DISINVESTMENT BEHAVIOUR OF AGRICULTURAL ENTREPRENEURS: EXPERIMENTAL RESULTS

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Abstract

Agrarian structures are often characterized by some kind of economic inertia. It is particularly puzzling why unprofitable farms persist over time instead of being sold. In this paper we analyze the exit decision of farmers using the real options approach. The validity of the real options theory is assessed by means of laboratory experiments. Our results show that real options models are able to predict actual disinvestment decisions better than traditional investment theory. Nevertheless, the observed disinvestment reluctance was even more pronounced as predicted by real options theory.

Keywords: Disinvestment, Real Options, Experimental Economics.

Subtheme: Business & Finance

Disinvestment Behavior of Agricultural Entrepreneurs: Experimental Results

Structural change in agriculture is frequently characterized by some kind of inertia. That means farmers respond surprisingly slowly to changes in the economic environment. The fact that land prices are often significantly higher than the annualized returns from land use raises the question as to why farmers continue producing instead of selling their land (Turvey 2002). Structural change in agriculture is, in essence, the outcome of aggregated investment and disinvestment decisions of farmers.

Several explanations for sluggish (dis)investment behavior have been developed. More recently, the real options approach (ROA) has been propagated as a comprehensive explanation concept for economic inertia (cf. Dixit and Pindyck 1994). The real options theory analyzes irreversible decisions in a dynamic context, utilizing the analogy between a financial option and a real (dis)investment. It asserts that a firm may increase its profit by deferring an irreversible investment though the expected present value of the investment cash flows exceeds the investment costs. Similarly, it may be optimal to defer an irreversible disinvestment even if the expected present value of the firm's cash flow falls below the liquidation value. The intuitive reason is that in cases of irreversible decisions, waiting has a positive value since new information about the expected cash flow arrives in subsequent periods. As long as the disinvestment has not been realized, a decision maker has the flexibility to continue an ongoing project. This is valuable in the event of increasing cash flows. Termination of the project (the firm) deletes this option and reduces the decision maker's flexibility. The loss of flexibility must be covered by the liquidation value, too, before a disinvestment becomes optimal. This mechanism results in a kind of inertia, which has been called a "tyranny of the status quo" (Dixit 1992).

The ROA has been intensively used in agricultural economics for about 15 years (e.g., Purvis et al. 1995; Odening et al. 2005); however, most of these applications are normative and thus they merely indicate the *potential* explanatory value of the ROA for observed economic inertia. A few attempts have been made to provide empirical evidence for the validity of the ROA in general and in an agricultural context in particular (e.g., Richards and Green 2003; Hinrichs et al. 2008). Unfortunately, the econometric validation of theoretical models explaining disinvestment behavior, such as the ROA, is plagued by some fundamental difficulties. Among them are unobservable explanatory variables, ambiguity of explaining factors and unobserved heterogeneity.In view of these difficulties in econometric estimation based on field data, it seems quite natural to resort to economic experiments for a validation of the ROA. Laboratory experiments allow data collection under controlled conditions as well as the elicitation of otherwise unobservable variables. Thereby the internal validity of empirical research can be improved (Roe and Just 2009). Despite these advantages, the experimental investigation of real options theory is still in its early stages. Rauchs and Willinger (1996) were among the first in testing the irreversibility effect of real options in an experimental setting. Yavas and Sirmans (2005) adopt this idea and find that participants invest earlier than predicted by the ROA as well as that their willingness to pay for an investment opportunity includes an option value. In a recent study, Oprea et al. (2009) investigate whether real options values in a monopolistic environment differ from those under competition. All aforementioned studies considered the value and the timing of investment decisions and the experiments were carried out with students. The study closest to ours is Sandri et al. (2010) who also experimentally analyzed a disinvestment problem. However, our study differs from their study in significant ways. First, the contribution of Sandri et al. (2010) is not developed in an agricultural economic context and implications are derived for non-farming entrepreneurs. Second – and most importantly – unlike their study, our experimental subjects are farmers. Third, our normative benchmark explicitly considers the effect of risk aversion. Finally, our econometric analysis differs by taking advantage of panel data.

In this article, we investigate if the real options approach is able to predict observed (dis)investment behavior of agricultural entrepreneurs and if these predictions are better compared to the simple net present value criterion and how risk aversion influences the decision process. The rest of the article is organized as follows: The next section derive normative hypotheses from the theoretical disinvestment model. The subsequent section describes the design of the experiments followed by a presentation of the outcome of the experiments. The article ends with a discussion on the validity of theoretical disinvestment models and directions for further research.

Derivation of Hypotheses and Experimental Design

Traditional investment theory asserts that the project should be terminated if the liquidation value exceeds the present value of the investment returns. The situation is different if the decision on the termination of the project can be deferred. Using financial wording, the decision maker now has an abandonment option that he/she can either exercise or retain until maturity. Deferring the decision has the potential advantage that it allows the decision maker to take into account further information. Thus, the myopic net present value (NPV) differs from the ROA, in general. Against this background we formulate the following alternate hypotheses:

H1: The disinvestment behavior of farmers is consistent with the NPV.
H2: The disinvestment behavior of farmers is consistent with the ROA.

Risk preferences are also relevant for the valuation of real options if it is impossible to set up a replicating portfolio of traded assets which duplicates the stochastic outcome of the investment project (cf. Dixit and Pindyck 1994). This finding leads to our final hypothesis:

H3: Risk averse farmers disinvest earlier.

Our experimental design follows Sandri et al. (2010) and consists of two parts. The first part describes a problem of optimal stopping, stylizing a context-free choice to abandon a project for a constant termination value. In the second part, a session of Holt and Laury (2002) lotteries (HLL) was conducted with real payments to elicit risk attitudes of the participants. Furthermore, some general information about the participants' characteristics (e.g., gender, education and age) was collected.

In our real options experiment, respondents could decide to stop an ongoing project in one of ten periods. This task was repeated over multiple rounds. Returns from the existing project followed a binomial arithmetic Brownian motion with $p = 50\%$, no drift and a standard deviation of 500 in the high volatility scenario and 200 points in the low volatility scenario. The binomial tree in Figure 1 visualizes possible realizations of the stochastic returns and their probabilities.

Figure 1: Binomial tree of potential revenues together with the associated probabilities of occurrence (standard deviation 500 points)

Period 0	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10
										6,000 **0.1%**
									5,500 **0.2%**	
								5,000 0.39%		**5,000** 0.98%
							4,500 0.78%		**4,500** 1.76%	
						4,000 1.56%		**4,000** 3.13%		**4,000** 4.39%
					3,500 3.13%		**3,500** 5.47%		**3,500** 7.03%	
				3,000 6.25%		**3,000** 9.38%		**3,000** 10.94%		**3,000** 11.72%
			2,500 12.5%		**2,500** 15.63%		**2,500** 16.41%		**2,500** 16.41%	
		2,000 25%		**2,000** 25%		**2,000** 23.44%		**2,000** 21.88%		**2,000** 20.51%
	1,500 50%		**1,500** 37.5%		**1,500** 31.25%		**1,500** 27.34%		**1,500** 24.61%	
1,000		**1,000** 50%		**1,000** 37.5%		**1,000** 31.25%		**1,000** 27.34%		**1,000** 24.61%
	500 50%		**500** 37.5%		**500** 31.25%		**500** 27.34%		**500** 24.61%	
		0 25%		**0** 25%		**0** 23.44%		**0** 21.88%		**0** 20.51%
			-500 12.5%		**-500** 15.63%		**-500** 16.41%		**-500** 16.41%	
				-1,000 6.25%		**-1,000** 9.38%		**-1,000** 10.94%		**-1,000** 11.72%
					-1,500 3.13%		**-1,500** 5.47%		**-1,500** 7.03%	
						-2,000 1.56%		**-2,000** 3.13%		**-2,000** 4.39%
							-2,500 0.78%		**-2,500** 1.76%	
								-3,000 0.39%		**-3,000** 0.98%
									-3,500 0.2%	
										-4,000 0.1%

First period cash flows were always 1,000 points. To simplify matters for the participants, the risk-free interest rate was fixed at 10%. Abandoning the project yielded a constant revenue of 11,000 points, was allowed in each of the 10 periods and was made compulsory in the last period to limit the planning horizon for all participants.

In period 0 the participant will receive 1,000 points. If the participant decides to disinvest in period 0, he receives the initial cash flow of 1,000 points plus the salvage value of 11,000 points. In such a case, the cash flow in subsequent periods is not relevant for this investor. If the participant opts for a continuation, the cash flow in period 1 increases to 1,500 or decreases to 500 points, each with a probability of 50%. The binomial tree will be adjusted accordingly. Irrelevant states are suppressed and the probabilities for future cash flows are updated. These steps are repeated until period 10 unless the participant terminates the project earlier. There were 20 repetitions of the experiment per individual carried out because we wish to discriminate between different decision rules. The respondents did not receive immediate payoff feedback, except in a trial run. The random cash flow developments were separately determined for each individual. With no immediate payoff feedback and randomly determined paths of revenues, we limited reinforcement learning from outcomes.

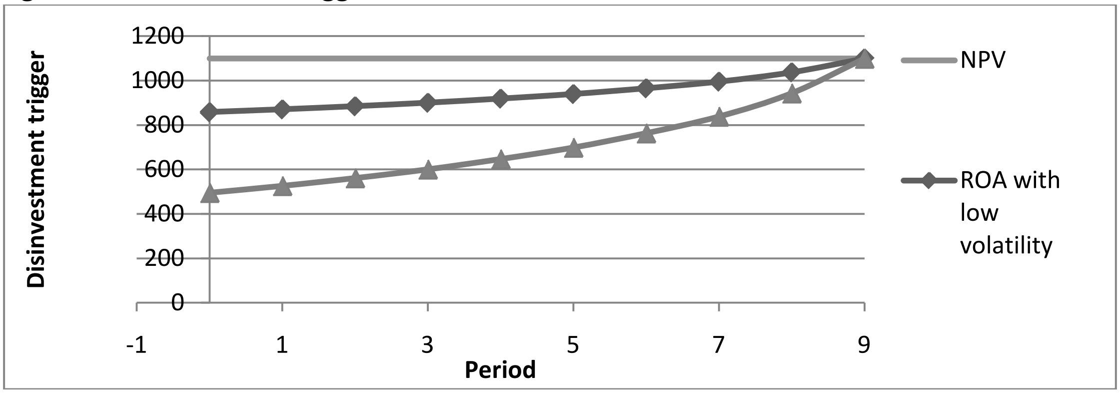
The participants were informed about all parameters and assumptions underlying the experimental setting. The binomial tree of potential revenues with their associated probabilities of occurrence was displayed on their screen. After each period and before the decision whether or not to disinvest had to be made, the binomial tree was updated based on the random outcome that had occurred in the previous period.

To ensure incentive compatibility of the experiment the hypothetical disinvestment decisions were related to an actual payment. The whole experiment took about 60 minutes per individual. Choices made by participants were not time constrained. A trial round gave the participants the opportunity to become acquainted with the experiment. The experiment was conducted in 2009 as an online experiment in which 63 agricultural entrepreneurs participated. They were recruited through alumni networks of German universities. In total 1,260 decisions (20 repetitions for each of the 63 participants) were observed.

Normative benchmarks

For the evaluation of the disinvestment behavior observed in the experiments and for an evaluation of our hypotheses we have to derive normative benchmarks which reflect the NPV and the ROA, respectively. Therefore, we determined the risk-adjusted discount rate and calculated the exercise frontiers. The determination of the risk-adjusted discount rate is based on the results of HLL. While the exercise frontier for the NPV can be easily calculated, the normative benchmark of the ROA has to be determined by backward dynamic programming (cf. Trigeorgis 1996, p.312). The resulting normative benchmarks, i.e., the “optimal” solutions for the disinvestment trigger according to the NPV and the ROA, are presented in Figure 2 exemplarity for a risk neutral decision maker.

Figure 2: Disinvestment trigger for a risk neutral decision maker



The exercise frontiers of the ROA increase exponentially reflecting the diminishing time value of the disinvestment option. The trigger values start at 858 and 495 points for the low and the high volatility scenario, respectively. Both curves coincide with the NPV criterion (1,100 points) at maturity, as is required by theory.

It should be noted that even if a higher volatility of the cash flow leads to a lower disinvestment trigger for the ROA, it does not necessarily translate into a later disinvestment time.

Results

Table 1 summarizes the main results of our experiments and provides information about the characteristic variables of the participants. The participating farmers were relatively young with an average age of 30 years, a minimum of 21 years and a maximum of 65 years. The proportion of farmers with an academic background was relatively high. Both features reflect a kind of sample selection that can be related to the fact that the experiments were conducted online and the manner in which participants were recruited. On average, the participants were slightly risk averse.

Table 1: Descriptive statistic

Variable	High volatility (N=30)		Low Volatility (N=33)		Total (N=63)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Normative disinvestment following NPV	0.913	2.525	0	0	0.435	1.801
Normative disinvestment following ROA	4.777	3.807	4.124	3.758	4.435	3.794
Experimentally observed time of disinvestment	6.412	3.448	6.091	3.734	6.244	3.603
Variance between observation and NPV	5.499	4.145	6.091	3.734	5.809	3.945
Variance between observation and ROA	1.635	4.556	1.967	4.604	1.809	4.582
Correlation between observation and ROA (Kendall's Tau)	0.275	0.278	0.306	0.283	0.292	0.334
Risk attitude of participant (HLL value) [a)]	4.930	1.946	5.090	1.684	5.020	1.800
Age of participant	30	10	31	11	30	10
Percentage of farmers studied	72.41	–	81.25	–	77.05	–
Percentage of female participants	24.14	–	21.88	–	22.95	–

[a)] 1-3 means risk seeking, 4 means risk neutrality and 5-10 means risk aversion.

The aforementioned disinvestment rules were applied to 1,260 random realization of the discrete arithmetic Brownian motion. The NPV criterion predicts a (risk-adjusted) disinvestment time of 0.9 periods on average in the high volatility scenario and an immediate disinvestment in period 0 in the low volatility scenario. The corresponding predictions from the ROA amount to 4.8 and 4.1 periods, respectively. The actual disinvestment time chosen by the participants was period 6.4 (high volatility) and 6.1 periods (low volatility). In what follows, we discuss whether or not these findings support our hypotheses on the disinvestment behavior.

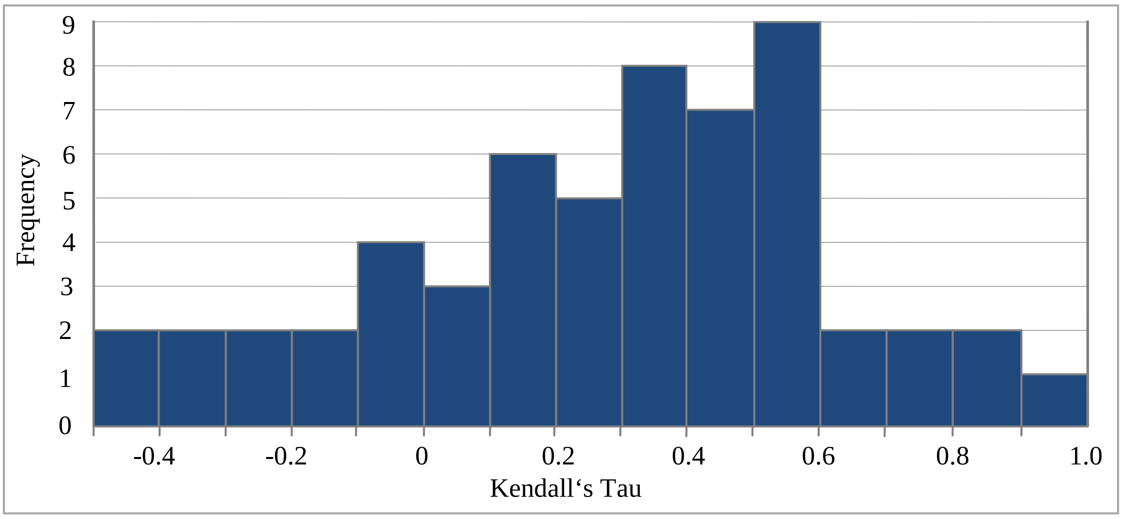
Test of H1

The disinvestments took place in the period which is suggested by the NPV in only 8.1% of all 1,260 observations. In the majority of all cases farmers chose to disinvest later. The average deviation between the predicted and the actual disinvestment time is 5.809 periods. This difference in the means of the disinvestment time is statistically significant (p-value < 0.001, two-sided t-test). On this basis, we reject H1 and conclude that the NPV criterion is in general not appropriate for predicting actual (experimentally observed) disinvestment behavior.

Test of H2

The average deviation between observed and optimal disinvestment time according to the ROA amounts to 1.809 periods. This deviation is also significantly different from zero (p-value < 0.001, two-sided t-test). Nevertheless, in 26.1% of the observations the participants disinvest in the optimal period. That means that more than one-fourth of all of the disinvestment decisions are correctly predicted by the ROA, which is significantly higher compared to the NPV. In 51.8% (22.1%) of all cases farmers decided to disinvested later (earlier) than optimal. Thus, for a further investigation of the predictive power of the ROA we calculate rank correlation coefficients (Kendall's tau) between optimal and actual disinvestment periods for each individual (see Figure 3).

Figure 3: Correlation between optimal disinvestment date after ROA and experimentally observed behaviour of individuals



The mean of Kendall's tau for all farmers is 0.291, meaning that the higher the optimal disinvestment period is the later observed disinvestment occurs. The rank correlation is positive for 87.9% of the participants and in 53.5% of all cases the correlation is significantly different from zero (at a significance level of 5%). Hypothesis 2 is not verified, but ROA outperforms NPV.

Test of H3

To test hypotheses 3 we ran a random effects model in which we regress the observed disinvestment periods on the risk aversion, age and gender of farmers, as well as the volatility of the project's cash flow. The results of this regression are presented in Table 2. The estimated coefficient of the risk aversion parameter is significant and has a negative sign. This result confirms our third hypothesis. Age and gender of farmers did not affect the disinvestment period significantly. The sign of the dummy variable representing the volatility treatment is positive, but not significant.

Table 2: Regression of the observed individual disinvestment period (N=1,260) [a)]

Parameter	Coefficient	Robust standard error	p-value
Constant	8.520	1.835	0.000
HLL-value	-0.419	0.165	0.011
Volatility (0: low volatility1: high volatility)	0.194	0.604	0.748
Age	-0.030	0.032	0.354
Gender (0: female, 1: male)	0.571	0.767	0.457

[a)] $R^2 = 0.111$

Discussion and Conclusions

Disinvestments and, in particular, farm exits represent basic decisions for agribusiness practices involving substantial risk. Due to their irreversibility, these decisions are important for understanding structural change in agriculture. Thus policy instruments, which are designed to provide incentives for a disinvestment, should take this into account and compensate the adjustment cost and value of waiting related to the disinvestment option. Otherwise they will fail to trigger the desired behaviour of farmers.
In view of problems related to an econometric validation of the ROA, we pursued a different approach in this paper and studied the disinvestment behaviour of farmers in a laboratory experiment under controllable conditions. The observed disinvestment decisions were contrasted with theoretical benchmarks, which were derived from static (NPV) and dynamic investment models (ROA).

The main findings from this experimental study are first that participants (farmers) postpone taking an irreversible decision. They postpone the termination of a project, even, if the risk adjusted NPV of the project cash flow falls below the liquidation value, hence rejecting traditional investment theory. A further insight from our experiments was the superiority of the ROA in explaining disinvestment behaviour in comparison with the NPV. The predicted disinvestment period was on average closer to observed disinvestment period and we found a significant positive correlation between them. Nevertheless, we have evidence that many participants at least intuitively understand the value of waiting and apply decision rules that result in choices somewhat consistent with those that would have occurred if they had applied such real options reasoning.

However, even though (intuitive) real options reasoning seems to be more appropriate to account for individuals' behaviour than the NPV approach, an "options-based" inertia appears not to be the entire story. In behavioural economics several drivers for this phenomenon have been discussed, such as sunk-cost fallacy (Ross and Staw 1993) or the status quo bias (Burmeister and Schade 2007). It would be interesting (and challenging) to disentangle these very different perspectives on inertia in disinvestment decisions from the option-based inertia which focused on in our experiments. Another interesting path to be taken is comparing the behavior of farmers with other entrepreneurs, as farmers have been alleged to be particularly conservative and averse to changes (e.g., Jose and Crumly 1993). Finally, we suggest investigating the effect of framing on disinvestment choices: Will farmers be more "attached" to a project that is described in terms that are more familiar to them? Framing might also be helpful in making a laboratory experiment more realistic and thereby increase its external validity.

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