decisions. Today, we will do several types of decisions. In a moment, I will explain all the different tasks on decision making in more detail, one after another.
  - Then, you will receive your payment. Payment will be effected in private and in cash at the end of today's workshop.

I have some additional general comments:

- Please turn off your mobile phones, etc.
- All decisions you make or answers you give during the workshop are private, confidential, and anonymous.
- Since all decisions and answers are private, please do not talk to each other anymore. If you have questions, please ask us by raising your hand.
- Please do not discuss with your neighbor except for the enumerator next to you. The enumerator next to you will record your answers.

- When making decisions, you should make the decision that you prefer the most as you will receive the cash payment on the basis of that decision, given that you have been selected as a winner. Please make your decisions as if they are real-life decisions.
- If there are any questions at any point, please raise your hand and ask.
- Any questions before we start?

3. Quiz

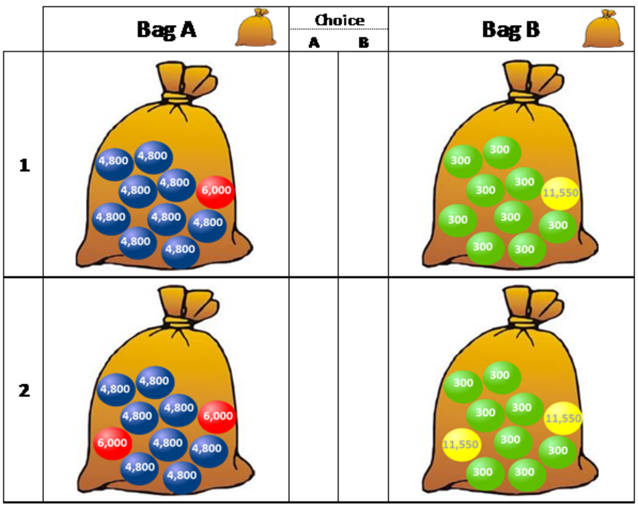
- *The experimenter hands out the questionnaire to the enumerator. Then, explanation and decision making would start.*
- We will start today's workshop with a short quiz.
- The quiz contains several tasks. It is not a test; you do not need to worry if the questions seem difficult.
- *Questions are asked with regard to probabilities and percentage calculation. This basically enables the participants to start thinking about the material and the decisions they will be presented with during the workshop. The participants make their choice, and their enumerators record the answers and tick the relevant box.*
- Now, we are coming to the first task.
- 1. Imagine, we toss a coin and the "head" (emblem) comes up. What comes up if we toss the coin again? (possible answers: a = head, b = tail, c = one cannot predict exactly)
- Now, we are coming to the second task.
- 2. If the chance of winning a prize is 10%, how many people out of 100 would be expected to get the prize? If you don't know, put an X.
- Now, we are coming to the last task of this quiz.
- 3. When you draw the red ball, you win! Look at the two boxes and mark the correct sentence. (Possible answers: a = my chance to win is higher if I choose Box A. b = my chance to win is equal, it does not matter which box I choose. c = my chance to win is higher if I choose Box.)

4. Instructions and decision making

4.1 Lottery game

- In the first session, you are asked to choose between two bags. You will be asked to make a number of repeated choices.
- I will now explain the first session. Then, you will make your decisions in this session.
- *Posters are displayed on a large white board at the front of the room. This is used to illustrate the basics of the game as explained below.*
- The objective of this task is to win money. There are four possible prizes: 300 UGX, 4,800 UGX, 6,000 UGX, and 11,550 UGX. The four different colored balls represent the four possible prizes. The green ball is worth 300 UGX, the blue ball is worth 4,800 UGX, the red ball is worth 6,000 UGX, and the yellow ball is worth 11,550 UGX.
- Note that we will randomly select one winner out of you for this task.
- *Show poster 2: The picture of the sheet with the lottery game*
- *Real balls will also be shown.*

Choose your preferred bag by marking either **Bag A** or **B** in each row.



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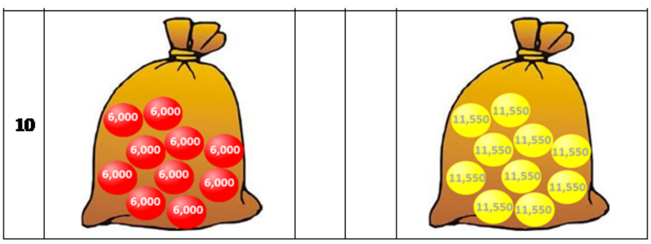
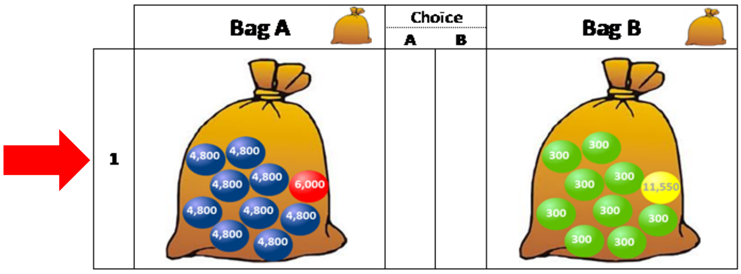
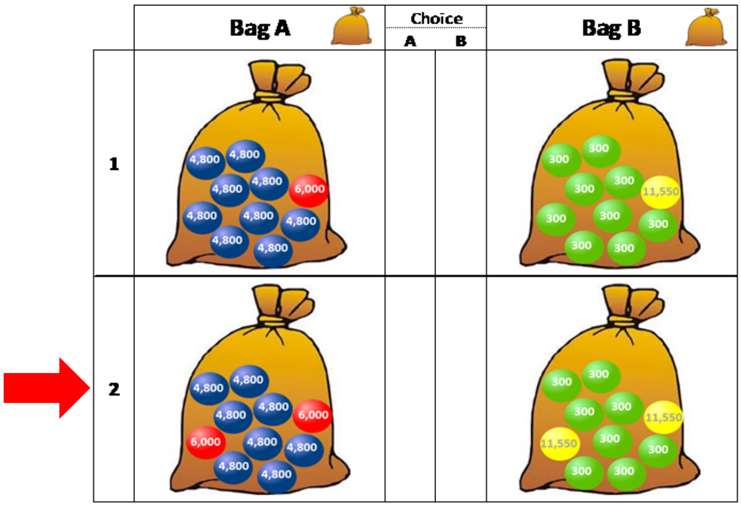


- How are you going to win these prizes?
- To win these prizes, you will first have to choose between two bags, Bag A and Bag B for each of the 10 rows. How do these two bags differ? Each bag contains 10 balls. The two bags contain differently colored balls (green, blue, red, and yellow) with a different value. We draw only one ball of the selected bag, which will be the prize. If you choose Bag A, you can win a prize of 6,000 UGX (red ball) or a prize of 4,800 UGX (blue ball). And if you choose Bag B, you can win a prize of 11,550 UGX (yellow ball) or a prize of 300 UGX (green ball). We are going to ask you which of these two bags you prefer.
- Note that with Bag A the difference between the prizes is small, while it is large in the case of Bag B.
- In addition, in Bag A the prize of 6,000 UGX is smaller than the prize of 11,550 UGX in Bag B, and the prize of 4,800 UGX in Bag A is greater than the prize of 300 UGX in Bag B.
- Thus, you will choose between Bag A and Bag B in 10 rows, one after another.
- Let's focus on the first row.
- *Show poster 2: example for Bag A or Bag B in row one*



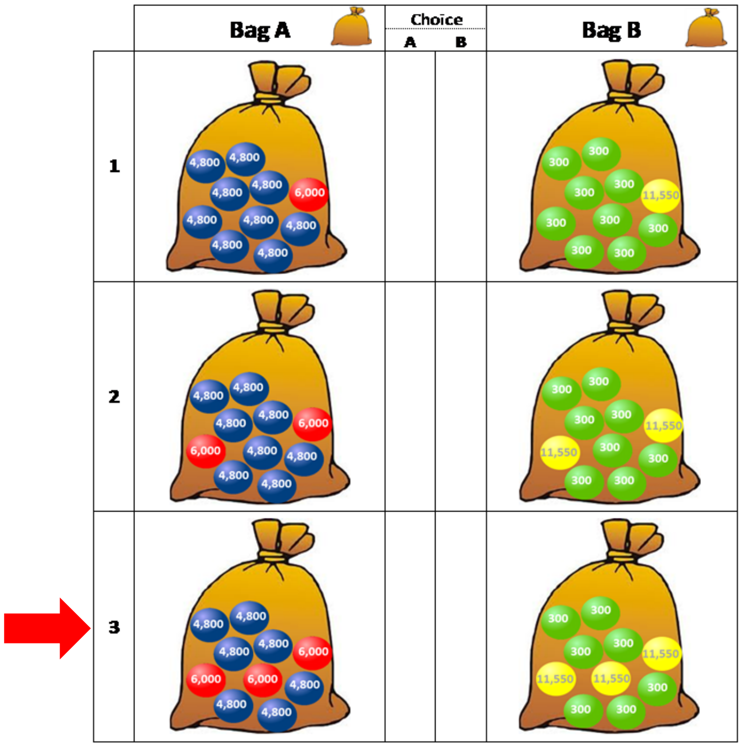
- Bag A:
  - Bag A contains nine blue balls and one red ball. Each blue ball is worth 4,800 UGX, and the red ball is worth 6,000 UGX.
  - If this bag is selected and the red ball is subsequently drawn, you will win 6,000 UGX. In the case that one of the blue balls is drawn, you will win 4,800 UGX.
  - So, if we pick a ball from the bag, it may be blue or red. But, it is more likely that we pick one of the blue balls because there are more blue balls (than red balls) in the bag.

- Bag B:
  - Now, let's look at Bag B. What is different about it? Well, this bag contains nine green balls and one yellow ball. Each green ball is worth 300 UGX, and the yellow ball is worth 11,550 UGX.
  - If this bag is selected and the yellow ball is subsequently drawn, you will win 11,550 UGX. In the case that one of the green balls is drawn, you will win 300 UGX.
  - So, if we pick a ball from the bag, it may be a green or a yellow one. But, it is more likely that we pick one of the green balls because there are more green balls (than yellow balls) in the bag.
- This explains row one. How do the other rows differ from row one?
- *Show poster 3: example for Bag A or Bag B in row two*



- Note that when we go from row one to row two, the only aspect that changes is the number of red balls in the bags. That is, the value of the balls does NOT change.
- Bag A:
  - Bag A contains eight blue balls and two red balls. Each blue ball is worth 4,800 UGX and each red ball is worth 6,000 UGX.
  - If this bag is selected and the red ball is subsequently drawn, you will win 6,000 UGX. In the case that one of the blue balls is drawn, you will win 4,800 UGX.
  - So, if we pick a ball from the bag, it may be blue or red. But, it is more likely that one of the blue balls is drawn because there are more blue balls (than red balls) in the bag.

- Bag B:
  - Bag B contains eight green balls (each worth 300 UGX) and two yellow balls (each worth 11,550 UGX). Each green ball is worth 300 UGX, and each yellow ball is worth 11,550 UGX.
  - If this bag is selected and the yellow ball is subsequently drawn, you will win 11,550 UGX. In the case that one of the green balls is drawn, you will win 300 UGX.
  - So, if we pick a ball from the bag, it may be green or yellow. But, it is more likely that one of the green balls is drawn because there are more green balls (than yellow balls) in the bag.
- *Quiz participants for understanding (control questions):*
- Now, what happens if we go from row two to row three?
- *Show poster 4: example for Bag A or Bag B in row three*



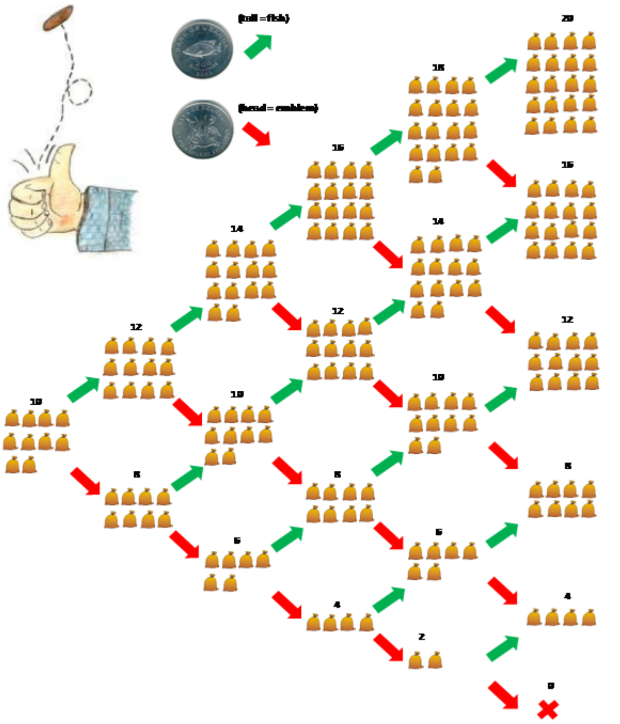
- How many blue and red balls does Bag A contain?
- How many green and yellow balls does Bag B contain?
- Suppose you choose Bag A and the red ball is drawn, how much do you win?
- Suppose you choose Bag B and the yellow ball is drawn, how much is it worth?
- *etc.*

- So, we are going to ask you to decide for bag A or B in each of the 10 rows.
- Note that your choice should really be guided by your preferences. There are no wrong or right decisions.
- *Then, participants are informed that only one row will be selected for payment and that only one person wins the prize.*
- How will we determine the amount of money you will win for participating in this task? Now, we will explain the payment for this game.
- Only one person will receive a payment for one of the choices he/she made in this task. However, you do not know yet for which of the choices the selected person will receive the payment, so that you better think about each choice very carefully. You will only find out at the end of this task for which of these choices the selected person is going to receive a payment.
- The payment in this game comprises three draws:
  - The first draw is to determine the person who wins a prize. Remember, in the beginning of today's workshop, you got a personal number. We will ask one of you to draw a number between 1 and 6 out of a bag. The holder of the number that is picked from the bag will be the winner of one of the prizes.
  - The second draw is to determine the row for which you will get paid. We will ask the selected person to draw a number between one and 10 out of a bag. The number that is picked from the bag will be the choice that counts for the selected person.
  - The third draw is to determine whether the person receives the low or high prize. We will ask the selected person to draw a ball out of Bag A in case he/she chose Bag A or one out of Bag B in case he/she chose Bag B. The ball that is picked from the respective bag will be the choice that counts for him/her.
- Are there any questions before we start?
- *Then, decisions will be made.*
- Which bag do you choose? Choose your preferred bag by marking either Bag A or B in each row.
- *The enumerators ask their farmers for each of the 10 rows which bag they prefer. The participants make their choice by pointing at the bag they prefer, and their enumerators record the answers and tick the relevant box.*

4.2 Coin tossing game (no price floor treatment)

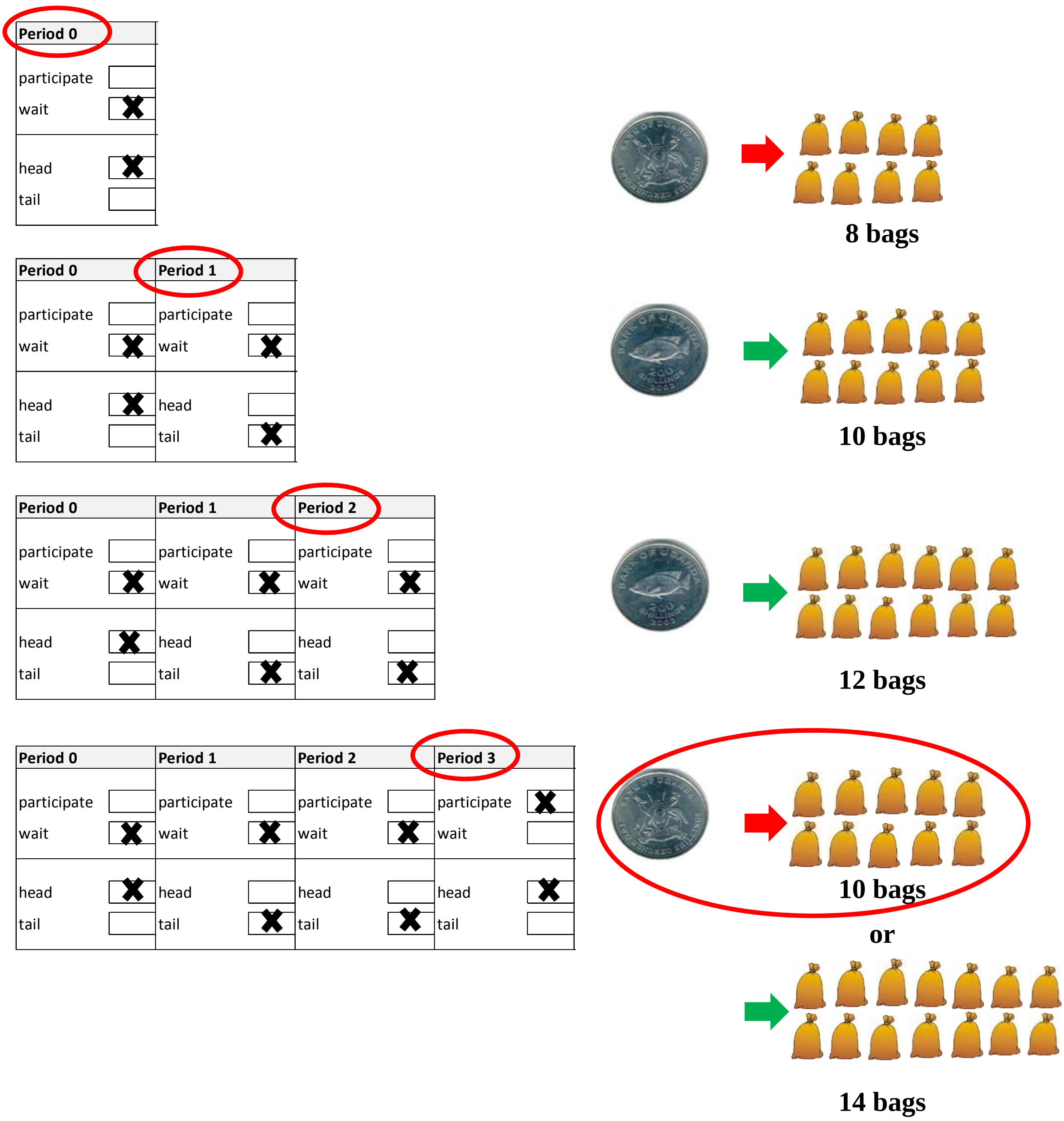
- The second/third session is a coin tossing game. It is possible to buy the right to participate in a coin tossing game and to earn money during the game.
- I will now explain the session. Then, you will make your decisions in this session.
- *Posters are displayed on a large white board at the front of the room. This is used to illustrate the basics of the game as explained below. Calculators are provided in case participants want to use them.*
- The objective of this task is to collect as many bags as possible. The more bags you earn, the greater your earnings. One bag is worth 1,000 UGX.
- The game consists of 10 repetitions of the same game. In each game, you will have the chance to earn some bags. How many bags you earn will depend on your decisions during the game.
- In the beginning of each game, you will have a starting balance of 10 bags.
- Imagine a friend offers you to participate in a coin tossing game. You can decide within 5 periods:
- to either immediately participate in the game and pay 10 bags and get a payoff in the following period,
- to wait and see the development of the bags that can potentially be achieved (up to 4 periods) and to participate in the coin tossing game later
- or not to participate in the coin tossing game and save the 10 bags.
- *Show poster 1: decision tree*
- In the period between 0 and 4, you can decide to participate in the game only once. If you decide to participate in the game, regardless in which period you participate, you have to pay 10 bags.
- Is this clear?
- Any questions at this point?
- The tree chart below shows the possible bags which you can earn in the respective periods when participating in the coin tossing game.
- In each game, you will start with a score of 10 bags in period 0. In the next period (period 1) and in any subsequent period: your bags can either increase by 2 bags or they can decrease by 2 bags depending on a coin that will be tossed, i.e. upper amount if tail (fish) appears or the lower amount if head (emblem) appears.

Period 0		Period 1		Period 2		Period 3		Period 4		Period 5
participate	☐	participate	☐	participate	☐	participate	☐	participate	☐	
wait	☐	wait	☐	wait	☐	wait	☐	not participate	☐	
head	☐	head	☐	head	☐	head	☐	head	☐	
tail	☐	tail	☐	tail	☐	tail	☐	tail	☐	

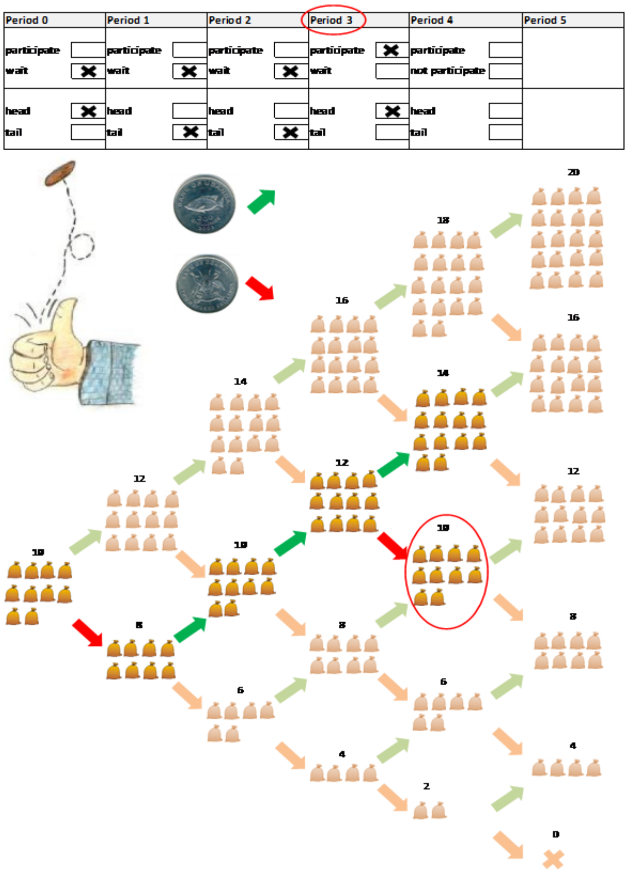


- Each period involves the following steps: You decide whether or not to participate in the coin tossing game. The enumerator will record your decision by marking the appropriate box on the decision form in front of you. Once the enumerator has marked your decision for the period, you can no longer change it. When all of you have made the decisions, the experimenter will toss a coin. The enumerator will mark the appropriate box on the decision form for the coin tossing, i.e. if head or tail appears. We then go to the next period. If you had chosen not to participate in the earlier period, you will make a decision whether or not to participate in this period after having observed the outcome of the previous period. If you had chosen to participate in the coin tossing game, the game is over for you and you have to wait for the next repetition of the game. Nevertheless, we toss the coin for each period in this game.
- We will now see a participation decision example.
- *Show poster 2: participation decision example*
- Imagine, you decide to participate in the coin tossing game in period 3. Tossing the coin will decide how the score will develop (it is a fair coin, i.e. head or tail appear with the same probability).
- In period 0, you do not participate in the game. Nevertheless, the coin will be tossed and head comes up. The bags decrease by 2 bags, from 10 bags to 8 bags.

- In period 1, you still decide not to participate. The coin will be tossed and tail comes up. The bags increase by 2 bags, from 8 bags to 10 bags.
- In period 2, you still decide not to participate. Nevertheless, the coin will be tossed and tail comes up. The bags increase by 2 bags, from 10 bags to 12 bags.
- In period 3, you decide to participate in the game and to pay 10 bags.
- If heads comes up, you will get 10 bags in period 4.
- If tails comes up, you will get 14 bags in period 4.
- We assume that the coin is tossed and head comes up, thus, resulting in a score of 10 bags in period 4.
- The development could be the following:



- *Show poster 3: participation decision example (decision tree)*



- We will now see an example for the calculation of your final account balance.
- *Show poster 4: example calculation final account balance*
- Imagine the situation of the aforementioned example. In period 3 at a score of 12 bags, you decided to participate in the coin tossing game.
- We assume that a coin is tossed and head comes up, thus, resulting in a score of 10 bags in period 4.
- In this case, your total balance of period 5 would be calculated as follows:
- Your starting balance of 10 bags will yield 10% interest by period 3 (10 bags $(0.1 \cdot 3 + 1 = 13$ bags)). This means that for each period you decided not to participate in the game you receive 1 bag.
- In Period 3 you decided to participate in the coin tossing game and to pay 10 bags (13 bags - 10 bags = 3 bags).
- In Period 4, you receive 10 bags from the participation in the coin tossing game.
- These 10 bags will yield 10% interest by Period 5 (another 1 period). (10 bags $(0.1 \cdot 1 + 1)$) = 11 bags.
- In this example, your total balance in Period 5 will correspond to the following:

3 bags + 11 bags = 14 bags.

- In this game, your account balance would be 14 bags in Period 5.
- If this game was randomly selected for the cash premium, you would receive 14,000 UGX.
- Now, we will see an example if you decide not to participate in the coin tossing game.
- For example, if you decide not to participate in the coin tossing game within the 5 periods (between period 0 and period 4), your chance to participate expires, and you will leave the game with your starting balance of 10 bags that has increased to 15 bags over the 5 periods (10 bags (0.1 · 5 + 1= 15 bags)). This means that for each period in that you decided not to participate in the game, you receive 1 bag, which is 10% of your starting balance. You can think of this increase as an interest payment.
- In case this game is randomly selected for the cash premium, you will receive 15,000 UGX.
- Now, we will explain the payment in this game.
- One participant will be randomly selected for payment.
- And only one repetition of the game will be randomly selected for payment. However, you do not know yet for which of the decisions we will pay the chosen participant, so that you better think about each decision very carefully.
- The payment in this game comprises two draws:
  - The first draw is to determine the participant who receives the payment. We will ask one of you to draw a number between 1 and 6 out of a bag. The holder of the number that is picked from the bag will receive the payment.
  - The second draw is to determine the repetition for which the chosen participant will get paid. We will ask the selected person to draw a number between 1 and 10 out of a bag. The number that is picked from the bag will be the choice that counts for payment.
- Before we start the game, we would like to ask you to answer some questions. This is to ensure that you understood the instructions.
- *Participants who did not answer the control questions correctly are informed that they have incorrect answers and are asked to re-think their answers and try again. If they make mistakes again, the enumerator goes over the instructions and quiz them for a third time, and then asks them to proceed regardless of their answers. Importantly, we record the number of attempts each participant needed to answer the control*

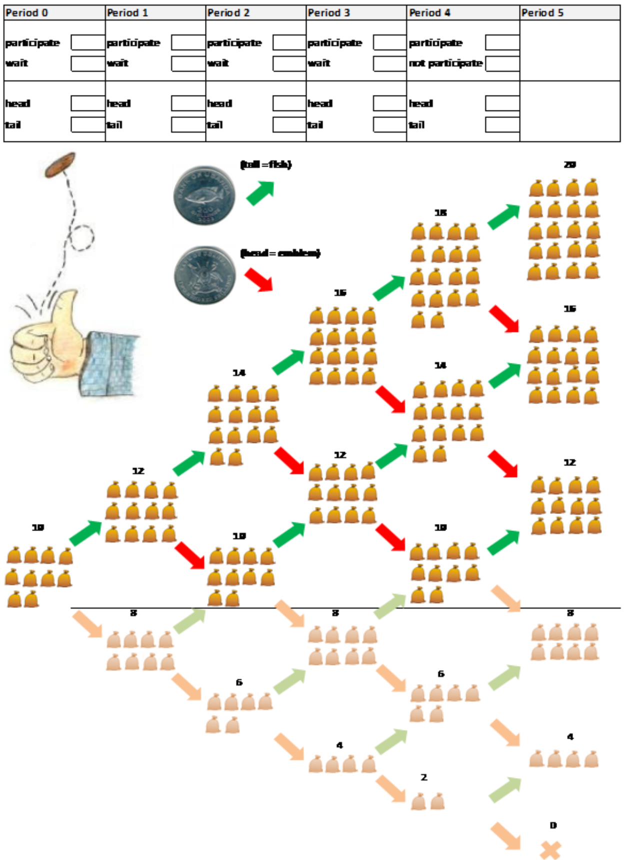
questions correctly.The participants make their choice and their enumerators record the choice.

- *Quiz participants for understanding (questions):*
  - What is the value of 1 bag?
  - If the score of the coin tossing game is 12 bags in one period, which two values can occur in the next period?
  - If you flip a coin, what is the chance that it lands "head" (emblem) or "tail" (fish)?
  - How much is the interest rate?
  - How much do you have to pay if you choose to participate in the coin tossing game?
- We are now going to do a practice period. The purpose of the practice period is to familiarize you with the procedure. Nothing that you do in the practice period will affect your earnings.
- *Practice period*
- This was a practice period. Now, we are going to start the real experiment where you can win real money.
- We are going to ask you to make a decision for each game. Remember that we will repeat this game 10 times.
- Is this clear?
- *Then, decisions will be made.*

4.3 Coin tossing game (with price floor treatment)

- The second/third session is a coin tossing game. It is possible to buy the right to participate in a coin tossing game and to earn money during the game.
- I will now explain the session. Then, you will make your decisions in this session.
- *Posters are displayed on a large white board at the front of the room. This is used to illustrate the basics of the game as explained below. Calculators are provided in case participants want to use them.*
- The objective of this task is to collect as many bags as possible. The more bags you earn, the greater your earnings. One bag is worth 1,000 UGX.
- The game consists of 10 repetitions of the same game. In each game, you will have the chance to earn some bags. How many bags you earn will depend on your decisions during the game.

- In the beginning of each game, you will have a starting balance of 10 bags.
- Imagine a friend offers you to participate in a coin tossing game. You can decide within 5 periods:
- to either immediately participate in the game and pay 10 bags and get a payoff in the following period,
- to wait and see the development of the bags that can potentially be achieved (up to 4 periods) and to participate in the coin tossing game later,
- or not to participate in the coin tossing game and save the 10 bags.
- In the period between 0 and 4, you can decide to participate in the game only once. If you decide to participate in the game, regardless in which period you participate, you have to pay 10 bags.
- Is this clear?
- Any questions at this point?
- The tree chart below shows the possible bags which you can earn in the respective periods when participating in the coin tossing game.
- In each game, we always guarantee you a payoff of 10 bags from participating in the coin tossing game. You will start with a score of 10 bags in period 0. In the next period (period 1) and in any subsequent period: your bags can either increase by 2 bags or they can decrease by 2 bags depending on a coin that will be tossed, i.e. upper amount if tail (fish) comes up or the lower amount if head (emblem) comes up. If the bags decrease under the score of 10 bags (light bags below the black line), you will get the missing bags from us, so that you always have a minimum of 10 bags.
- *Show poster 1: decision tree*



- Each period involves the following steps: You decide whether or not to participate in the coin tossing game. The enumerator will record your decision by marking the appropriate box on the decision form in front of you. Once the enumerator has marked your decision for the period, you cannot change it anymore. When all of you have made the decisions, the experimenter will toss a coin. The enumerator will mark the appropriate box on the decision form for the coin tossing i.e. if head or tail comes up. We then go to the next period. If you had chosen not to participate in the earlier period, you will make a decision whether or not to participate in this period after having observed the outcome of the previous period. If you had chosen to participate in the coin tossing game, the game is over for you and you have to wait for the next repetition of the game. Nevertheless, we toss the coin for each period in this game.
- We will now see a participation decision example.
- *Show poster 2: participation decision example*
- Imagine, you decide to participate in the coin tossing game in period 2. Tossing the coin will decide how the score will develop (it is a fair coin, i.e. head or tail appear with the probability).
- In period 0, you do not participate in the game. Nevertheless, the coin will be tossed and tail comes up. The bags increase by 2 bags, from 10 bags to 12 bags.

- In period 1, you still decide not to participate. The coin will be tossed and head comes up. The bags decrease by 2 bags, from 12 bags to 10 bags.
- In period 2, you decide to participate in the game and to pay 10 bags.
- If heads comes up, you will get 8 bags in period 3.
- If tails comes up, you will get 12 bags in period 3.
- We assume that the coin is tossed and head comes up, thus, resulting in a score of 8 bags in period 3.
- The development could be the following:

Period 0	
participate	
wait	X
head	
tail	X

12 bags

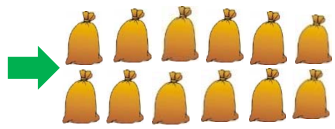
Period 0		Period 1	
participate		participate	
wait	X	wait	X
head		head	X
tail	X	tail	

10 bags

Period 0		Period 1		Period 2	
participate		participate		participate	X
wait	X	wait	X	wait	
head		head	X	head	X
tail	X	tail		tail	

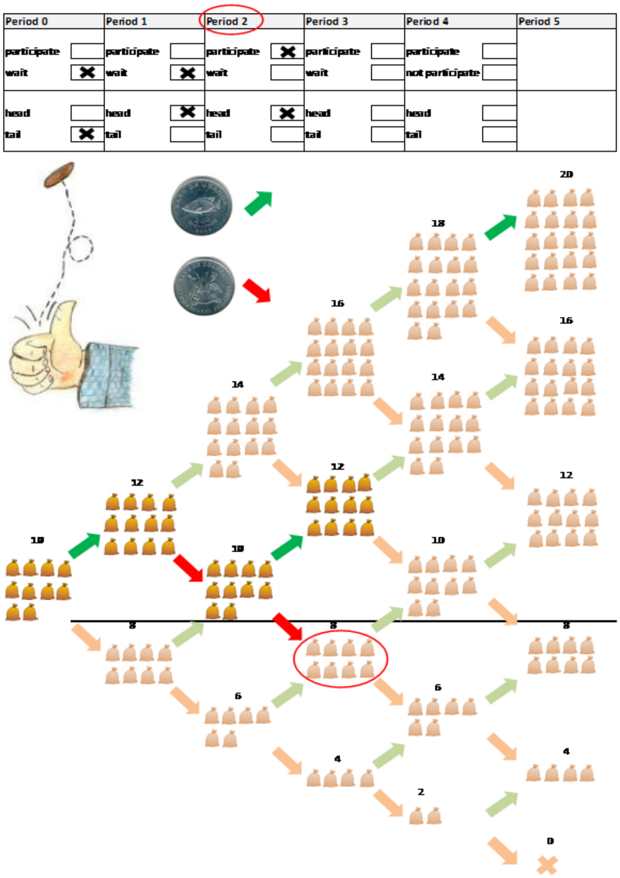
8 bags

or



12 bags

- *Show poster 3: participation decision example (decision tree)*



- We will now see an example for the calculation of your final account balance.
- *Show poster 4: example calculation final account balance*
- Imagine the situation of the aforementioned example. In Period 2 at a score of 10 bags, you decided to participate in the coin tossing game.
- We assume that in period 3 a coin is tossed and head comes up, thus, resulting in a score of 8 bags.
- In this case, your total balance of period 5 would be calculated as follows:
- Your starting balance of 10 bags will yield 10% interest by period 2 (10 bags (0.1 · 2 + 1 = 12 bags)). This means that for each period you decided not to participate in the game you receive 1 bag.
- In Period 2 you decided to participate in the coin tossing game and to pay 10 bags (12 bags - 10 bags = 2 bags).
- In Period 3, you receive 8 bags from the participation in the coin tossing game. In this case the bags decrease under the score of 10 bags (light bags below the black line). As we guarantee you a payoff of 10 bags, you will get the 2 missing bags from us.
- These 10 bags will yield 10% interest by Period 5 (another 2 periods). (10 bags (0.1 · 2 + 1)) = 12 bags.

- In this example, your total balance in Period 5 will correspond to the following:
  2 bags + 12 bags = 14 bags.
- In this game, your account balance would be 14 bags in Period 5.
- If this game was randomly selected for the cash premium, you would receive 14,000 UGX.
- Now, we will see an example if you decide not to participate in the coin tossing game.
- For example, if you decide not to participate in the coin tossing game within the 5 periods (between period 0 and period 4), your chance to participate expires and you will leave the game with your starting balance of 10 bags that has increased to 15 bags over the 5 periods (10 bags (0.1 · 5 + 1= 15 bags)). This means that for each period in that you decided not to participate in the game, you receive 1 bag, which is 10% of your starting balance. You can think of this increase as an interest payment.
- In case this game is randomly selected for the cash premium, you will receive 15,000 UGX.
- Now, we will explain the payment in this game.
- One participant will be randomly selected for payment.
- Only one repetition of the game will be randomly selected for payment. However, you do not know yet for which of the decisions we will pay the chosen participant, so that you better think about each decision very carefully.
- The payment in this game comprises two draws:
  - The first draw is to determine the participant who receives the payment. We will ask one of you to draw a number between 1 and 6 out of a bag. The holder of the number that is picked from the bag will receive the payment.
  - The second draw is to determine the repetition for which the chosen participant will get paid. We will ask the selected person to draw a number between 1 and 10 out of a bag. The number that is picked from the bag will be the choice that counts for payment.
- Before we start the game, we would like to ask you to answer some questions. This is to ensure that you understood the instructions.
- *Participants who did not answer the control questions correctly are informed that they have incorrect answers and are asked to re-think their answers and try again. If they make mistakes again, the enumerator goes over the instructions and quiz them for a third time, and then asks them to proceed regardless of their answers. Importantly, we record the number of attempts each participant needed to answer the control*

questions correctly. The participants make their choice and their enumerators record the choice.

- *Quiz participants for understanding (questions):*
  - What is the value of 1 bag?
  - If the score of the coin tossing game is 12 bags in one period, which two values can occur in the next period?
  - If you flip a coin, what is the chance that it lands “head” (emblem) or “tail” (fish)?
  - How much is the interest rate?
  - How much do you have to pay if you choose to participate in the coin tossing game?
  - How many bags do we always guarantee you in case the bags decrease under the score of 10 bags?
- We are now going to do a practice period. The purpose of the practice period is to familiarize you with the procedure. Nothing that you do in the practice period will affect your earnings.
- *Practice period*
- This was a practice period. Now, we are going to start the real experiment where you can win real money.
- We are going to ask you to make a decision for each game. Remember that we will repeat this game 10 times.
- Is this clear?
- *Then, decisions will be made.*

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