GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

GlobalFood

www.uni-goettingen.de/globalfood

RTG 1666 GlobalFood

Transformation of Global Agri-Food Systems:
Trends, Driving Forces, and Implications for Developing Countries

Georg-August-University of Göttingen

GlobalFood Discussion Papers

No. 9

Comparison of the Investment Behavior of German and Kazakhstani Farmers: an Experimental Approach

Dulat Tubetov
Syster Christin Maart
Oliver Musshoff

April 2012

RTG 1666 GlobalFood · Heinrich Düker Weg 12 · 37073 Göttingen · Germany
www.uni-goettingen.de/globalfood

ISSN (2192-3248)

Comparison of the Investment Behavior of German and Kazakhstani Farmers: an Experimental Approach

Dulat Tubetov[a1], Syster Christin Maart[a], Oliver Musshoff[a]

[a]Department of Agricultural Economics and Rural Development, Georg-August-Universität Göttingen, Platz der Göttinger Sieben 5, D-37073, Göttingen, Germany.

Abstract

Kazakhstan and Germany have different development levels of the agricultural sectors. One of the explanations for this fact might be the different investment behavior of farmers in the two countries. We experimentally analyze whether the investment behavior of farmers is consistent with the normative benchmarks of the net present value criterion or the real options approach. Furthermore, we experimentally compare the investment behavior of farmers in the two countries in an agricultural and a non-agricultural treatment. In addition, farmers were confronted with the two treatments in a different order. Our results show that both theories cannot exactly predict the investment behavior of farmers. Farmers invest later than the net present value criterion suggests and earlier than the real options approach suggests. However, German farmers invest later than Kazakhstani farmers, which mean that the investment behavior of German farmers is more in accordance with the superior real options approach. Therefore, the different investment behavior might partly be an explanation for different development levels of the agricultural sectors of the two countries. Moreover, results are independent from the framing of an agricultural and a non-agricultural treatment. However, farmers learn from their former investment decisions and consider the value of waiting over time.

Keywords:

Experimental Economics, Investment Timing, Real Options, Kazakhstan, Germany

JEL classification: C91, D03, D81, D92

[1]Corresponding author. Email: dtubeto@uni-goettingen.de. Tel. +49(0)551394841 Fax. +49(0)5513922030

1. Introduction

Kazakhstan and Germany are two representative examples for a currently transforming country and a Western industrialized country, respectively. The agricultural sectors of Kazakhstan and Germany have different levels of development. This fact can be substantiated by comparing some indicators: The added value per labor of the Kazakhstani agricultural sector equals $2,033, while the added value per labor of the German agricultural sector is $31,659 (World Bank, 2011a). The average yield of cereals is 1,254 kg/hectare in Kazakhstan and 7,201 kg/hectare in Germany (World Bank, 2011b). An average annual milk productivity of cows amounts to 2,241 kg/cow in Kazakhstan and to 6,643 kg/cow in Germany (Food and Agriculture Organization of the U.N., 2011).

There are several explanation concepts for the aforementioned differences. First, Kazakhstan and Germany are situated in two geographically different locations with diverse weather conditions. Kazakhstan has an extreme continental type of climate with an average annual rainfall of 400 mm, while Germany has a moderate continental climate with an average annual rainfall of 770 mm. That means that the land fertility in Germany is positively affected by high soil moisture as well as mild weather conditions. Second, the two countries have a different political and economic situation. Western Germany is considered to be a country with the predictable and stable economy, which has not experienced shocks since World War II. In contrast, Kazakhstan declared its independence only 20 years ago, as a result of the dissolution of the Soviet Union. Although the country has launched significant reforms during a short period of time, it still has a relatively young market economy in which some mechanisms still are not effectively adjusted.

A further explanation for the observed discrepancy between the development levels of the agricultural sectors of the two countries might be the different investment behavior of farmers. Investment decisions play an important role in economic development and growth of an agricultural sector. The production volume, employment rate, structural changes, and the dynamics of business cycles in agriculture are determined to a great extent by the investment decisions of farmers. As stated by Gardebroek and Oude Lansink (2004), it is necessary to understand investment decisions at the farm level to be able to analyze structural developments in farming.

There are different investment theories that could be used to analyze the investment decisions of farmers. The net present value (NPV) is a very common approach for evaluating investment decisions (Mathews and Short, 2001; Vanhoucke et al., 2001). According to this approach, the value of the investment corresponds to its NPV, which is the difference between the present value of the expected incremental cash flows and the investment costs. The approach recommends conducting an investment if its NPV is positive. Another comparatively new framework is the real options approach (ROA) (Odening et al., 2005; Luong and Tauer, 2006; Seo et al., 2008; Richards et al., 2009). From a normative point of view, the ROA is more advantageous for the valuation of investment decisions than the NPV. The ROA asserts that an investor might increase returns by postponing an irreversible investment decision instead of realizing the investment instantly even if it has a positive NPV. The ROA states that there might be an advantage in waiting to invest until the uncertainty on the future returns has cleared up since new information regarding the investment returns might occur. As long as the investment has not been realized, the investor has the flexibility to reject the investment in the case of "bad news" (Dixit and Pindyck, 1994, p. 6). Carrying out the investment "kills" the investment option. The lost option value has to be included in the investment cost and has to be covered by the expected cash flows from the investment. That means, compared to the NPV, the ROA requires a higher performance of the investment in order to accept an investment decision. In the context of our study, we suppose that different development levels of the agricultural sectors of Kazakhstan and Germany might be partly explained by the different investment behavior of Kazakhstani and German farmers. We expect that German farmers take into account the value of waiting more than Kazakhstani farmers when they make investment decisions. Therefore, more optimal investment decisions of German farmers result in the higher level of performance of investments and partly contribute to the higher level of development of the agricultural sector than it can be observed in Kazakhstan.

Although the benefits of real options have been presented by theoretical studies, it is not certain if investors make investment decisions in accordance with the ROA or the traditional NPV criterion. There are econometric studies regarding the analysis of the investment behavior (O'Brien et al., 2003; Hinrichs et al., 2008). The observation of farmers' investment decisions might be of little use in this context since investment decisions for a capital intensive object (such as a cow barn or a biogas plant) are relatively rare in the agricultural business (Gardebroeck and Oude Lansink, 2008). Moreover, basic conditions like financial resources differ among farms (Wale et al., 2005; Joshi and Pandey, 2006). Hence, it is hardly possible to draw meaningful conclusions from econometric analyses regarding investment behavior. An experimental analysis of the investment behavior of entrepreneurs could be used to avoid these problems.

An advantage of laboratory experiments is that they give the researcher the possibility to collect the data under controlled conditions. An experiment can be designed in a way that it allows the researcher to change desired variables and hold the other variables permanent. A review of the existing literature shows that, in spite of its relevance, experimental studies on the investment behavior are still scarce. Rauchs and Willinger (1996) were among the first who experimentally investigated the effects of the ROA. They tried to identify how irreversibility of choices influences the investment behavior of subjects under uncertainty. Howell and Jägle (1997) asked 82 skilful managers to value a set of real options parameters encountered in their workplaces. The options were valued irregularly and optimistically. Yavas and Sirmans (2005) used an experimental methodology to test the optimal timing of an investment and found that participants invest earlier than predicted by the ROA. However, when participants competed with each other for the right to invest, their willingness to pay for an investment opportunity reflected an option value. Oprea et al. (2009) examined in experimental settings whether the optimal exercise of wait options can be closely approximated if a subject has the opportunity to learn from personal experience. Denison (2009) analyzed whether the application of the ROA in capital budgeting reduces the tendency of decision makers to continue a project after incurring losses. In a recent study, Sandri et al. (2010) carried out an experiment with students and high-tech entrepreneurs to test the applicability of the ROA for decisions to exit a business. All these aforementioned studies mainly focus on the decision behavior of student participants and they do not compare the investment behavior of entrepreneurs in developed and developing countries.

Hence, the objective of our study is to experimentally examine the investment behavior of Kazakhstani and German farmers. To achieve this objective, we run an experiment on repeatedly ongoing investment opportunities in an agricultural and in a non-agricultural treatment. Within each repetition, farmers should decide to postpone or realize an investment. As the investment behavior could be influenced by the decision makers’ risk attitudes (Knight et al., 2003), an additional experiment based on a Holt and Laury lottery (HLL) is carried out (Holt and Laury, 2002). We analyze whether the investment behavior of farmers is consistent with the NPV or the ROA. A further objective of our study is to test whether the investment behavior of German farmers differs from that of Kazakhstani farmers. We also test the presence of a learning effect in the investment behavior of farmers. In particular, we analyze if farmers learn from their experience during the experiment and invest more in accordance to the ROA over the repetitions. In addition, we define farmer-specific variables and factors causing cognitive bias related to the design of the experiment, which also might influence the investment behavior of Kazakhstani and German farmers. In the framework of factors causing cognitive bias, we test whether the framing of an investment treatment (agricultural vs. non-agricultural investment context) and the order how farmers are confronted with the treatments have an influence on their investment behavior. We suppose that this comparative study could be interesting for readers considering the fact that Kazakhstan grew up in a centrally planned administrative economy and West Germany in a market-oriented environment. Furthermore, improved policy impact analysis is possible when investment decisions are well understood at the farm level.

The study closest to ours is Sandri et al. (2010) who experimentally analyzed a disinvestment problem. However, our study significantly differs from their study. First, we focus on investment decisions instead of disinvestment decisions. Second, our experimental subjects are farmers. Third, to derive our normative benchmark, we do not assume risk neutrality of decision makers. Rather individual risk propensity is explicitly taken into account when determining the normative benchmark for investment decisions. Finally, to our knowledge, this is the first study which experimentally compares investment behavior between decision makers in a developing and a developed country.

Section 2 presents the derivation of hypotheses. Section 3 describes the experimental settings, while Section 4 shows how normative benchmarks were calculated. In section 5, descriptive statistics and the approach to data analysis are presented. The results of the experiments are discussed in Section 6. Finally, the paper ends with conclusions (Section 7).

2. Derivation of hypotheses and theoretical background

The classical investment theory has been frequently used for evaluating the investment behavior of entrepreneurs (Singh et al., 2010; Wu et al., 2010). It suggests that investment should be realized immediately as soon as its NPV gets a positive value; otherwise it needs to be cancelled. In contrast to the NPV approach, the ROA states that the investor may increase profits by deferring an investment decision instead of realizing the investment immediately, even if the NPV is positive. The value of deferring an investment decision is especially pronounced if investment is at least partially sunk or irreversible and the expected returns of the investment are uncertain (Pindyck, 1991). When the investor carries out the investment she or he loses the option to wait for new information, which might have changed the investment decision. This lost option value has to be included in the investment cost and has to be covered by the expected investment returns. As a result, this requires a higher investment trigger than that suggested by the NPV rule in order to make an investment decision (Dixit and Pindyck, 1994, 6-7).

In the following, we describe an investment situation to derive the NPV and the ROA related hypotheses. Imagine the rational farmer, who plans to invest in land. The investment can be realized only once - either immediately or it can be deferred up to one period. The cost of the investment I is fixed at 100,000 and must be paid immediately after realizing the investment. The costs of the investment are completely sunken once it has been implemented. The future development of the present value of the investment returns paid out one period after implementation is uncertain and modeled by a binomial approximation of the arithmetic Brownian process in discrete time. We assume that the present value of an investment in period 0 is V_0 =120,000, whereas the present value in period 1 will change. With probability p =50%, the present value in period 1 will rise by h =20,000, and with probability $1-p$, it will fall by h. In period 2, the present value can take the following 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 $2 \cdot p \cdot (1-p)$. The question arises under which conditions this hypothetical investment should be realized.

To answer this question the value of the investment opportunity has to be calculated. The value of an investment $\hat{F}$ according to the NPV rule can be calculated as follows:

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

where

$$E(NPV_0) = \left(\left(p \cdot (V_0 + h) + (1-p) \cdot (V_0 - h)\right) \cdot q^{-1}\right) - I$$

$E(\cdot)$ indicates the expectation operator and $q^{-1} = 1/(1+r*)$ is a discount factor and $r*$ denotes the risk-adjusted discount rate. In the example, we assume a risk neutral decision maker with a risk-adjusted discount rate equal to the risk-free interest rate of 10%. That means for our example:

$$\begin{aligned} E(NPV_0) &= \left(\left(0.5 \cdot (120{,}000 + 20{,}000) + (1-0.5) \cdot (120{,}000 - 20{,}000)\right) \cdot 1.1^{-1}\right) - 100{,}000 \\ &= 9{,}091 \end{aligned}$$

But how high must the present value be to induce farmers to invest? To answer this question it is necessary to calculate the investment trigger, which is the critical present value of the investment returns that initiates the investment. The investment trigger $\hat{V}_0$ can be derived by equating the expected present value of the investment returns defined in equation (1) and the investment cost I:

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

That means for our example:

$$\hat{V}_0 = 20{,}000 - 2 \cdot 0.5 \cdot 20{,}000 + 100{,}000 \cdot 1.1 = 110{,}000$$

The optimal investment behavior changes if it is taken into account that the decision to invest can be postponed up to one period. The postponement of the investment decision is valuable since new information about the expected present value may become available in the subsequent period. A rational decision maker would only invest immediately if the current expected NPV is higher than the discounted expected NPV of investing one period later. The value of an investment $\tilde{F}$ according to the ROA is defined as follows:

$$\tilde{F} = \max\left(E(NPV_0); E(NPV_1) \cdot q^{-1}\right), \tag{3}$$

where

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

The first term on the right-hand side of equation (3) is the expected NPV in period 0. The second term is the discounted expected NPV of investing one period later. For our example this means the following:

$$\begin{aligned} E(NPV_1) = &\left(0.5 \cdot \left((0.5 \cdot (120{,}000 + 2 \cdot 20{,}000) + (1-0.5) \cdot (120{,}000 + 20{,}000 - 20{,}000)\right)\right. \\ &\left.\cdot 1.1^{-1} - 100{,}000\right) + (1-0.5) \cdot 0\big) \cdot 1.1^{-1} = 12{,}397 \end{aligned}$$

If we wait one period before deciding whether to invest in farmland or not, the discounted expected value of the NPV in period 1 is 12,397, whereas, the expected value of the NPV in period 0 is 9,091. Therefore, in our example, it is clearly better to wait one period instead of investing immediately. We receive the investment trigger $\tilde{V}_0$ by equating (1) and (3):

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

That means for our example:

$$\tilde{V}_0 = \frac{1.1 \cdot 20{,}000 - 2 \cdot 0.5 \cdot 1.1 \cdot 20{,}000 + 100{,}000 \cdot 1.1^2 + 2 \cdot 0.5^2 \cdot 20{,}000 - 0.5 \cdot 100{,}000 \cdot 1.1}{1.1 - 0.5}$$
$$= 126{,}667$$

The investment trigger following the NPV differs from the investment trigger following the ROA. The difference between the two triggers amounts to

$$\tilde{V}_0 - \hat{V}_0 = \frac{p \cdot h}{q - p} = \frac{0.5 \cdot 20{,}000}{1.1 - 0.5} = 16{,}667 \tag{5}$$

It can be seen that $\hat{V}_0$ is smaller than $\tilde{V}_0$ as long as $p > 0$. The ROA is more advantageous than the NPV criterion because it leads to higher performance (returns) from the investment. Against this background, we can formulate the following hypotheses:

Hypothesis H1 “NPV conformity”: The investment behavior of farmers is consistent with the NPV.

Hypothesis H2 “ROA conformity”: The investment behavior of farmers is consistent with the ROA.

As already mentioned in the introduction, different development levels of the agricultural sectors of Kazakhstan and Germany might be explained by the fact that when making investment decisions, German farmers might consider the value of waiting more than Kazakhstani farmers. Therefore, we want to test the following hypothesis:

Hypothesis H3 “country differences”: The investment timing of German farmers is closer to the optimal investment periods predicted by the ROA than those of Kazakhstani farmers.

In reality, entrepreneurs tend to perform various operations repeatedly. During these repetitions they are learning from their previous experience, which helps them to make optimal decisions. This phenomenon was studied and described by Brennan (1998), Oprea et al. (2009) and Gilbert and Harris (1981) with reference to investment decisions. In our experiment, farmers deal with repeating investment opportunities and we test the presence of a learning effect in the investment behavior of farmers. In particular, we test the following hypothesis:

Hypothesis H4 “learning effect”: With increasing number of repetitions the investment timing of farmers will approximate to the optimal investment periods predicted by the ROA.

Farmer-specific variables also could have a considerable impact on the investment behavior of farmers. Therefore, our fifth hypothesis is:

Hypothesis H5 “farmer-specific variables”: Farmer-specific variables have a significant influence on the investment behavior of farmers.

We focus on nine farmer-specific variables, which are selected from the literature related to investment behavior. They are reputed to have a strong positive or negative relationship with investment behavior:

- The variable “farm size” measures the size of arable land of a farm. Savastano and Scandizzo (2009) found out that the larger the farmer`s present use of land is, the higher is the threshold value of the revenue per hectare to justify further land development. That means the larger the size of original land is, the later is the time at which the farmer exercises the option to invest in new land. The positive relation between land size and the threshold value was explained by the fact that larger size of farmland is associated with decreasing return to scale and increasing uncertainty. We expect that the variable “farm size” will lead to the prolongation of the investment period of farmers.

- The variable “farm type” is accounted for a series of binary variables for farm specialty. The farm type variable has a value of 1 for crop producing farms and 0 for farms specializing in animal husbandry, fodder production, processing of agricultural products and other types of agricultural activity. O`Brien et al. (2003) stated that entry into some target industries requires more irreversible investments compared to other industries. Subsequently, they argue that as the level of irreversibility of investments required to enter an industry increases, uncertainty will have a stronger negative effect on entry. We consider that crop producing farms own less assets with irreversible costs than other types of farms. Therefore, we expect that crop producing farms will invest earlier than non-crop producing farms.
- A study by Gardebroek and Oude Lansink (2004) found that age reduces the willingness of farmers to invest. The older farmer is willing to invest only if the marginal benefits of the investment are high. In the present study, we therefore expect that older farmers will invest later than younger farmers because they are more reluctant to make investments.
- The dummy variable “gender” is used as an independent variable because prior research on gender showed that women make more conservative investment decisions (Coleman, 2003; Jianakoplos and Bernasek, 1998; Bajtelsmit and VanDerhei, 1997). Based on that, we expect that female farmers are more reluctant to make investment decisions and, therefore, will invest later than male farmers.
- Considering the level of the education of farmers, we distinguish between the variables “higher education” and “economic education”. The first variable indicates whether or not the farmer has higher education, while the second variable indicates whether or not the farmer holds a degree in an economy-related subject. Managers with higher education and with a degree in a business-related subject estimate the value of a real option, and, therefore, the value of waiting higher than those who do not have higher education (Howell and Jägle, 1997). Therefore, we expect that farmers with higher education and with economic education will invest later than other farmers.
- The variable “family size” indicates the number of family members of the farmer. Lewellen et al. (1977) found that investors with many dependents stick to conservative

investment behavior. Based on their study we expect that the larger the family of the farmer is the later she or he will invest.

- The variable “farmer`s income type” is a dummy variable that measures whether or not farming is a principal income for the farmer. Adesina et al. (2000) suggested that an additional non-agricultural income may allow farmers to meet capital costs for technology implementation, which increase the likelihood to adopt new technology. Therefore, we expect that farmers with a principal income from farming are more reluctant to invest due to financial restrictions, which will lead to later investment timing.
- The variable “HLL value” is a person-specific measure of the risk preferences and equals to the number of safe choices made by farmers during the HLL experiment. Higher values of HLL correspond to a more risk-averse decision maker. Kroll and Viskusi (2011) argue that risk-averse respondents make less investment decisions. This could also be considered as the manifestation of investment reluctance. We expect that the higher level of individual risk-aversion will lead to later investment decisions.

The investment behavior of farmers during the experiment might be biased by the design of the experiment. In order to control these biases, we additionally derive two hypotheses. Firstly, we pay attention to a framing effect based on the findings in other studies. They experimentally demonstrated that participants are more “attached” to a project, which is described in terms that are more familiar to them (Bettman and Sujan, 1987; Cronk and Wasielewski, 2008). In our study, we suppose that a treatment describing farmland investment will be closer to the perception of farmers than a treatment describing investment in a coin tossing game. Subsequently, we expect that farmers will show different investment behavior depending on the framing of a treatment. Thus, our sixth hypothesis is:

Hypothesis H6 “framing effect”: Farmers demonstrate different investment behavior if they are confronted with an agricultural or a non-agricultural investment treatment.

Secondly, responses given in a series of questions and treatments often depend on the order in which these questions and treatments are presented to a respondent (Perreault, 1975-6; Macfie et al., 1989; Legrenzi et al., 1993). With respect to our study that means that the order in which farmers are confronted with both treatments might influence their investment decision behavior. Therefore, we formulate our last hypothesis as follows:

Hypothesis H7 “order effect”: Farmers demonstrate different investment behavior depending on the order how they are confronted with an agricultural and a non-agricultural investment treatment.

3. Experimental setting

The experiment consisted of three parts. The first part described two investment treatments stylizing an agricultural and a non-agricultural option to invest. In the second part, a HLL experiment was conducted in order to elicit the risk attitudes of farmers. The final part was a questionnaire gathering data about the socio-demographic characteristics of participants. There was no time constrain for participants in the experiment. Participants spent on average about 45 minutes for completing the experiment.

The first part was carried out in two treatments differing in the framing. In the Appendix, we give English version of the Russian and German instructions used in the experiment. In an agricultural investment treatment, participants had the hypothetical possibility to invest in farmland. We chose farmland as an exemplary investment object because it is one of the most important production factors in agriculture (Turvey, 2003) and therefore we expected that farmers might be more “attached” to it. In a non-agricultural treatment, participants were given the hypothetical possibility to purchase the right to participate in a coin tossing game. The order in which participants were confronted with the treatments was randomly determined. Each participant was confronted with ten (individual) randomly determined paths of the binomial tree for each treatment. The entire binomial tree was newly determined by a random mechanism. Hence, over the course of the entire experiment, each respondent was confronted with 20 potentially different, randomly determined paths of the binomial tree. Apart from the different wording of the investment treatments, the parameters in the experiment (initial outlay, interest rate, standard deviation of returns etc.) were the same. Participants were informed about all parameters before the experiment started. To ensure that participants understood the instructions, they had to answer some control questions before the incentive compatible part of the real options experiment started (see Appendix for this information). Furthermore, a trial round gave participants the opportunity to become acquainted with the experiment.

The design of the real options experiment employed the model outlined in the previous section. Within each repetition, respondents could decide to take part an ongoing investment opportunity in one of ten periods. In every repetition, participants started the experiment with a deposit of 100,000 points. The initial investment outlay was also 100,000 points. According to a binomial approximation of an arithmetic Brownian process in discrete time, the returns evolved stochastically over ten periods with no drift but with a standard deviation of 20,000 points. The probability that the returns increase or decrease for 20,000 points equaled 50%. The return in period 0 was always 100,000 points. The risk-free interest rate was fixed at 10%. The binomial tree of potential returns in figure 1 with their associated probabilities of occurrence was displayed on a screen and accordingly adjusted.

Participants had three possibilities: First, participants could pay the initial outlay of 100,000 points in period 0 and receive the return of period 1. Second, participants could decide to postpone the investment decision until period 9. Third, participants could invest in none of 10 periods and save the initial outlay of 100,000 points.

If participants realized the investment in period 0, they paid the initial outlay of 100,000 points and acquired 120,000 points or 80,000 points with probability 50% in period 1 and the first repetition ended. In an agricultural treatment, the return could be seen as the present value of an investment which participants could earn in the respective periods. The return corresponded to the present value of the gross margin, which could be achieved during

Period 0	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10
										300 (0.1%)
									280 (0.2%)	
								260 (0.39%)		**260** (0.98%)
							240 (0.78%)		**240** (1.76%)	
						220 (1.56%)		**220** (3.13%)		**220** (4.39%)
					200 (3.13%)		**200** (5.47%)		**200** (7.03%)	
				180 (6.25%)		**180** (9.38%)		**180** (10.94%)		**180** (11.72%)
			160 (12.5%)		**160** (15.63%)		**160** (16.41%)		**160** (16.41%)	
		140 (25%)		**140** (25%)		**140** (23.44%)		**140** (21.88%)		**140** (20.51%)
	120 (50%)		**120** (37.5%)		**120** (31.25%)		**120** (27.34%)		**120** (24.61%)	
100		**100** (50%)		**100** (37.5%)		**100** (31.25%)		**100** (27.34%)		**100** (24.61%)
	80 (50%)		**80** (37.5%)		**80** (31.25%)		**80** (27.34%)		**80** (24.61%)	
		60 (25%)		**60** (25%)		**60** (23.44%)		**60** (21.88%)		**60** (20.51%)
			40 (12.5%)		**40** (15.63%)		**40** (16.41%)		**40** (16.41%)	
				20 (6.25%)		**20** (9.38%)		**20** (10.94%)		**20** (11.72%)
					0 (3.13%)		**0** (5.47%)		**0** (7.03%)	
						-20 (1.56%)		**-20** (3.13%)		**-20** (4.39%)
							-40 (0.78%)		**-40** (1.76%)	
								-60 (0.39%)		**-60** (0.98%)
									-80 (0.2%)	
										-100 (0.1%)

Fig. 1. Binomial tree of potential investment returns.
Notes: 1. The associated probabilities of occurrence are indicated in parentheses.
2. The investment returns are given in thousand points.

an infinite useful lifetime of the investment object. Moreover, it was assumed that the gross margin observed at the period after the investment realisation was guaranteed by an appropriate insurance during the entire useful lifetime. That means that the risk-free interest rate is the appropriate discount rate for determining the present value of the investment returns. This assumption of an infinite useful lifetime was described by Dixit and Pindyck (1994) (see the two-period example in Section 2). Therefore, a gross margin of e.g. 12,000 points per period resulted in a present value of 120,000 points, while a gross margin of e.g. 8,000 points per period resulted in a present value of 80,000 points. If the investment was made in period 0, the cells of the tree in the following periods were deactivated. In case participants did not invest in period 0, they faced again with the investment decision in period 1. It was randomly determined if the return in period 2 increased or decreased starting from the value of period 1. Potential return developments, which were not relevant anymore, were suppressed and probabilities for future present values were updated. This process was repeated until expiration of the investment option in period 9. The deposit and the returns less the initial outlay realized before period 10 increased by an interest rate of 10% for every period left in the tree.

The design of the HLL carried out in the second part of the experiment, is illustrated in Table 1. In this lottery, participants could choose between two alternatives: The first alternative provided the opportunity to win 4,000 tenge[2] or 3,200 tenge with probabilities of 10% and 90%, respectively. The second alternative provided the opportunity to win 7,700 tenge or 200 tenge with the same probabilities as in the first alternative. The probabilities varied systematically creating 10 possible combinations: In the first combination, participants could win 4,000 tenge or 7,700 tenge with probability 10% and 3200 tenge and 200 tenge with probability 90%. In the second combination, the probabilities raised to 20% and 80%. Until the fourth combination, the expected value of the less risky alternative 1 was higher. When achieving the fifth combination, the expected value of the second alternative exceeded the expected value of the first alternative.

[2] €1 = 200 tenge

Table 1
Structure of the HLL

	Alternative 1 (A_1)	Alternative 2 (A_2)	Expected value A_1	Expected value A_2	Critical constant relative risk aversion coefficient
1	with 10% gain of **4,000 tenge** with 90% gain of **3,200 tenge**	with 10% gain of **7,700 tenge** with 90% gain of **200 tenge**	3,280 tenge	960 tenge	-1.71
2	with 20% gain of **4,000 tenge** with 80% gain of **3,200 tenge**	with 20% gain of **7,700 tenge** with 80% gain of **200 tenge**	3,360 tenge	1,700 tenge	-0.95
…	…	…	…	…	…
9	with 90% gain of **4,000 tenge** with 10% gain of **3,200 tenge**	with 90% gain of **7,700 tenge** with 10% gain of **200 tenge**	3,920 tenge	6,960 tenge	1.37
10	with 100% gain of **4,000 tenge** with 0% gain of **3,200 tenge**	with 100% gain of **7,700 tenge** with 0% gain of **200 tenge**	4,000 tenge	7,700 tenge	-

Notes: 1. The last three columns were not displayed in the experiment.
2. A power risk utility function is assumed.

Participants were asked to choose between two alternatives in each of the ten combinations. The observation of the choices of participants regarding the question when they opted for a riskier alternative allowed us to determine their individual risk attitude. A risk neutral decision maker would always decide in favor of the alternative with the higher expected value. Therefore, the decision maker would have had to prefer alternative 1 four times before switching to alternative 2. A HLL value (=number of safe choices) between 0 and 3 expressed risk-preference, a HLL value of 4 implied risk neutrality, whereas a HLL value between 5 and 9 expressed risk aversion of a decision maker. The last combination was used to test the comprehension of the HLL experiment by participants. If participants understood the terms of the lottery, it was supposed that even the most risk-averse decision makers should switch to alternative 2 as it yields a secure winning of 7,700 tenge.

The experiments were conducted in Kazakhstan and Germany between the end of 2010 until the beginning of 2011. Farmers were recruited through alumni networks of Kazakhstani and German universities. The alumni provided us with addresses of active farmers who were invited to participate in the computer-based experiment. Farmers were also asked to suggest other farmers who might be willing to participate in the experiment. In both countries, participants received a fixed amount for participating in the experiment (2,000 tenge in Kazakhstan and €10 in Germany). The target was to recruit around 100 farmers in each country with an acceptable deviation of 10% in both directions. We randomly spoke to approximately 500 farmers, if they would like to participate in our experiment. In total, 100 Kazakhstani and 106 German farmers participated in the computer-based experiment. That means 4,120 (2·10 repetitions for each of 206 farmers) investment decisions and 206 HLL values were given by participants. The hypothetical decisions were related to real winnings of participants to ensure incentive compatibility of the experiment. After all experiments had been carried out, two winners were randomly selected in each experiment carried out for Kazakhstani and German farmers. The chance to be the winner in one of the experiments amounted to approximately 1%. The winning of the farmer in the first part of the experiment was based on her individual scores earned on a randomly chosen repetition of the treatments. The Kazakhstani winner received 2,000 tenge for each 25,000 points, i.e., the potential winnings varied between 4,000 tenge and 36,000 tenge. In the second part of the experiment, the farmer received a payoff dependent on her expressed preference for or aversion against different alternatives. The potential winnings varied between 200 tenge and 7,700 tenge.

Financial incentives in experiments have been subject to controversial discussions. Ideally, all participants should be paid for their performance during an experiment in order to provide a maximal consequentiality of participants` decisions. Unfortunately, the introduction of a sufficient financial incentive for each participant is too costly. Ding (2007) carried out an experiment in which only a fraction of winners was received the reward based on their decisions. Despite this fact, he revealed that the experiment was able to elicit true preferences of participants. In addition, Camerer and Hogarth (1999) revealed that higher incentives often improve participants' performance during an experiment. Furthermore, they mentioned that it might be more motivating to pay one out of N participants if participants overweigh their chances of being selected.

The winnings in the experiment intended for German farmers were ten times higher than those in the experiment with Kazakhstani farmers. This adjustment was done on the basis of the ratio of the average salaries in agriculture in both countries, which is ten times higher in Germany than in Kazakhstan (Agency of Statistics of the Republic of Kazakhstan, 2011a; Federal Statistical Office, 2011).

4. Normative benchmark

We have to derive normative benchmarks, which reflect the NPV criterion and the ROA for the evaluation of the investment behavior observed in the experiments and for an evaluation of our hypotheses. For this purpose, equations (2) and (4) can be used; in view of the experimental design, however, an extension is necessary. Especially, the equations need to be adapted to the number of potential investment times of ten instead of two. In addition, the risk-adjusted discount rate r^* must be calculated on the basis of the results of the HLL. The solutions of these two tasks are expounded in this section.

Calculation of the risk-adjusted discount rate

The risk-adjusted discount rate is calculated using the results of the HLL. In accordance with Holt and Laury (2002), we assume a power risk utility function, which implies declining absolute risk aversion and constant relative risk aversion:

$$U(V) = V^{1-\theta}, \tag{6}$$

where U is utility and θ denotes the relative risk aversion coefficient. Based on equation (6), we can match θ for each farmer based on their choices given in the HLL. On the basis of this information the certainty equivalent CE of a risky prospect is formulated as:

$$CE = V(E(U(V))) = E(U(V))^{\frac{1}{1-\theta}} = E(V) - RP \tag{7}$$

Here, $E(V)$ is the expected 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:

$$CE_0 = CE_T \cdot (1+r)^{-T} = (E(V_T) - RP_T) \cdot (1+r)^{-T} \tag{8}$$

where r is the risk free interest rate. An equivalent risk-adjusted discount rate $r^* = r + v$ can be derived from equation (8) using the following equation:

$$(E(V_T) - RP_T) \cdot (1+r)^{-T} = E(V_T) \cdot (1+r+v)^{-T} \tag{9}$$

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

Obviously, 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.

Calculation of the exercise frontiers

The calculation of the exercise frontier according to the NPV is presented in equation (2). As you can see in Figure 2 the exercise frontier according to the NPV amounts to a value of 110,000 points and does not change over the periods. That is explained by the fact that the NPV criterion does not consider the value of entrepreneurial flexibility to postpone an investment.

The exercise frontier according to the ROA is determined by dynamic stochastic programming (Trigeorgis, 1996, 312). However, it is problematic to apply dynamic programming to the binomial tree depicted in Figure 1 by using the risk-adjusted discount rates following equation (9), because the problem of non-recombining binomial tree for the expected net present value of the project may arise. That means the amount of potential states increases exponentially as the number of time periods rises (Longstaff and Schwartz, 2001). In the following, we suggest a simplification, which makes the calculation of the exercise frontier tractable. First, we fix the level of the returns at its initial value when calculating the risk-adjusted discount rate by equation (9). Second, we fix T at one period in equation (9). Finally, we derive nine discount rates representing different risk attitudes. The risk-adjusted discount rate varies in the range from 6.8% (HLL value = 0-1) to 13.1% (HLL value = 9-10). Figure 2 depicts the normative benchmarks obtained for the NPV criterion and the ROA for a risk neutral decision maker.

The exercise frontiers of the ROA decrease exponentially reflecting the diminishing

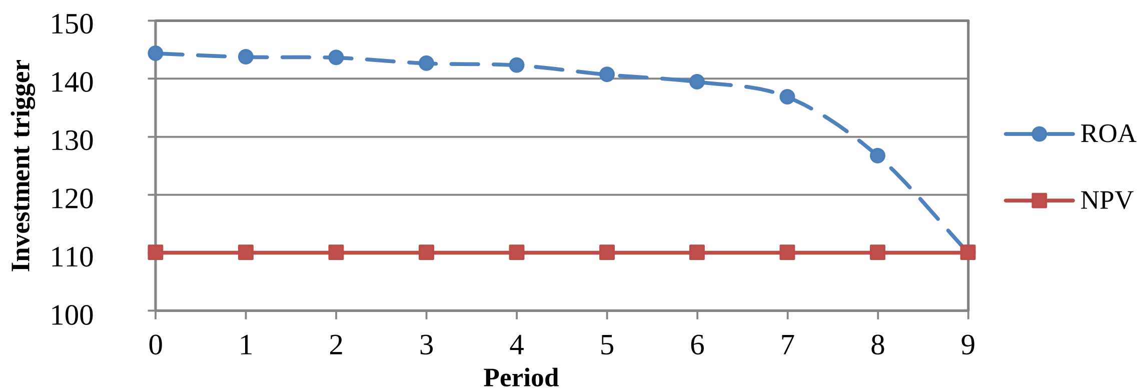

Fig. 2. Investment trigger for a risk neutral decision maker.
Notes: The investment triggers are given in thousand points.

time value of the investment option. The trigger value starts at 144,000 in period 0. The curves coincide with the NPV criterion at 110,000 points in period 9 because there is no more time to wait with the investment decision in period 9. The curve shape of the ROA and the NPV would change slightly according to different risk attitudes of participants, whereas the basic structure is maintained. The investment trigger in period 8 corresponds to the trigger derived in equation (4) of Section 2.

5. Descriptive statistics and approach to data analysis

Descriptive statistics

As it is shown in Table 2, the average agricultural land size of Kazakhstani participants is much larger than that of German participants. This is not surprising because according to statistical data from the Agency of Statistics of the Republic of Kazakhstan (2011b) and the Federal Ministry of Food, Agriculture and Consumer Protection (2011), the average Kazakhstani farmer has a larger area of agricultural land than the average German farmer. Furthermore, the proportion of Kazakhstani farmers engaged in crop production reaches 52% and exceeds an analogous parameter of German farmers (32%). This is explained by the prevalence of the number of grain producing farms in the Kazakhstani agricultural sector. More than half of Kazakhstani farmers are female, while only 19.8% of the German farmers are female. This difference results from the different structural features of farms in the two countries. The Kazakhstani farms consist of several divisions lead by managers who were also involved in the experiment together with the head of the farm. Most of these managers were female in our experiment. In Germany, family farms with a simple organizational structure, are prevailing in the agricultural sector. Another considerable discrepancy between Kazakhstani and German participants is in the proportions of farmers with higher education. The proportion of Kazakhstani farmers with higher education exceeds the proportion of the German farmers with higher education. A reason for this might be the fact that it takes more time to get a university degree in Germany than in Kazakhstan. For example, in Germany two more years in school are required for university entrance than in Kazakhstan. According to the characteristics of farmers, the sample was unrepresentative for Kazakhstani as well as for German farmers.

The period of investment of Kazakhstani farmers is about 0.4 periods longer than the period of investment of German farmers. However, compared to Kazakhstani farmers, German farmers have a higher percentage of non-investment decisions. That means that German farmers decided not to invest in any of the 10 periods provided by the design of the experiment more often than Kazakhstani farmers. The average period of investment does not take into account the cases of non-investment. Normative benchmarks derived for the NPV and the ROA were applied to 2,000 (Kazakhstan) and 2,120 (Germany) random realizations of the discrete approximation of an arithmetic Brownian process generated during the experiment. As it can be seen in Table 2, the average periods of investment according to the ROA benchmark are considerably later than suggested by the NPV benchmark. In addition, the ROA benchmark has a higher percentage of non-investment decisions than the NPV benchmark. Kazakhstani and German farmers invest later than suggested by the NPV criterion and earlier than suggested by the ROA.

Table 2
Descriptive statistics

	Kazakhstan		Germany	
	Agricultural treatment with 1,000 decisions	Non-agricultural treatment with 1,000 decisions	Agricultural treatment with 1,060 decisions	Non-agricultural treatment with 1,060 decisions
Average farm size	11,685 ha (12,956 ha)		304 ha (570 ha)	
Crop producers	52.0%		32.0%	
Average age of farmers	37.5 years (11.1 years)		30.1 years (10.3 years)	
Female farmers	53.0%		19.8%	
Farmers with higher education	70.0%		37.7%	
Farmers with economic education	55.0%		34.9%	
Principal income farmers	88.0%		81.7%	
Average risk attitude of farmers (HLL value)	5.3 (2.6)		4.8 (2.4)	
Average period of investment of farmers without non-investment periods	3.5 (2.8)	3.4 (2.8)	3.0 (3.0)	3.2 (3.0)
Percentage of non-investment of farmers	8.5%	7.4%	12.1%	9.5%
Average period of investment according to NPV without non-investment periods	2.2 (2.1)	2.3 (2.0)	2.3 (2.1)	2.4 (2.1)
Normative percentage of non-investment following NPV	27.3%	26.8%	27.8%	27.8%
Average period of investment according to ROA without non-investment periods	6.0 (2.2)	6.3 (2.1)	6.1 (2.2)	6.0 (2.1)
Percentage of non-investment according to ROA	46.6%	47.1%	48.3%	46.7%

Notes: Standard deviations are indicated in parentheses.

Approach to data analysis

In order to test the hypotheses *H1* and *H2,* we have to define whether there is dependence between the periods of investment of farmers and the periods of investment according to the forecast following the NPV criterion or the ROA. For this purpose, it is necessary to regress the periods of investment of farmers against the periods of investment according to the NPV criterion or the ROA. The regression is complicated by the fact that, both the dependent variable (the periods of investment of farmers) and the independent variable (the periods of investment according to the NPV criterion or the ROA) have observations which are censored. Censoring takes place because both the dependent variable and the independent variable are interval-censored and measures the time of investment between 0 and 9. Therefore investment decisions made after these investment periods provided by the experimental design are not observable. Given that the dependent variable and the independent variable are subject to censoring, an appropriate way to estimate the dependence parameter between them is a modified Theil-Sen estimator (Akritas et al., 1995). A modified Theil-Sen estimator is a non-parametric regression based on Kendall`s tau correlation coefficient. We now describe the application of a modified Theil-Sen estimator in the context of our two hypotheses.

X_i^t and Y_i^t, $i = 1,...N$, are the investment periods according to the normative benchmarks and the investment periods of farmers, correspondingly. Both variables are not censored. The variables X_i^c and Y_i^c are censoring variables. The observed values X_i and Y_i are defined as the minimum of the non-censored variables and the censoring variables $X_i = \min(X_i^t, X_i^c)$ and $Y_i = \min(Y_i^t, Y_i^c)$. Censoring indicators, $\delta_i^x = I(X_i = X_i^t)$ and $\delta_i^y = I(Y_i = Y_i^t)$ are observed. I is an indicator function for an event. We need to estimate an unknown dependence parameter β in the following regression model:

$$Y_i^t = \beta X_i^t + u_i^t, \qquad (10)$$

where β measures the change in Y_i^t associated with a one-period change in X_i^t.

In the uncensored case, the Theil-Sen estimator of the parameter β (Theil, 1950; Sen, 1968) is obtained as the value of b that makes Kendall`s τ statistics between the residuals $y_i - bx_i$ and x_i (approximately) equal to zero. But if both the dependent variable and the independent variable are subject to censoring, the residuals can be right censored, left censored, or both. Akritas et al. (1995) proposed a modification of the Theil-Sen estimator for doubly censored data, which is defined as the solution of b of the equation:

$$T_n(b) = \sum_{i<j} \delta_i^x \delta_j^x \left(I\{X_i < X_j\} - I\{X_j < X_i\} \right)$$

$$\cdot \left(\delta_i^y I\{r_i(b) < r_j(b)\} - \delta_j^y I\{r_j(b) < r_i(b)\} \right) \tag{11}$$

where $r_i(b)$ is the (possibly) censored analog of $r_i(b)^t = Y_i^t - bX_i^t$.

The modified Theil-Sen estimator of the slope (dependence) parameter with doubly censored data is:

$$\hat{\beta} = \frac{(\hat{b}_1 + \hat{b}_2)}{2}, \tag{12}$$

where $\hat{b}_1 = \sup\{b : T_n(b) > 0\}$ and $\hat{b}_2 = \inf\{b : T_n(b) < 0\}$.

Furthermore, a tobit model (Tobin, 1958) is used in order to test *H3* to *H7*, i.e. to analyze the impact of different independent variables on the investment behavior of farmers. Independent variables are not censored, whereas the dependent variable, i.e., the time of investment of farmers, is subject to censoring. It could be observed only when it falls between 0 and 9. For values below 0, we observe 0; for values above 9, we observe 9. Denoting the time of investment of farmers as Y_i,

$$Y_i = \beta X_i + u_i, \text{ with } i = 1,2,..., N \tag{13}$$

where N is the number of observations, Y_i is the dependent variable, X_i is a vector of independent variables, β is a vector of unknown regression parameters to be estimated, and u_i is a normal random variate with a mean of 0 and a variance of σ^2. The model for the dependent variable Y_i under interval censoring can be presented as follows:

$$Y_i = \begin{cases} 0 & \beta X_i + u_i < 0, \\ 9 & \beta X_i + u_i > 9, \\ \beta X_i + u_i & \text{otherwise,} \end{cases} \tag{14}$$

where 0 and 9 are the censoring interval endpoints. The equation (14) presents a tobit model with double censoring (Maddala, 2006, 150-151).

6. Experimental results

In this section, we test the aforementioned hypotheses.

Hypotheses H1 "NPV conformity" and H2 "ROA conformity"

In order to test *H1* and *H2*, we compare the investment behavior of farmers with the benchmark prediction given by the NPV and the ROA in an agricultural and a non-agricultural treatment. Results are shown in Table 3. On the one hand, around 45% of both

Kazakhstani and German farmers invest earlier than suggested by the NPV criterion in both treatments. On the other hand, around 40% of Kazakhstani and German farmers invest later than suggested by the NPV criterion in both treatments. Regarding the ROA benchmark, around 75% of investment decisions are made earlier than suggested by the ROA. The proportion of optimal investment decisions exceeds the proportion of the investment decisions which are made later than predicted by the ROA benchmark. This applies to Kazakhstani and German farmers in both treatments.

Table 3
Hit ratio of the investment behavior of farmers and investment behavior according to the normative benchmarks

	Kazakhstan		Germany	
	Agricultural treatment with 1,000 decisions	Non-agricultural treatment with 1,000 decisions	Agricultural treatment with 1,060 decisions	Non-agricultural treatment with 1,060 decisions
Earlier investment than predicted by the NPV	44.2%	46.8%	49.3%	47.2%
Optimal investment as predicted by the NPV	13.2%	12.3%	13.3%	16.0%
Later investment than predicted by the NPV	42.6%	40.9%	37.4%	36.8%
Earlier investment than predicted by the ROA	76.5%	77.5%	74.8%	76.7%
Optimal investment as predicted by the ROA	13.1%	11.6%	15.1%	13.5%
Later investment than predicted by the ROA	10.4%	10.9%	10.1%	9.8%

Table 4 illustrates the p-values of a dependence parameter $\hat{\beta}$ between the investment timing of farmers and the optimal investment timing according to the NPV criterion or the ROA for Kazakhstan and Germany. The value of a dependence parameter $\hat{\beta}$ equals -6.7055e-08, which is identical for both benchmarks and both countries. The p-values of the dependence parameter are not significant. That means that there is no dependence between the investment timing of farmers and the investment timing according to the normative benchmarks for both countries. Consequently, neither the NPV criterion nor the ROA is able to predict the investment timing of farmers. Thus, the hypotheses *H1 "NPV conformity"* and *H2 "ROA conformity"* are rejected.

Table 4
p-values of modified Theil-Sen estimators

Criterion	Kazakhstan	Germany
NPV	0.700	0.294
ROA	0.680	0.792

For testing the hypotheses *H3* to *H7*, we run a tobit model in which we regress the investment timing of farmers in an agricultural as well as in a non-agricultural treatment on different independent variables. The results of the tobit regression are presented in Table 5.

Hypothesis H3 "country differences"

The results of the tobit model show that the estimated coefficient of the variable "country" is highly significant and has a positive sign (p-value < 0.001), i.e. on average, German farmers invest 0.946 periods later than Kazakhstani farmers. That means that in contrast to Kazakhstani farmers, German farmers time their investment decisions closer to the optimal investment periods predicted by the ROA. Hence, we fail to reject *H3 "country differences"*. This might be one of the explanations for the fact that German farmers make more profitable investments than Kazakhstani farmers and, therefore, the level of development of the agricultural sector in Germany is higher than in Kazakhstan.

Hypothesis H4 "learning effect"

For testing *H4 "learning effect"*, we insert the variable "repetition" in the tobit model. The variable "repetition" corresponds to the number of paths of the binomial tree discussed in Section 3. The estimated coefficient of the variable "repetition" is highly significant and has a positive sign (p-value < 0.001), i.e., with each repetition of an investment treatment, Kazakhstani and German farmers invested 0.067 periods later. Therefore, we fail to reject *H4*

Table 5
Tobit regression of the individual investment period of farmers (N=4,120)

	Coefficient	Robust standard error	p-value	
Constant	0.131	0.450	0.771	
Repetition (from 1 to 20 repetitions)	0.067	0.010	<0.001	***
Country (1: Germany, 0:Kazakhstan)	0.946	0.172	<0.001	***
Farm size	4.1281e-05	7.4307e-06	<0.001	***
Farm type (1: crop producer, 0: other)	0.324	0.125	0.010	***
Age	0.019	0.006	0.003	***
Gender (1: male, 0: female)	0.830	0.133	<0.001	***
Higher education (1: with, 0: without)	0.650	0.126	<0.001	***
Economic education (1: economic, 0: other)	-0.225	0.133	0.091	*
Family size	0.054	0.035	0.116	
Farmer`s income type (1: principal income, 0: sideline)	1.238	0.182	<0.001	***
HLL value (from 0 to 10)	-0.023	0.025	0.359	
Framing (1: non-agricultural, 0: agricultural)	-0.061	0.120	0.611	
Order (1: first non-agricultural; second agricultural, 0: first agricultural; second non-agricultural)	-0.575	0.122	<0.001	***

Notes: Chi2 = 249.25, Log-Likelihood = -9411.27. Asterisk (*), double asterisk (**) and triple asterisk (***) denote variables significant at 10%, 5% and 1%, respectively.

"learning effect". That means that with an increasing number of repetitions the investment timing of farmers will approximate to the optimal periods predicted by the ROA.

Hypothesis H5 "farmer-specific variables"

As we can see from Table 5, the estimated coefficients of the variables "farm size", "age", "higher education" and "farmers' income type" are significant and have a positive sign. This implies that farmers with a larger size of farmland, older farmers, farmers with higher education and farmers earning a principal income from farm business invest later. All these findings meet our expectations described in Section 2. It can be seen from Table 5 that crop producing farmers and male farmers invest later, which contradicts to our expectations. The variable "economic education" has a negative sign, which implies that farmers with economic education invest earlier. This finding also runs counter to our expectation. There is no statistically significant effect of the variables "family size" and "HLL value". In general, based on these results, we fail to reject *H5 "farmer-specific variables"*.

Hypothesis H6 "framing effect"

As it can be seen in Table 5, coefficient "framing" is not significant. That means that the framing of the investment experiment has no impact on the investment behavior of farmers in an agricultural context as well as in a non-agricultural context. Farmers demonstrate similar investment behavior in an agricultural as well as in a non-agricultural investment treatment. Therefore, a framing effect is not revealed and *H6 "framing effect"* is rejected. However, we have to consider that the opportunities to invest in farmland and to participate in a coin tossing game were only hypothetical in our experiment. Framing might be helpful in making a laboratory experiment more realistic and thereby increases its external validity.

Hypothesis H7 "order effect"

As already mentioned, a framing effect has no influence on the investment behavior of farmers. But it could be possible that farmers who are first confronted with a non-agricultural treatment and afterwards with an agricultural treatment show different investment behavior than farmers who were faced with the two treatments in a reverse order. We test this assumption by means of the variable "order" included in the tobit model. The variable "order" is a dummy variable, which takes the value of 1 if the farmer was at first confronted with a non-agricultural treatment and then with an agricultural treatment and 0 if the farmer was confronted with both treatments in a reverse order. The coefficient of the parameter "order" is significant. That means that the investment behavior of farmers regarding the two variations of the order is different. Farmers, who are first confronted with a non-agricultural treatment, invest 0.575 periods earlier than farmers who are first confronted with an agricultural treatment. Therefore, we fail to reject *H7 "order effect"*.

7. Discussion and conclusions

The agricultural sectors of Kazakhstan and Germany have significantly different levels of development. We assumed that the different investment behavior of farmers in the two countries could be one of the explanations for this fact. In order to test this assumption, we experimentally analyzed whether the investment behavior of Kazakhstani or German farmers is more consistent with the NPV criterion or with the ROA. These two approaches are commonly applied for analyzing the investment decisions. However, we could not indicate that the NPV criterion or the ROA can predict the investment behavior of Kazakhstani as well as German farmers. On average, they invested later than predicted by the NPV criterion but earlier than predicted by the ROA. That means farmers failed to completely recognize the value of waiting provided by the ROA. Therefore, a lot of effort is still needed to be done in order to improve the knowledge of farmers and close the gap between theory and practice.

Furthermore, we found that the investment behavior of German farmers is closer to the predictions of the ROA than those of Kazakhstani farmers. This might be one of the explanations for the fact that German farmers make more profitable investments than Kazakhstani farmers and, therefore, the level of development of the agricultural sector in Germany is higher than in Kazakhstan. Based on the findings of other experimental economic researchers we tested if the investment behavior of farmers improves with an increasing number of repetitions of investment treatments. We found out that with each repetition farmers invest later. That means with each repetition farmers approximate to the optimal investment periods predicted by the ROA.

Further findings are that a number of farmer-specific variables influence the investment behavior of farmers. In particular, factors as “farm size”, “age”, “higher education” and “farmers’ income type” result in later investment timing. In contrast to our expectations, the variables “farm type” and “gender” lead to a later investment decision. This is surprising because these findings run counter to the findings of many other studies. A negative sign of the variable “economic education” might be explained by the fact that the classical investment theory was much more popular in the past than the ROA, which is a relatively new topic in the study program of most economics schools. This is valid for Kazakhstani as well for German economic schools. Therefore, farmers with economic education seem to be less likely to realize the benefits provided by the ROA, which arise from deferring the investment decision.

We expected that farmers would demonstrate different investment behaviors in an agricultural treatment and in a non-agricultural treatment. However, results show that the investment behavior of farmers in an agricultural treatment does not differ significantly from that in a non-agricultural treatment. An important aspect is the order in which the two treatments were allocated to farmers. Farmers, who are first confronted with a non-agricultural treatment, invest earlier than farmers who are first confronted with an agricultural treatment.

There are some directions of future research for explaining the deviation of observed investment behavior from the normative predictions given by the superior ROA. It would make sense to measure the impact of loss aversion on premature investment. As it is stated in the literature, gains tend to cause the risk-aversion, whereas losses tend to cause risk-seeking behavior (Cullis et al., 2012; Kühberger et al., 2002). In addition, it was found that losses influenced preferences of a decision-maker stronger than gains (Epley and Gneezy, 2007; Tversky and Kahneman, 1991). Further research in the vein of this study should investigate why the variables "farm type" and "gender" resulted in a later investment decision. It is also interesting to observe how the investment decisions of farmers would change if another asset was taken in the experiment instead of land investment (i.e. cow barn, pig-fattening barn, irrigation technology etc.). Researchers also may compare disinvestment decisions in developed and developing countries. Finally, it is worth pursuing if farmers from other countries with a post-transitional economic system would show different investment behavior compared to a high-income country as Germany.

Acknowledgments

The authors would like to gratefully acknowledge financial support from German Research Foundation (DFG).

References

Adesina, A.A., Mbila, D., Nkamleu, G.B., Endamana, D., 2000. Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. Agriculture, Ecosystems and Environment 80, 255-265.

Agency of Statistics of the Republic of Kazakhstan, 2011a. Main Indicators of Labor in the Republic of Kazakhstan. http://www.stat.kz/publishing/Pages/Trud_2011_arxiv.aspx.

Agency of Statistics of the Republic of Kazakhstan, 2011b. Agriculture, Forestry and Fishery, 2006-2010. http://www.stat.kz/publishing/20111/SelXozEnd.pdf.

Akritas, M.G., Murphy, S.A., LaValley, M.P., 1995. The Theil–Sen estimator with doubly censored data and applications to astronomy. Journal of the American Statistical Association 90, 170–177.

Bajtelsmit, V.L., VanDerhei, J.L., 1997. Risk aversion and pension investment choices. In: Gordon, M.S., Mitchell, O.S., Twinney, M.M., (Eds.). Positioning Pensions for the Twenty-first Century. Philadelphia PA: University of Pennsylvania Press, 45-66.

Bettman, J.R., Sujan, M., 1987. Effects of framing on evaluation of comparable and noncomparable alternatives by expert and novice consumers. The Journal of Consumer Research 14, 141-154.

Brennan, M.J., 1998. The role of learning in dynamic portfolio decisions. European Finance Review 1, 295-306.

Camerer, C.F., Hogarth, R.M., 1999. The effects of financial incentives in experiments: a review and capital-labor-production framework. Journal of Risk and Uncertainty 19, 7-42.

Coleman, S., 2003. Risk tolerance and the investment behavior of black and Hispanic heads of household. Financial Counseling and Planning 14, 43-52.

Cronk, L., Wasielewski, H., 2008. An unfamiliar social norm rapidly produces framing effects in an economic game. Journal of Evolutionary Psychology 6, 283−308.

Cullis, J., Jones, P., Savoia, A., 2012. Social norms and tax compliance: framing the decision to pay tax. Journal of Socio-Economics 41, 159-168.

Denison, C.A., 2009. Real options and escalation of commitment: a behavioral analysis of capital investment decisions. The Accounting Review 84, 133−155.

Ding, M., 2007. An incentive-aligned mechanism for conjoint analysis. Journal of Marketing Research 44, 214-223.

Dixit, A.K., Pindyck, R.S., 1994. Investment under Uncertainty. Princeton: Princeton University Press.

Epley, N., Gneezy, A., 2007. The framing of financial windfalls and implications for public policy. Journal of Socio-Economics 36, 36-47.

Federal Ministry of Food, Agriculture and Consumer Protection, 2011. Agricultural Policy Report of the Federal Government (in German).

Federal Statistical Office, 2011. The Development of Gross Earnings (in German). https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/VerdiensteArbeitskosten/VerdiensteArbeitskosten.html.

Food and Agriculture Organization of the U.N., 2011. Cow Milk Yield. http://faostat.fao.org/site/569/DesktopDefault.aspx?PageID=569#ancor.

Gardebroek, C., Oude Lansink, A.G.J.M., 2008. Dynamic micro-econometric approaches to analysing agricultural policy. Plenary paper presented at the 107th EAAE Seminar Modeling of Agricultural and Rural Development Policies, 29 January - 1 February, 2008, Sevilla, Spain. Sevilla: EAAE, 2007. – CD-ROM.

Gardebroek, C., Oude Lansink, A.G.J.M., 2004. Farm-specific adjustment costs in Dutch pig farming. Journal of Agricultural Economics 55, 3-24.

Gilbert, R.J., Harris, R.G., 1981. Investment decisions with economies of scale and learning. The American Economic Review 71, 172-177.

Hinrichs, J., Mußhoff, O., Odening, M., 2008. Econometric hysteresis in hog production. Applied Economics 40, 333-340.

Holt, C.A., Laury, S.K., 2002. Risk aversion and incentive effects. American Economic Review 92, 1644−1655.

Howell, S.D., Jägle, A.J., 1997. Laboratory evidence on how managers intuitively value real growth options. Journal of Business Finance and Accounting 24, 915-935.

Jianakoplos, N.A., Bernasek, A., 1998. Are women more risk averse? Economic Inquiry 36, 620-631.

Joshi, G.R., Pandey, S., 2006. Farmers` perceptions and adoption of modern rice varieties in Nepal. Quarterly Journal of International Agriculture 45, 171-186.

Knight, J., Weir, S., Woldehanna, T., 2003. The role of education in facilitating risk-taking and innovation in agriculture. Journal of Development Studies 39, 1-22.

Kroll, S., Viscusi, W.K., 2011. Risky investment decisions: how are individuals influenced by their groups? Journal of Risk and Uncertainty 43, 81-106.

Kühberger, A., Schulte-Mecklenbeck, M., Perner, J., 2002. Framing decisions: hypothetical and real. Organizational Behavior and Human Decision Processes 89, 1162-1175.

Legrenzi, P., Girotto, V., Johnson-Laird, P.N., 1993. Focusing in reasoning and decision making. Cognition 49, 37-66.

Lewellen, W.G., Lease, R.C., Schlarbaum, G.G., 1977. Patterns of investment strategy and behavior among individual investors. The Journal of Business 50, 296-333.

Longstaff, F.A., Schwartz, E.S., 2001. Valuing American options by simulation: a simple least-squares approach. Review of Financial Studies 14, 113−148.

Luong, Q.V., Tauer, L.W., 2006. A real options analysis of coffee planting in Vietnam. Agricultural Economics 35, 49-57.

Macfie, H.J., Bratchell, N., Greenhoff, K., Vallis, L.V., 1989. Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. Journal of Sensory Studies 4, 129-148.

Maddala, G.S., 2006. Limited-dependent and qualitative variables in econometrics. New-York, NY: Cambridge University Press.

Mathews, K.H., Short, S.D., 2001. The beef cow replacement decision. Journal of Agricultural Business 19, 191-211.

O`Brien, J.P., Folta, T.B., Johnson, D.R., 2003. A real options perspective on entrepreneurial entry in the face of uncertainty. Managerial and Decision Economics 24, 515-533.

Odening, M., Mußhoff, O., Balmann, A., 2005. Investment decisions in hog production – an application of the real options approach. Agricultural Economics 32, 36–47.

Oprea, R., Friedman, D., Anderson, S.T., 2009. Learning to wait: a laboratory investigation. The Review of Economic Studies 76, 1103−1124.

Perreault, Jr. W. D., 1975-6. Controlling order-effect bias. Public Opinion Quarterly 39, 544-551.

Pindyck, R.S., 1991. Irreversibility, uncertainty, and investment. Journal of Economic Literature 29, 1110-1148.

Rauchs, A., Willinger, M., 1996. Experimental evidence on the irreversibility effect. Decision and Theory 40, 51−78.

Richards, T.J., Nganje, W.E., Acharya, R.N., 2009. Public goods, hysteresis, and underinvestment in food safety. Journal of Agricultural and Resource Economics 34, 464–482.

Sandri, S., Schade, C., Mußhoff, O., Odening, M., 2010. Holding on for too long? Journal of Economic Behavior and Organization 76, 30−44.

Savastano, S., Scandizzo, P.L., 2009. Optimal farm size in an uncertain land market: the case of Kyrgyz Republic. Agricultural Economics 40, 745-758.

Sen, P.K., 1968. Estimates of the regression coefficient based on Krendall`s Tau. Journal of the American Statistical Association 63, 1379-1389.

Seo, S., Segarra, E., Mitchell, P.D., Leatham, D.J., 2008. Irrigation technology adoption and its implication for water conservation in the Texas High Plains: a real options approach. Agricultural Economics 38, 47-55.

Singh, V.P., Sharma, V.K., Sidhu, M.S., Kingra, H.S., 2010. Broiler production in Punjab-an economic analysis. Agricultural Economics Research Review 23, 315-324.

Theil, H., 1950. A rank-invariant method of linear and polynomial regression analysis. Koninklijke Nederlandse Akademie var Wetenschappen Proceedings 53, 386-392 (Part 1), 521-525 (Part 2), 1397-1412 (Part 3).

Tobin, J., 1958. Estimation of relationships for limited dependent variables. Econometrica 26, 24−36.

Trigeorgis, L., 1996. Real Options. Cambridge: MIT-Press.

Turvey, C.G., 2003. Can hysteresis and real options explain the farmland valuation puzzle? In: Moss, A.B., Schmitz, A. (Eds.). Government Policy and Farmland Markets: The Maintenance of Farmer Wealth. Ames IA: Iowa State University Press, 179−207.

Tversky, A., Kahneman, D., 1991. Loss aversion in riskless choice: a reference-dependent model. The Quarterly Journal of Economics 106, 1039-1061.

Vanhoucke, M., Demeulemeester, E., Herroelen, W., 2001. On maximizing the net present value of a project under renewable resource constraints. Management Science 47, 1113-1121.

Wale, E., Holm-Müller, K., Mburu, J., Zeller, M., 2005. Economic analysis of farmer`s preferences for coffee variety attributes: lessons for on-farm conservation and variety adoption in Ethiopia. Quarterly Journal of International Agriculture 44, 121-139.

World Bank, 2011a. Agriculture Value Added per Worker. http://data.worldbank.org/indicator/EA.PRD.AGRI.KD.

World Bank, 2011b. Cereal Yield. http://data.worldbank.org/indicator/AG.YLD.CREL.KG.

Wu, J., Sperow, M., Wang, J., 2010. Economic feasibility of a woody biomass-based ethanol plant in Central Appalachia. Journal of Agricultural and Resource Economics 35, 522-544.

Yavas, A., Sirmans, C.F., 2005. Real options. Experimental evidence. The Journal of Real Estate Finance and Economics 31, 27−52.

Appendix: Experimental Instruction

English version of the Russian and German instructions used in the experiments

Instructions for farmland investment (agricultural treatment)

General Information

[…] The game consists of three parts and would require approximately 40 minutes of your time. Please, read the following instructions carefully as your earnings from the experiment will depend on your decisions. Of course, your data will be treated as confidential and will be analyzed anonymously. […]

In each game you should try to collect as many points as possible because your potential earnings are proportional to the number of points you collect during the game.

Beside an expense allowance of 2,000 tenge[3] each participant has two times the chance to receive a bonus if she or he completes the entire game.

- In the first part of the game a player is randomly selected and is given 2,000 tenge cash per 25,000 points achieved in a randomly selected round. The selected player will therefore receive between 4,000 tenge and 36,000 tenge.
- In the second part of the game again a player is selected randomly and is given a cash bonus of between 200 tenge and 7,700 tenge.

In total, up to 100 farmers can participate in the game. They will be informed via e-mail by the 30th of July 2011 if they receive one of the two cash bonuses in addition to the expense allowance. The earnings can be paid out or transferred to an account specified by the selected player.

Good luck!

Please note that submitted decisions cannot be changed.

----

[3] It should be noted that in the original German version of this instruction euro (€) is used as the monetary unit instead of tenge.

First Part *(Instruction: Real Options Experiment)*

The game consists of various repetitions of one game with an equal basic structure.

Imagine you as the farmer have liquid assets of 100,000 tenge at your disposal and you are offered land for purchase. The land can be used for cultivation and will yield an annual gross margin over an infinite useful lifetime. You can decide within the next 10 years:

- to immediately invest in farmland
- to wait and see the development of the gross margins that can potentially be achieved (up to 10 years) and to invest in farmland later
- or not to invest in farmland

In the period between 0 and 9 years you can invest in farmland only once. If you decide to invest in farmland you have to pay 100,000 tenge/ha.

The tree chart below shows the possible present values of the returns in thousand tenge, which you can earn in the respective years (year 1 to year 10) when investing in farmland. The present value corresponds to the gross margins in tenge/ha, which can be achieved in case of a risk-free investment, at the respective time of investment assuming an infinite useful lifetime of the farmland and an interest rate of 10%. Moreover, it is assumed that the gross margin observed at the time of investment is guaranteed by an appropriate insurance during the entire useful lifetime. A gross margin of e.g. 10,000 tenge/ha and year then results in a present value of 100,000 tenge/ha, while a gross margin of 12,000 tenge/ha and year would result in a present value of 120,000 tenge/ha etc.

The tree chart starts with a present value of 100,000 tenge/ha in year 0. Starting from this initial value the present value of the following years increases or decreases by 20,000 tenge/ha. The probability of the occurrence of the present value in each year is indicated under the present value.

Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
										300 (0.1%)
									280 (0.2%)	
								260 (0.39%)		260 (0.98%)
							240 (0.78%)		240 (1.76%)	
						220 (1.56%)		220 (3.13%)		220 (4.39%)
					200 (3.13%)		200 (5.47%)		200 (7.03%)	
				180 (6.25%)		180 (9.38%)		180 (10.94%)		180 (11.72%)
			160 (12.5%)		160 (15.63%)		160 (16.41%)		160 (16.41%)	
		140 (25%)		140 (25%)		140 (23.44%)		140 (21.88%)		140 (20.51%)
	120 (50%)		120 (37.5%)		120 (31.25%)		120 (27.34%)		120 (24.61%)	
100		100 (50%)		100 (37.5%)		100 (31.25%)		100 (27.34%)		100 (24.61%)
	80 (50%)		80 (37.5%)		80 (31.25%)		80 (27.34%)		80 (24.61%)	
		60 (25%)		60 (25%)		60 (23.44%)		60 (21.88%)		60 (20.51%)
			40 (12.5%)		40 (15.63%)		40 (16.41%)		40 (16.41%)	
				20 (6.25%)		20 (9.38%)		20 (10.94%)		20 (11.72%)
					0 (3.13%)		0 (5.47%)		0 (7.03%)	
						-20 (1.56%)		-20 (3.13%)		-20 (4.39%)
							-40 (0.78%)		-40 (1.76%)	
								-60 (0.39%)		-60 (0.98%)
									-80 (0.2%)	
										-100 (0.1%)

Fig. A.1 Binomial tree of potential investment returns from investing in farmland.
Notes: The investment returns are given in thousand tenge.

An investment decision example

Imagine you decide to invest in land in year 5. The present value has developed randomly as shown below and currently amounts to 160,000 tenge/ha. What exactly you will earn from the investment in land depends on the present value development in the next year (year 6):

- you will either earn 180,000 tenge/ha with probability 50%
- or you will earn 140,000 tenge/ha with probability 50%

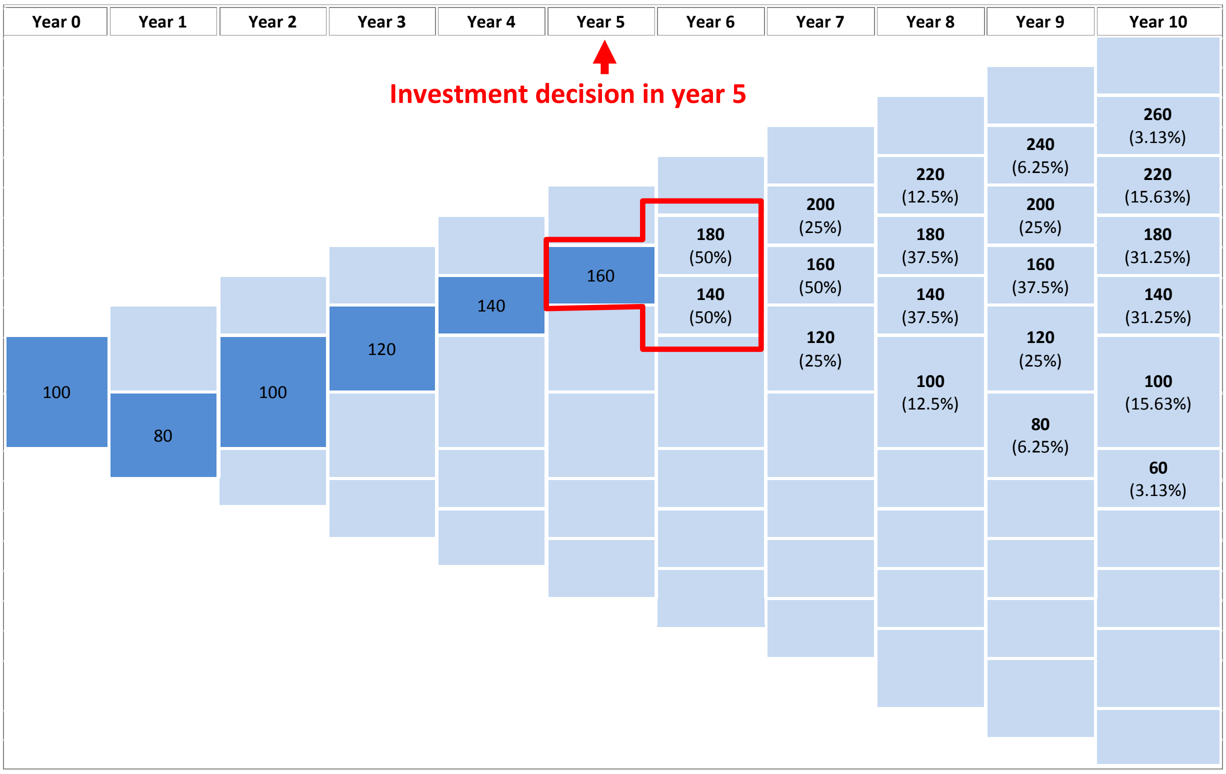

Fig. A.2 Binomial tree of potential investment returns from investing in farmland in year 5.
Note: The investment returns are given in thousand tenge.

The liquid assets you dispose of in your account in a given year will yield an interest rate of 10% meaning that they will increase by a tenth of their value. For example, if you do not decide to invest in land within the 10 years (between year 0 and year 9), your chance to invest expires and you will leave the game with your starting credit of 100,000 tenge that has increased to 259,374 tenge over the 10 years. In case this game is randomly selected for determining the cash premium, you will receive 20,750 tenge (=259,374/25,000*2,000 tenge).

Example for the calculation of your final account balance in case of an investment in year 10

Imagine the situation of the aforementioned example. In year 5 you decided to invest at a present value of 160,000 tenge/ha. We assume a negative development of the present value from year 5 to year 6 resulting in a decrease of 20,000 tenge/ha. With this investment you would therefore earn 140,000 tenge/ha. In this case your total balance of year 10 would be calculated as follows:

- Your starting credit of 100,000 tenge increases by 10% to 100,000 tenge*1.1^5 = 161,051 tenge.
  Your account balance in year 5 is therefore 161,051 tenge.

- You will invest 100,000 tenge of these 161,051 tenge to purchase 1 hectare of land.
- The residual amount of 61,051 tenge yields 10% interest by year 10 (another 5 years) meaning that it increases as follows: 161,051 tenge*1.1^5 = 98,323 tenge.
- In year 6 you receive a present value from the investment in 1 hectare of land of 140,000 tenge, which also will yield 10% interest by year 10 (another 4 years). 140,000 tenge *1.1^4 =204,974 tenge.

In this example your total balance in year 10 will correspond to the following:

98,323 tenge + 204,974 tenge = 303,297 tenge.

In this example your account balance would be 303,297 tenge in year 10. If this game was randomly selected for determining the cash premium, you would receive 24,264 tenge (=303,297 tenge/25,000* *2000 tenge).

Before the game starts we would like to ask you to answer some control questions. This is to ensure that you understand all instructions.

If the present value of the investment in land is 200,000 tenge/ha in one year, which two present values can occur in the next years?

Please indicate the two present values here:

____________ tenge/ha

____________ tenge/ha

What is the probability (in %) that the present value in the tree chart increases by 20,000 tenge/ha from one year to another?

Please indicate your answer here: ____________ %

What is the probability (in %) that the present value in the tree chart decreases by 20,000 tenge/ha from one year to another?

Please indicate your answer here: ____________ %

How much interest (in %) do your liquid assets in your account yield per year?

Please indicate your answer here: ____________ %

How much are the costs of the investment in land?

____________ tenge/ha

In the observed year 5 the present value in the tree chart is 120,000 tenge/ha. The possible present values which can be realised in the next years are indicated in bold.

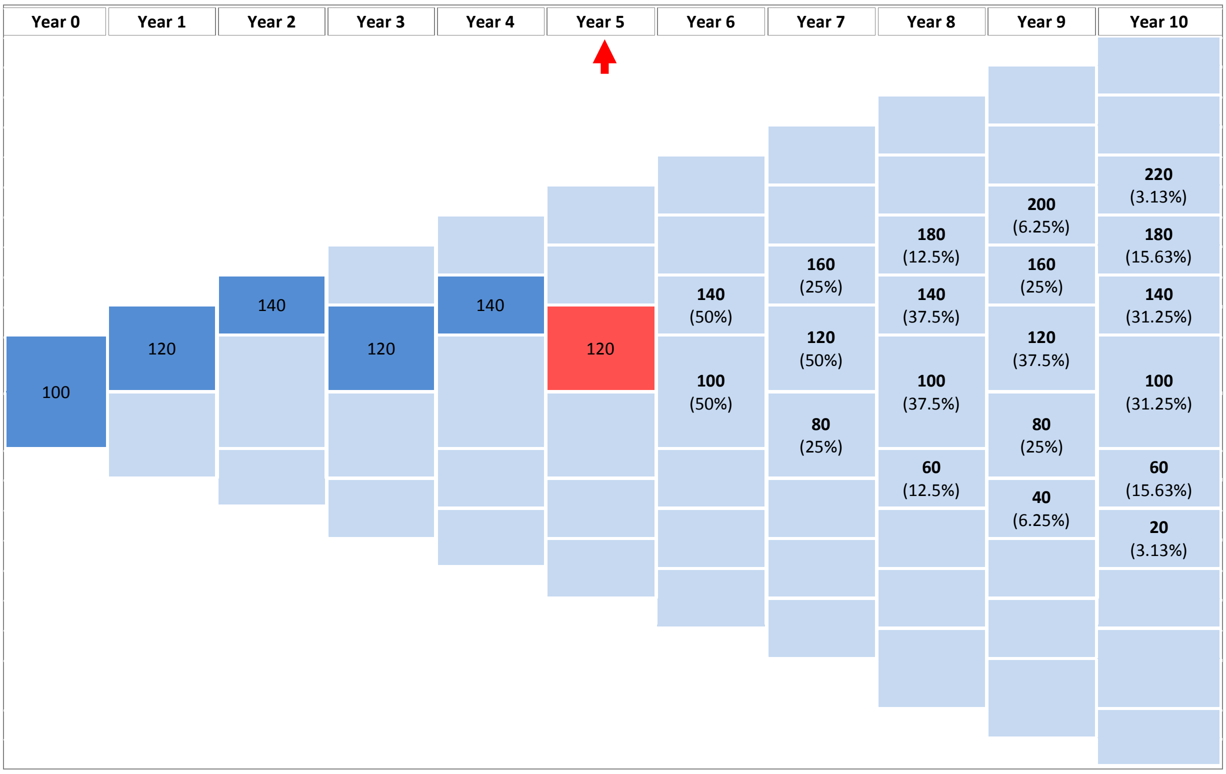

Fig. A.3 Randomly chosen fragment of a binomial tree in a control question.
Note: The investment returns are given in thousand tenge.

Which of the two present values can potentially be realised in the coming year (year 6)?

Please indicate the two present values here:

____________ tenge/ha

____________ tenge/ha

You answered all control questions correctly!

Please click “continue” to start the game.

- Here, the experiment starts –

[The real options experiment (first part) consists of two scenarios differing in the framing of the investment situation.

1) *The aforementioned instruction describes an investment situation in an agricultural context. Farmers have the hypothetical possibility to invest in farmland.*
2) *The following scenario would describe an investment situation in a non-agricultural framing. It is possible to purchase the right to participate in a coin tossing game.*

Besides the different wording of the investment situations the parameters in the experiment are exactly the same (e.g. investment cost and discount rate). Therefore, we will not repeat the instruction for the coin tossing game in the appendix. It is randomly determined in which order the individuals were confronted with both investment situations.

Farmers repeated both investment situations (farmland investment and coin tossing game) 10 times.]

Second Part *(Instruction: Holt and Laury lottery)* [24]

Even for the second part of the game a player who receives a cash premium is selected randomly. Your cash premium only depends on your own decisions and on chance. […]

Third Part *(Ex post perception of the experiment and personal information)*

Finally, we would like to ask you some questions about personal details. All results of the survey will be presented anonymously and it will not be possible to draw any inferences in respect of the actual persons or farms providing the information. […]