We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900
Open access books available

185,000
International authors and editors

200M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Chapter 3

Option Models Application of Investments in Organic Agriculture

Karmen Pažek and Črtomir Rozman

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/52008

1. Introduction

Farmers constantly face decisions about whether to invest in a new production method with increased risks and uncertainties or to maintain the current system without new risks and uncertainties. The possible method to evaluate a new business or investment opportunity is to use traditional discounted cash flow methods [23, 24]. Investment assessment is the very important part of the capital operations and important perception for the success of investment projects. Although the Net Present Value (NPV_t) methodology is widely used by project decision making process, a disadvantage of the NPV_t is that the method does not include the flexibility or uncertainty. Several researchers argue that Net Present Value (NPV_t) is not adequate under uncertain conditions and typically considers projects to be irreversible [1, 4, 8, 29]. To evaluate suitable investment possibilities, an investor-farmer needs to take into account the value of keeping options open, including the impact of sources of uncertainty and risk attitudes. The risk and uncertainty associated with management decisions are included in the formulation of real options problems [8, 30] and real option models [3]. However, real options approach (ROA) rise from the doubt of NPV_t method and can make up for it in assessment investment agricultural projects.

There are some limitations of NPV_t by evaluating agricultural investment project. [32] presented some of them; $NPV_t$is not flexible and only uses information available at the time of the decision. It does not account for changes to the project after the initial decision being made. Further, NPV_t method only emphasize that a prospective project must be positive value. The traditional discount cash will not recommend embedding an option to expansion which is expected to be negative – the expansion is an option and not an obligation. In fact, not all agricultural venture capital projects could make a profit immediately, because the sustainable development needs to be considered. For example, if the agricultural project of

INTECH
open science | open minds

© 2012 Pažek and Rozman ; licensee InTech. This is an open access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

seed – improvement, as a long-term project, succeeds, it will greatly improve the food production and increase farmer's income. Real options approach can make up for the deficiencies of $NPV_{t,}$ which greatly enhance the accuracy of investment decisions.

A real option is defined as the value of being able to choose some characteristic of a decision with irreversible consequences, which affects especially on a financial income. Real options uses a flexible approach to uncertainty (i.e. ecological and technological production possibilities, economic efficiency of production, market and trade opportunity) by identifying its sources, developing future business alternatives, and constructing decision rules. It attempts to reduce risk by monitoring the implementation of its decisions and requiring decision making to be adaptive throughout the life cycle of a project.

Further, ROA approach focus on irreversibility of investment in agricultural venture capital project. NPV_t method has such a hypothesis that the investment is reversible, and the investment can not be delayed. In reality, the majority of investment projects are irreversible. This is one of the major theoretical flaws of NPV_tmethod. Real options approach reputes that, in most cases, although the investment is irreversible, investment could be postponed. Many uncertainties in the environment may eventually be eliminated. NPV_t method ignores the strategic value of the projects, such as the opportunity to expand into a new market, to develop natural resources or technology. By taking this method, decision maker will have to consider questions from the static view, and think that the cash flow of investment is fixed, only make decision whether to accept the investments immediately or not. On the contrary, ROA carries on the decision making from dynamic view. What ROA obtains is the expansion of $NPV_{,}$ which include traditional NPV_t and the value of options [32].

ROA approach takes into consideration the flexibility of agricultural venture capital project. Example, NPV method does not allow for the management flexibility that is often present. Many investments opportunities have options embedded in them and the traditional NPV misses this extra value because it treats investors as passive. However, by using ROA, decision maker can adjust value by reacting to changing conditions. For example, they could expand operations of the project if the outlook seems attractive, while reduce the scope of activities if the future outlook is unattractive. When considering uncertainty and managerial flexibility, NPV does not properly capture the non-linear nature of the cash flow distribution or the changing risk profile over time. In fact, the agricultural reproduction process is the process that the social economy reproduction and the nature reproduction are interwoven, so the benefit of agricultural project has the big instability. ROA takes into consideration the flexibility of agricultural investment project, which confirms to the characteristic of agriculture capita project evaluation [32].

Theoretical advances in real options methodology have been formulated and assimilated in several empirical applications [7, 20, 21]. The practice of real options approach has played a positive role in reachening the theory of real options. Therefore real options, just as the same as financial options, is not only the right to investment, but also gradually become a kind of investment philosophy. Real options theory is increasingly used in industry projects too.

http://dx.doi.org/10.5772/52008

Real options methodology was used to evaluate organic agriculture [31]. The authors stressed the new European policy measures, where adoption of environmental friendly production systems should be considered. The adoptions is includes risk and uncertainty and to overcome this parameters well designed policy schemes are required. The study attempts to examine the effects of income variability upon the decision on adopting or not environmental friendly production systems in order to evaluate the organic financial incentives to farmers by introducing the real options methodology. The technology adoption of a free-stall dairy housing under irreversibility and uncertainty and its implications in the design of environmental policies was examined [26]. Further, the stochastic dynamic model of investment decision of an individual farmer under risk in the presence of irreversibility and technical change was assessed [9]. [18] explore the potential of the real options approach for analysing farmers' choice to switch from conventional to organic farming. The model for effect-assessment of prices variability by the decision to invest in conservation with application to terrace construction was developed too [33]. A model for determining optimal entry and exit thresholds for investment in irrigation systems when there is given irreversibility and uncertain returns with price and yield as stochastic variables were developed [25]. The model for investment decision to convert farmland to urban as an irreversible investment under uncertainty when use of this land is restricted by government policies so as to protect the environment were developed [29]. The appliance of real options evaluation is showed on model of plum and plum brandy as an extension. The research implies that plum plantation has an option value (call value) regarding extension to plum brandy production. This option was determined using the most frequently used option valuation method - Black-Scholes model [10]. The impact of price uncertainty and expectations of declining fixed costs on the optimal timing site specific crop management was presented by [11]. However, there are presentedsome more studies on the application of real options in agriculture [13, 15, 16, 17, 19, 22].

In the presented research the use of the decision making process and its tools for evaluating investments in organic spelt processing business alternatives using elements of the real options methodology is presented. The study focuses on the impact of Net Present Value (NPV_t) as a parameter for investment decisions in the framework of Cost Benefit Analysis (CBA) and the real options model (Black-Scholes and binominal model).

2. Model development

The methodological framework for the financial and real option approach assessment of spelt processing alternatives lies within the inter-relation of the organic spelt processing simulation model KARSIM 1.0 [23]. The first technique presented is one of the common methodological approaches to farm management, while the real option approach is based on the Black-Scholes and binominal models.

2.1. KARSIM 1.0 integrated technologic-economic deterministic simulation model

Simulation modelling can be efficiently applied in both cost estimation and cost benefit analysis [6, 27]. Furthermore, simulation represents one of the fundamental tools for making management decisions [12]. The computer simulation model KARSIM 1.0 was developed for the financial and technological analysis of food processing (organic and conventional).The system as a whole represents a complex calculation system and each sub-model results in a specific enterprise budget. Through a special interface, the system enables simulation of different alternatives at a farm level. Furthermore, based on enterprise budgets, cash flow projections can be conducted together with investment costs for each spelt business alternative, and the net present values for each simulated alternative can be computed. All iterations (calculations for individual alternative) are saved into a database, which is finally used as one of the data sources for real option analysis. The simulation system is built in an Excel spread sheet environment in order to ensure better functionality of a user friendly calculation system. The model structure is presented in Figure 1.

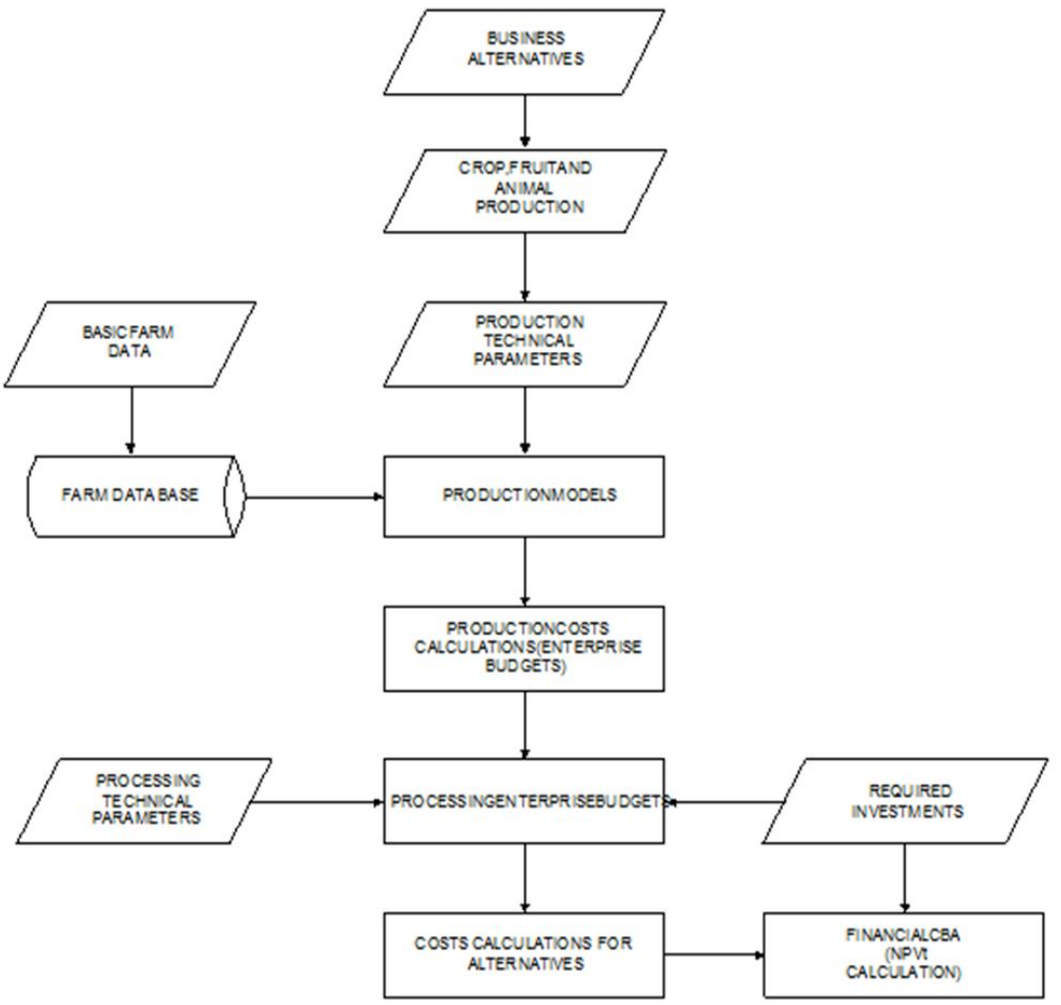


Figure 1. The structure of deterministic simulation model for cost calculations and planning on organic farms KARSIM 1.0.

http://dx.doi.org/10.5772/52008

As presented, the KARSIM 1.0 model is based upon deterministic technologic-economic simulation where the technical relations in the system are expressed with a set of equations or with functional relationships. The amounts of inputs used are calculated as a function of given production intensity, while spelt production costs are calculated as products between the model's estimated inputs usage and their prices. Furthermore, based on enterprise budgets, cash flow projections can be conducted together with the investment costs for each business alternative, and the NPV_t for each simulated alternative can be computed.

2.2. The standard Net Present Value (NPV_t) analysis versus the real options approach

The decision as to which spelt processing method to undertake on an individual farm is rarely made on the basis of NPV_t calculation alone. At this point, we can introduce real option methodology into the planning process where some further KARSIM 1.0 results represent input variables for Black-Scholes and binomial model analysis. The preferred approach to evaluating investments is NPV_tanalysis. For an investment of t periods the formula is:

$$NPV_t = -I + \sum_{i=1}^{n} \frac{TR - TC}{(1+r)^2} \tag{1}$$

Where:

NPV_t - standard Net Present Value (€)

I - investment costs (€)

TR - total revenue (€)

TC - total costs (€)

r - interest rate (%)

t - time - number of years [30].

According to the standard CBA approach, it was presumed that the maximization of the Net Present Value (NPV_t) of the project investment used market prices for expenditures and commodities and describes the financial feasibility. The Net Present Value (NPV_t) parameter is most commonly used in the evaluation of investments in specific investment projects. However, the basic objective of financial analysis is the Net Present Value (NPV). By isolating the cash costs from enterprise budgets, the annual cash flows are estimated, representing a basic input parameter for the computation of NPV_t. In NPV_t equation, the aggregate benefitsTR and the aggregate costs TC are annually summed and discounted to the present with the selected discount rate r.

With isolation of cash costs from enterprise budgets the annual cash flows are estimated, representing a basic input parameter for computation of NPV_t. In equation, where NPV_t is presented, the aggregate benefits SP and the aggregate costs SS are annually summed and discounted to the present with the selected discount rate r. If the sum is positive, investment

generatesmore benefits than costs to the project manager (in our case the farmer) and vice versa if the sum is negative. If the NPV_t of the investment after discounting is positive then this investment is better than the alternative earnings. However, in the continuation the concept of options will be introduced how the real options can be appended to the basic NPV_t model.

2.3. Black-Scholes model (BS)

To illustrate the real options methodology, two examples of developed real options model organic spelt processing output are presented, i.e., the Black-Scholes and the binomial models for organic spelt processing business alternatives were developed. Real option describes an option to buy or sell an investment in physical or intangible assets rather than in financial assets. Thus, any corporate investment in plant, equipment, land, patents, brand names, for example, can be the assets on which real options are written. In addition, the investments could be evaluated as real options. Investment (real) opportunities could be treated analogically as financial options. The value of real options is described by the best known Black-Scholes option model (BSOPM)[2]. The link between investments and Black-Scholes inputs are presented in Figure 2.

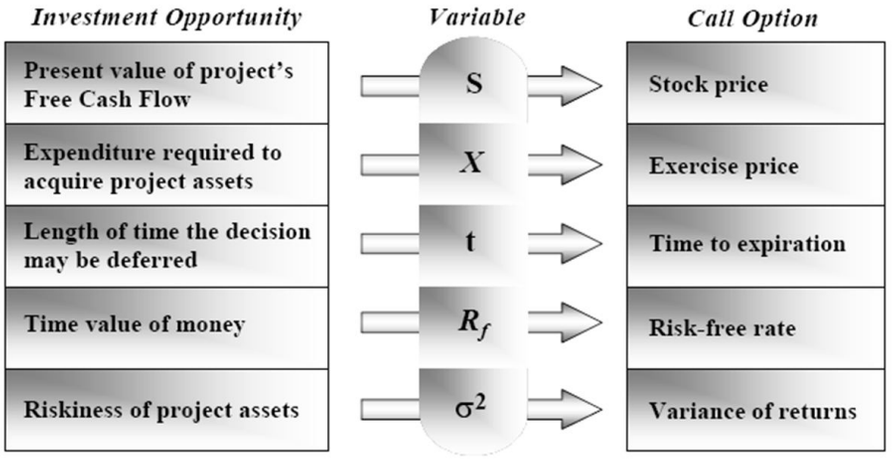


Figure 2. The connections between investments opportunity and Black-Scholes inputs [14].

However, the BS model is one of the most outstanding models in financial economics. The BSOPM based on stochastic calculus is shown below:

$$OV = SN(d_1) - X / e^{-rt}N(d_2) \tag{2}$$

$$d_1 = \left[\ln(S/X) + \left(r_f + \tfrac{1}{2}\sigma^2\right) * t \right] / \sigma\sqrt{t} \tag{3}$$

$$d_2 = d_1 - \sigma\sqrt{t} \tag{4}$$

http://dx.doi.org/10.5772/52008

Where:

OV - option value (€),

S - present value of cash flows from optional investment (€),

d_1 - lognormal distribution of $N(d_1)$,

d_2 - lognormal distribution of $N(d_2)$, X - investment expenditure (€),

r_f- annual risk free continuously compounded rate (%),

σ - annualized variance (risk) of the investment's project, t - period until investment (years),

e^{-rt}- the exponential term = 2,71828.

The real options method explicitly accounts for uncertainty in the determination of an optimal decision in light of the stochasticity of an asset's value. The stochastic variable is in calculus expressed in the concept of annual risk free continuously compounded rate and annualized variance (risk) of the investment's project. In the presented case, some of stochastic variables could be defined as risk and uncertainly variables too. Example, the agriculture policy has an important role on organic spelt grain production at this moment.

$$\text{Option value OV} = \text{SN}(d_1) - \text{present value of X times N}(d_2) \tag{5}$$

Where$N(d_1)$ and $N(d_2)$ represent the probability distributions. The values of $N(d_1)$ and $N(d_2)$ are obtained from normal probability distribution tables. They give us the probability that S or X will be below d_1 and d_2. In the BS model, they measure the risk associated with the volatility of the value of S.

However, the strategic real options of the investment project are calculated using the Black-Scholes methodology and is calculated as:

$$NPV_{SRO} = NPV_t + OV \tag{6}$$

Where NPV_{SRO}-strategic real option (€).

2.4. The binomial model

The binomial option-pricing model is currently the most widely used real options valuation method. The binomial model (i.e., lattice) describes price movements over time, where the asset value can move to one of two possible prices with associated probabilities [32]. The binomial model is based on a replicating portfolio that combines risk-free borrowing (lending) with the underlying asset to create the same cash flows as the option. Figure 3 represents the binomial process through a decision tree. Since an option represents the right but not the obligation to make an investment, the payoff scheme for the option is asymmetric. The analysis

performed in this work makes use of the multiplicative binomial model of Cox and Rubinstein [5], the standard tool for option pricing in discrete time.

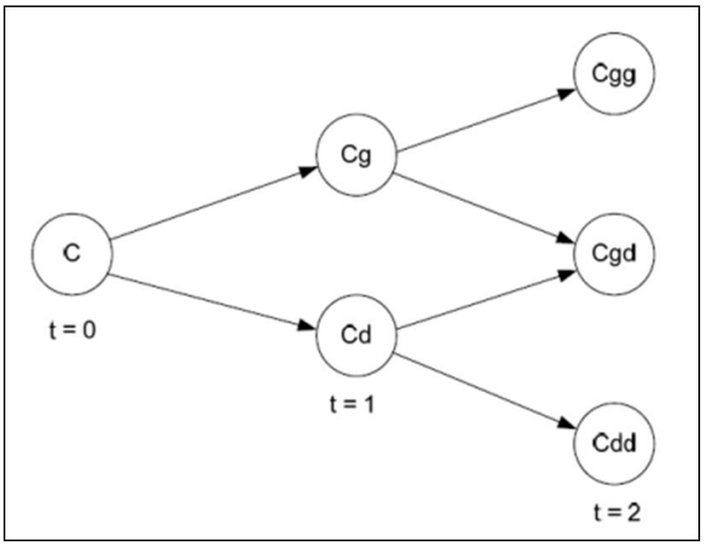


Figure 3. Binominal lattice structure (C= NPV_t with probability d_1 = Cg and d_2 = Cd; Cgg = Cg * d_1, Cgd = Cd * d_1 and Cdd = Cd * d_2).

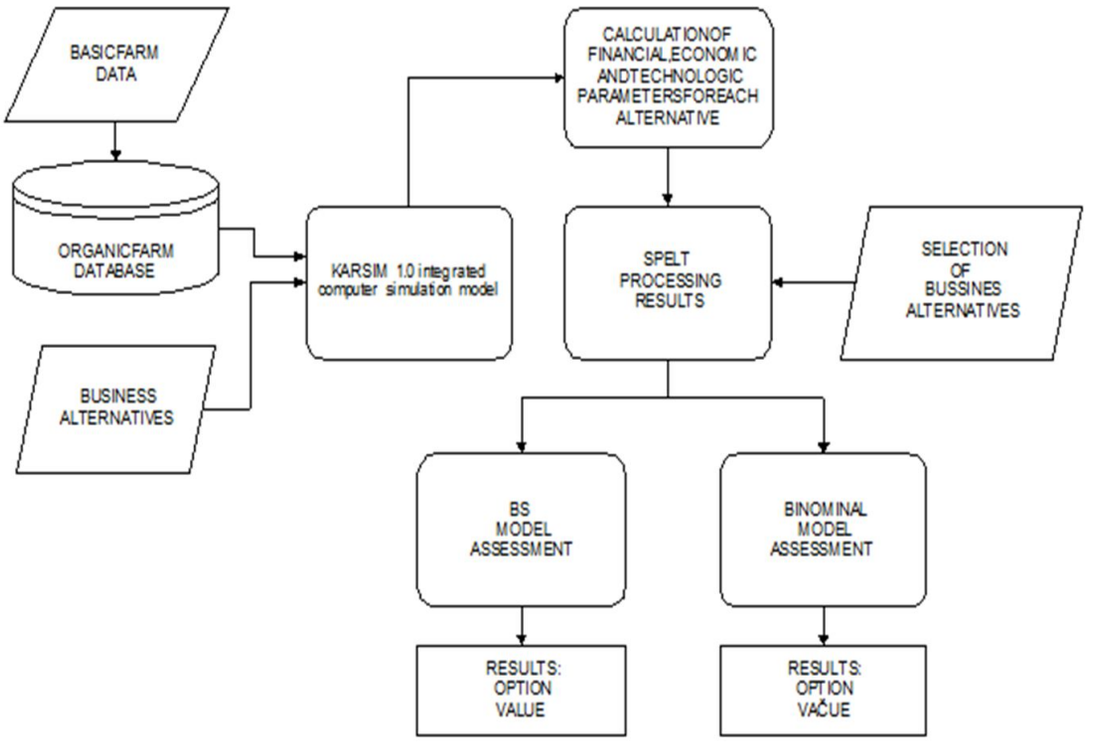


Figure 4. Decision Support Structure for organic spelt processing and option value calculation.

According to Figure 3, a node of value C= NPV_t can lead to two nodes with their values being given by C= NPV_t with probability 1+d = d_1= Cg and 1-d = d_2 = Cd, respectively. Thus,

http://dx.doi.org/10.5772/52008

the lattice provides a representation of all possible demand values throughout the whole project life [7]. The investment project option value (OV) could be calculated using the backward induction process [28, 33].

In the next part, for easier understanding of assessments operation and models functionality, the cumulative structure of integrated decision support system for organic spelt processing alternatives and its option values calculation is in details presented in Figure 4.

However, the goal of integrated model development is to provide answers which business alternative is the best solution for the given sample organic farm.

3. Case study

In the chapter the application of the presented methodology in the context of organic spelt processing investments alternatives is presented.An organic part time-farm with 5,1 ha of arable land in north eastern Slovenia was considered in order to compare spelt processing investment projects using the real option models methodology. The presented farm regularly includes besides other grains spelt wheat (*Triticumspelta*L.) in its crop rotation. The basic characteristic of spelt wheat is its high resistance to diseases, and low input of nitrogen. On the other perspective, spelt wheat can be directly processed into different kinds of food products on the farm itself, and represents additional business and market opportunities for organic farmers. However, the annual area of spelt wheat is, according to crop rotation rules, limited to 1 ha with an average yield of 2500 kg unhusked spelt grain (the average yield/ha on Slovene organic farms). The service of husking and milling the grain is outsourced by the farmer and is calculated as variable cost. Spelt is used for animal fodder, but the alternative option considered in this model is to produce and sell spelt grain and spelt flour to individual customers for human nutrition.

4. Results and discussion

The identified business alternatives are evaluated using a specially developed simulation models in Excel spreadsheet environment. Basic production data and calculated economical parameters for individual business alternatives in spelt processing are presented in Table 1.

Based on discounted cash flow methodology, the traditional net present value (NPV_t) criterion is used extensively in assessing an investment opportunity for three analysed spelt products (table 2).The results are calculated under the assumption of successful product selling at the expected prices. The estimated production levels were calculated on the basis of the annual spelt production area. As shown in table 2, CBA analysis shows positive net present values for both processed spelt for human nutrition (spelt grain and spelt flour). The highest NPV_t was observed for husked spelt grain (NPV_t = 9.224,84 €). The relatively high estimated NPV_t for spelt grain can be explained by high prices, achieved in the market. The negative

NPV_t was calculated for spelt grain for animal nutrition and is expected (the price on the market is compared to husked spelt grain for human nutrition lower, but on the other hand the basic production costs are the same as by processed spelt grain). The investment return period (Pd) is for husked spelt grain and spelt flour 2 years. However, the corresponding NPV_t by Pd is for husked spelt grain (human nutrition) higher compared to spelt flour (NPV_t= 2.482,12 € and NPV_t= 1.066,96 €).

Business alternative	Products quantity** (kg)	Total costs (€)	Total revenue (€)	Coefficient of economics
Husked spelt* (animal fodder)	1.688,00	478,00	591,15	1,24
Husked spelt grain (human nutrition)	1.688,00	1.495,30	4.389,25	2,94
Spelt flour	1.350,00	1.675,15	3.795,05	2,27

*on Slovene organic farms is spelt usually used in animal feed rations as husked spelt
**products quantity based on annual spelt average yield/ha on Slovene organic farms

Table 1. The simulation model results for the planned spelt processing projects on a sample farm.

Product	Investment costs (€)	Annual cash flow (€)	NPV_t (€)	Investment return period=Pd (years)	NPV_t by Pd (€)
Spelt grain (animal nutrition)	580,00	113,19	-128,08	/	/
Spelt grain (human nutrition)	2.960,00	3.051,77	9.224,84	2	2.482,12
Spelt flour	2.960,00	2.259,19	6.056,31	2	1.066,96

Table 2. Financial CBA analysis of the planned spelt processing projects on a sample farm (after 5 years, discount rate = 8%).

However, as expected, the investment into spelt grain for animal fodder is financial unfeasible (NPV_t = -128,97€) and investment return period is not possible to assessed. From financial aspect this project should be rejected. Further, the results of traditional Net Present Value for spelt grain production (animal fodder) presents the base for calculation of strategic real option of spelt grain (for human nutrition) and spelt flour. The risk-free rate and variance of the investment's project were defined deterministic. To illustrate the real options methodology, we present two examples of our real options model output. In the first part of tables 3 and 4 the parameters used in the real options model calculation for the spelt grain and spelt flour production are demonstrated. In the second part of the table 3 and 4 there are calculated simulation models results for real options calculation.

http://dx.doi.org/10.5772/52008

Parameters description	Value
Present Value of cash flows from optional investment (€)	3.051,77
Investment expenditure (€)	2.960,00
Exponential function	2,71828
Risk-free rate (%)	8,00
Period until investment (years)	5
Variance (Risk) of the investment's project (%)	50
d1	0,9440974
d2	-0,173936588
Lognormal distribution of d1	0,827440061
Lognormal distribution of d2	0,430957649
Option value of spelt grain (human nutrition)(€)	1.670,07
Strategic real option of spelt grain for animal nutrition (processing of spelt grain for human nutrition) (€)	1.541,99

Table 3. Descriptions and values of parameters for the real options model for spelt grain (human nutrition).

As seen in table 3, option value for husked spelt grain, calculated by Black-Scholes methodology, is 1.670,07 €. Further, the strategic real option of spelt grain (animal nutrition) is a positive value too. The results of the application of BS methodology by analysed farm business alternative showed the interest in investment project (strategic real option = 1.541,99 €) and is suggested to accept the project.

Parameters description	Value
Present Value of cash flows from optional investment (€)	2.258,19
Investment expenditure (€)	2.960,00
Exponential function	2,71828
Risk-free rate (%)	8
Period until investment (years)	5
Variance (Risk) of the investment's project (%)	50
d1	0,674733898
d2	-0,443300091
Lognormal distribution of d1	0,750077578
Lognormal distribution of d2	0,328774345
Option value of spelt flour (human nutrition)(€)	1.041,48
Strategic real option of spelt grain for animal nutrition (processing in spelt flour)(€)	913,40

Table 4. Descriptions and values of parameters for the real options model for spelt flour.

The results of analysed farm business alternative (spelt flour, Table 4) indicate that the calculated option value is 1.041,48 €. According to the option value calculation, the strategic real option of spelt grain for animal nutrition and further processing into spelt flour is a bit lower value as by processing into spelt grain for human nutrition, but in analysed case again the positive value (SRO = 913,40€). Under the model assumptions,the spelt flour production option is suitable and financial interesting for the farmer.

On the basis of calculated data with BS methodology it can be concluded, that under presumed input parameters both business alternative are for the farmer suitable option.

Further, investment project option values are calculated using the binomial lattice too. However, the results of real options approach show more favourable picture from farmers' perspective by binominal model. The results showed that financially the most interesting and suitable investment is spelt grain for human nutrition where the option value results in a value of 2.678,81 € followed by spelt flour production (1.577,37€). All binomial model results are calculated under the assumption presented in Table 5.

Parameter	Spelt grain (human nutrition)	Spelt flour
OV (€)	2.678,81	1.577,37

Table 5. Option value assessments for spelt processing using binominal model.

$upfactord_1 = 1{,}648720716$

$down\ factord_2 = 0{,}606530864$

$p = 0{,}457456139$

$1\text{-}p = 0{,}542543861$

The detailed presentation of the binomial lattice calculations is in Table 6 to Table 9.

Time (years)	*0*	*1*	*2*	*3*	*4*	*5*
OV (€)	3.051,77	5.031,52	8.296,57	1.3677,08	22.549,68	37.178,14
		1.850,99	3.051,77	5.031,52	8.295,57	13.677,09
			1.122,68	1.850,99	3.051,77	5.031,52
				680,94	1.122,68	1.850,99
					413,01	680,94
						250,50

Table 6. Asset valuation lattice for spelt grain for human nutrition using binominal model (for first 5 years of production).

As seen previously in all cases, is the most suitable alternative production spelt grain for human consumption. It should be mentioned that there are between both model results differ-

ences in the individual alternative assessments. The presented results showed that binominal models further confirm the preliminary CBA results (Table 2).

Time (years)	*0*	*1*	*2*	*3*	*4*	*5*
OV (€)	2.678,81	5.208,81	8.432,14	13.639,89	19.589,68	34.218,14
		956,82	1.827,69	3.290,62	5.335,57	10.717,09
			155,99	369,40	874,77	2.071,52
				0,00	0,00	0,00
					0,00	0,00
						0,00

Table 7. Option value assessments for spelt grainwith binominal model (for first 5 years of production).

Time (years)	*0*	*1*	*2*	*3*	*4*	*5*
OV (€)	2.258,19	3.723,12	6.138,39	10.120,50	16.685,88	27.510,37
		1.369,66	2.258,19	3.723,13	6.138,40	10.120,51
			830,74	1.369,66	2.258,19	3.723,13
				503,61	830,74	1.369,66
					305,61	503,87
						185,36

Table 8. Asset valuation lattice for spelt flour for human nutrition using binominal model (for first 5 years of production).

Time (years)	*0*	*1*	*2*	*3*	*4*	*5*
OV (€)	1.577,37	3.208,96	5.553,91	9.382,44	13.725,88	24.550,37
		443,81	889,58	1.724,39	3.178,40	7.160,51
			57,47	136,08	322,26	763,13
				0,00	0,00	0,00
					0,00	0,00
						0,00

Table 9. Option value assessments for spelt flour with binominal model (for first 5 years of production).

However, the model results showed that both project results with positive values. But it should be mentioned that does not mean that the project may be accepted and invested immediately. It should be taken into account the flexibility and possible options. The positive option values means that the farmer should hold the option of analyzed project investment and do not abandon the project simply.

5. Conclusion

The application of discount cash flow approach in agriculture is not always the appropriate way to decide if an investment project is feasible or not. In the paper, an attempt was made to employ a real options approach to evaluate the spelt processing business alternatives on a farm. The general implication from this empirical analysis is that uncertainty and risk attitudes play an important role in farmers' decision to adopt a new business. Empirical results reveal that the production of spelt grain for animal fodder versus spelt grain (for human nutrition) and spelt flour is not advisable for the analysed farm. The model results are useful in practice and helpful in setting up hedges in the correct proportions to minimize risk. However, real option approach offers a new point of view to investment evaluation of agri-food project. The option methodology takes into account uncertain parameters, forecasting and the most important, the value of opportunity. We can conclude, that real options are comprehensive and integrated solution to apply options theory to value real investments project to improve the decision making process.

Author details

Karmen Pažek* and Črtomir Rozman *

*Address all correspondence to: karmen.pazek@uni-mb.si

Chair of Agricultural Economics and Rural Development/University of Maribor/Faculty of Agriculture and Life Sciences/Pivola, Slovenia

References

[1] Amram, M., & Kulatilaka, N. (1999). *Real Options: Managing Strategic Investment in an Uncertain World*, Boston, Massachusetts, Harvard Business School Press.

[2] Black, F., & Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy*, 81(5-6), 637.

[3] Brennan, M., & Schwartz, E. (1985). Evaluating natural resource investments. *Business*, 58135-157.

[4] Collins, R., & Hanf, C. H. (1998). Evaluation of farm investments: Biases in Net Present Value estimates from using quasi-deterministic models in an uncertain world. *Agricultural Finance Review*, 58-81.

[5] Cox, J. C. , & Rubinstein, M. (1990). Option Pricing: A Simplified Approach. *Financial Econ.*, 1979, 7229-263, reprinted in The Handbook of Financial Engineering, Harper Business Publishers.

[6] Csaki, C. (1985). *Simulation and System Analysis in Agriculture*, Amsterdam, Elsevier.

[7] Dalila-Fontes, B. M. M. (2008). Fixed versus flexible production systems: A real options analysis. *European Journal of Operational Research*, 188169-184.

[8] Dixit, A., & Pindyck, R. (1994). *Investment Under Uncertainty*, Princeton, NJ, Princeton University Press.

[9] Ekboir, J. M. (1997). Technical change and irreversible investment under risk. *Agricultural Economics*, 16(1), 54-65.

[10] Hadelan, L., Njavro, M., & Par, V. (2008). Option Models in Investment Appraisal. 43rd Croatian & 3rd International Symposium on Agriculture. *Book of Abstracts*, 47-48.

[11] Khanna, M., Isik, M., & Winter-Nelson, A. (2000). Investment in site-specific crop management under uncertainty: implications for nitrogen pollution control and environmental policy. *Agriculture Economics*, 249-21.

[12] Kljajić, M., Bernik, I., & Škraba, A. (2000). Simulation approach to decision assessment in enterprises. *Simulation*, 75(4), 199-210.

[13] Kuminoff, N., & Wossink, A. (2010). Why isn't more US farmland Organic? *Journal of Agricultural Economics*, 61(2), 240-258.

[14] Leuhrman, T. (1998). Investment Opportunities as Real Options. *Harvard Business Review*.

[15] Morgan, D. G., Abdallah, S. B., & Lasserre, P. (2007). A Real Options Approach to Forest-Management Decision Making to Protect Caribou under the Threat of Extinction. *Ecology and Society*.

[16] Musshoff, O. (2012). Growing short rotation coppice on agricultural land in Germany: A Real Options Approach. *Biomass and Bioenergy*, 41-73.

[17] Musshoff, N. H. (2008). Adoption of organic farming in Germany and Austria: An integrative dynamic investment perspective. *Agricultural Economics*, 39-135.

[18] Musshoff, O., & Odening, M. (2005, June 22-25). Adoption of Organic Farming. Real Options, Theory Meets Practice. Paris- France. *9th Annual International Conference*.

[19] Nadolnyak, D., Miranda, M. J., & Sheldon, I. (2011). *International Journal of Industrial Organization*, 29-455.

[20] Nishihara, M., & Fukushima, M. (2008). Evaluation of firm's loss due to incomplete information in real investment decision. *European Journal of Operational Research*, 188569-585.

[21] Pandza, K., Horsburgh, S., Gorton, K., & Polajnar, A. (2003). A real options approach to managing resources and capabilities Inter J. *Operations & Production Management*, 23(9), 1010-1032.

[22] Pažek, K., & Rozman, Č. (2011). Business opportunity assessment in Slovene organic spelt processing: application of real options model. *Renewable agriculture and food systems*, 26(3), 179-184.

[23] Pažek, K. (2006). Integrated computer simulation model KARSIM 1.0. *Internal database*, University of Maribor, Faculty of Agriculture and Life Sciences, Slovenia.

[24] Pažek, K., Rozman, Č., Borec, A., Turk, J., Majkovič, D., Bavec, M., & Bavec, F. (2006). The use of multi criteria models for decision support on organic farms. *Biological Agriculture and Horticulture*, 24(1), 73-89.

[25] Price, T. J., & Wetzstein, M. E. (1999). Irreversible investment decisions in perennial crops with yield and price uncertainty. *Journal of Agricultural and Resource Economic*, 24-173.

[26] Purvis, A., Boggess, W. G., Moss, C. B., & Holt, J. (1996). Technology adoption decisions under irreversibility and uncertainty: An Ex Ante approach. *American Journal of Agricultural Economics*, 541-551.

[27] Rozman, Č., Tojnko, S., Turk, J., Par, V., & Pavlovič, M. (2002). Die Anwendungeines Computersimulationsmodellszur Optimierung der Erweiterungeiner Apfelplantageunter den Bedingungen der Republik Slowenien. *Berichteüber Landwirtscahft*, 80(4), 632-642.

[28] Rozman, Č., Pažek, K., Bavec, M., Bavec, F., Turk, J., & Majkovič, D. (2006). The Multi-criteria analysis of spelt food processing alternatives on small organic farms. *Journal of Sustainable Agriculture*, 28159-179.

[29] Tegene, A., Wiebe, K., & Kuhn, B. (1999). Irreversible investment under uncertainty: Conservation easements and the option to develop agricultural land. *Journal of Agricultural Economics*, 50(2), 203-219.

[30] Turk, J., & Rozman, Č. (2002). A feasibility study of fruit brandy production. *Agricultura*, 1(1), 28-33.

[31] Tzouramani, I., & Mattas, K. (2009). Evaluating Economic Incentives for Greek Organic Agriculture: A Real Options Approach. Ed. Rezitis, A. E-book series, Research Topics in Agricultural and Applied Economics. *Benthan Science Publishers*, 1-23.

[32] Wang, Z., & Tang, X. (2010). Research of Investment Evaluation of Agricultural Venture Capital Project on real Options Approach. *Agriculture and Agricultural science Procedia*, 1-449.

[33] Winter-Nelson, A., & Amegbeto, K. (1998). Option values to conservation and agricultural price policy: Application to terrace construction in Kenya. *American Journal of Agricultural Economics*, 80409-418.