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Binominal models application of investments in agri-food production

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ABSTRACT

The paper presents the integrated technologic-economic deterministic simulation system for decision-making support in agri-food production. Under current agricultural situation and conditions the standard management evaluation methods do not account the uncertainty. An emphasis was made on the use of standard financial analysis (i.e. Cost Benefit Analysis, CBA) and its indicator, net present value (NPVt) upgraded with the real options approach for fruit processing as a supplementary activity on a part time farm. The application of real options (RO) was presented using the binomial model. Three different apple processing alternatives were assessed; juice, vinegar and dried apples. Real options have an important value in decision management where standard methods of investment analysis are upgraded and take into consideration stochastic elements as well.

Key words: fruit processing, simulation, investments, binominal models

INTRODUCTION

Farmers constantly face decisions about whether to invest in a new production process 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 (Pažek 2006, Pažek et al. 2006). 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 (NPVt) methodology is widely used by project decision making process, a disadvantage of the NPVt is that the method does not include the flexibility or uncertainty. Several researchers argue that Net Present Value (NPVt) is not adequate under uncertain conditions and typically considers projects to be irreversible (Dixit and Pindyck 1994, Collins and Hanf 1998, Amram and Kulatilaka 1999, Tegene et al. 1999). To evaluate suitable investment possibilities (Leuhram 1998) 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 (Dixit and Pindyck 1994, Turk and Rozman 2002) and real option models (Brennan and Schwartz 1985). However, real options approach (ROA) rise from the doubt of NPVt method and can make up for it in assessment investment agricultural projects.

There are some limitations of NPVt by evaluating agricultural investment project. Wang and Tang (2010) presented some of them; NPVt is not flexible and only uses information available at the time of the decision. NPVt method only emphasizes 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 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 NPVt, 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 (Black and Scholes 1973). Real options use a flexible approach to uncertainty by identifying its sources, developing future business alternatives, and constructing decision rules. Further, ROA approach focus on irreversibility of investment in agricultural venture capital project. In reality, the majority of investment projects are irreversible. This is one of the major theoretical flaws of NPVt method. Real options approach reputes that, in most cases, although the investment is irreversible, investment could be postponed. NPVt method ignores the strategic value of the projects, such as the opportunity to expand into a new market, to develop natural resources or technology. ROA approach takes into consideration the flexibility of agricultural venture capital project too (Wang and Tang 2010).

Theoretical advances in real options methodology have been formulated and assimilated in several empirical

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applications (Dalila-Fontes 2008, Nishihara and Fukushima 2008, Pandža et al. 2003). The practice of real options approach has played a positive role in richening the theory of real options. Therefore real options, just as the same as financial options, are 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. Real options methodology was used to evaluate organic agriculture scheme by Tzouramani and Mattas (2009). The technology adoption of a free-stall dairy housing under irreversibility and uncertainty and its implications in the design of environmental policies was examined by Purvis et al. (1995). Further, the stochastic dynamic model of investment decision of an individual farmer under risk in the presence of irreversibility and technical change was assessed (Ekboir 1997). Musshoff and Odening (2005) explore the potential of the real options approach for analyzing 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 by Winter – Nelson and Amegbeto (1998). Price and Wetzstein (1999) developed 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. 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 by Tegene et al. (1999). The appliance of real options evaluation is showed on model of plum and plum brandy as an extension with option valuation method - Black-Scholes model by Hadelan et al. (2008). The impact of price uncertainty and expectations of declining fixed costs on the optimal timing site specific crop management was presented by Khana et al. (2000). The application of real options in agriculture further presented Morgan et al. (2007), Musshoff and Hirschhauet (2008), Kuminoff and Wossink (2010), Nadolnyak et al. (2011), Pažek and Rozman (2011) and Musshoff (2012).

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

MATERIAL AND METHODS

Model development

The methodological framework for the financial and real option approach assessment of fruit processing alternatives lies within the inter-relation of the agricultural product processing simulation model KARSIM 1.0 (Pažek 2006). The first technique presented is one of the common methodological approaches to farm management, while the real option approach is based on the binominal models.

KARSIM 1.0 integrated technologic-economic deterministic simulation model

Simulation modeling can be efficiently applied in both cost estimation and cost benefit analysis (Csaki 1985, Rozman et al. 2002). Furthermore, simulation represents one of the fundamental tools for making management decisions (Kljajić et al. 2000). 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 apple processing 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 spreadsheet environment in order to ensure better functionality of a user friendly calculation system.

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 apple 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 NPVt for each simulated alternative can be computed.

The standard Net Present Value (NPVt) analysis versus the real options approach

The decision as to which farm management decision method to undertake on an individual farm is rarely made on the basis of NPVt calculation alone. Traditional investment appraisal should be completed with real option methodology into the planning process where some further KARSIM 1.0 results represent input variables for binomial model analysis. The preferred approach to evaluating investments is NPVt analysis. For an investment of t periods the formula is:

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

Where:
NPVt - standard Net Present Value (€)
I - investment costs (€)
TR - total revenue (€)
TC - total costs (€)
r - discount rate (%)
t - time - number of years (Turk and Rozman 2002).

According to the standard CBA approach, it was presumed that the maximization of the Net Present Value (NPVt) of the project investment used market prices for expenditures and commodities and describes the financial feasibility. The

Net Present Value (NPVt) 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 NPVt. In NPVt equation, the aggregate benefits TR 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 NPVt. In equation, where NPVt is presented, the aggregate benefits and the aggregate costs are annually summed and discounted to the present with the selected discount rate r. If the sum is positive, investment generates more benefits than costs to the project manager (in our case the farmer) and vice versa if the sum is negative. If the NPVt 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 NPVt model.

The binominal model

To illustrate the real options methodology, example of developed real options model apple processing output is presented, i.e. the binomial models for apple processing business alternatives were developed. 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 (Wang and Tang 2010). 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 (1979), the standard tool for option pricing in discrete time.

According to Figure 1, a node of value C = NPVt can lead to two nodes with their values being given by C = NPVt with probability 1+d = d1= Cg (up factor, u) and 1-d = d2 = Cd (down factor, d), respectively. The up and down factors are calculating using the underlying volatility (σ):

Cg = 1 + upside change = e^{σ} (2)

Cd = 1 + downside change = 1 / Cg (3)

Next period underlying asset price (Vs) is calculated as:

V_s up = V_0 * u (4)

V_s down = V_0 * d (5)

Probability of up and down change of the asset price (p) is followed:

Up change = $p = \frac{e^{rt} - d}{u - d}$ (6)

Where:

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

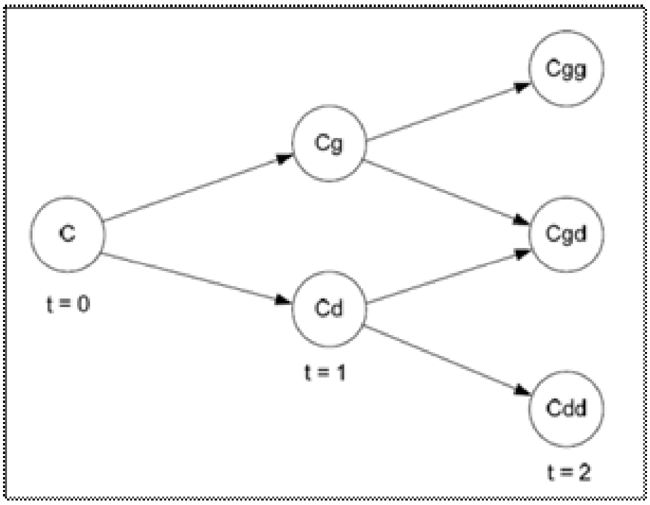

Figure 1: Binominal lattice structure (C = NPVt with probability d1 =Cg and d2 = Cd)

Down change = 1 – p (7)

Binomial option is done by asset and option value tree (i.e. lattice) project, using all maintained elements. The option valuation begins solving the tree's node value at the latest year and work back to the beginning year through backward induction (Rozman et al. 2006, Winter-Nelson and Amegbeto 1998).

The option on the node resulted by the n price increase (un) and can be calculated by the formula (Hadelan et al. 2009):

$OV(u^n) = \max(Vs(u^n) - X;0)$ (8)

Value of the option in the node dn can be formulated as:

$OV(d^n) = \max(Vs(d^n) - X;0)$ (9)

The calculation of the option value in previous steps is:

$$OV(u^{n-1}) = \frac{p * OV(u^n) + (1-p) * OV(u^{n-1}d)}{1+r} \quad (10)$$

Where:

X – investment's value (€)

OV - option value of project (€)

r - annual risk free continuously compounded rate (%)

σ - annualized variance (risk) of the investment's project.

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

$NPV_{SRO} = NPV_t + OV$ (11)

Where:

NPV_{SRO}-strategic real option (€).

Thus, the lattice provides a representation of all possible demand values throughout the whole project life (Dalila-Fontes 2008).

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

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 apple processing are presented in Table 1.

Based on a discounted cash flow methodology, the traditional net present value (NPV_t) criterion is used extensively in assessing an investment opportunity for three analysed apple products (Table 2). The results are calculated under the assumption of successful product selling at the expected prices. As shown in Table 2, economic analysis of apples production indicates relatively high profitability. Further, CBA analysis shows positive net present values for two processed apple alternatives (juice and vinegar). The highest NPV_t was observed for apple juice (NPV_t = 4.239,48 €). The relatively high estimated NPV_t for juice can be explained by high prices, achieved in the market. The negative NPV_t was calculated for dried apples and is expected to be so.

Table 1: The simulation model results for the planned fruit processing projects on a sample farm

Business alternative	Products quantity (l, kg)	Total costs (€)	Total revenue (€)	Coefficient of economics
Apple juice	5.025	4.745,33	8.094,66	1,71
Apple vinegar	5.980	4.354,04	6.580,23	2,99
Dried apples	1.507,5	13.865,51	15.163,18	1,09

Table 2: CBA analysis of the planned fruit processing projects on a sample farm (after 5 years, r = 8%)

Product	Investment costs (€)	Annual cash flow (€)	NPV_t (€)	Investment return period=Pd (years)	NPV_t by Pd (€)
Apple juice	9.133,43	3.349,33	4.239,48	4	447,43
Apple vinegar	6.666,41	2.226,19	2.222,13	5	2.222,13
Dried apples	6.066,95	1.297,66	-886,76	6	22,53

However, as expected, the investment into dried apples production is financial unfeasible (NPVt = -886,76 €) and investment return period is under presumed model input parameter (see Table 2) not possible to be assessed. From financial aspect this project should be rejected by the farmer.

Further, the results of traditional Net Present Value for all business alternatives present the base for calculation of strategic real option of apple processing. The risk-free rate and variance of the investment's project were defined deterministic. To illustrate the real options methodology, we present some examples of our real options model output.

Investment project option values are calculated using the binomial lattice. However, the results of real options approach show more favorable picture from farmers' perspective by binominal model. The results showed that financially the most interesting and suitable investment is again apple juice production where the option value results in a value of 221,48 € followed by apple vinegar production (129,74 €). All binomial model results are calculated under the assumption presented in Tables 1 and 2.

The detailed presentation of the binomial lattice calculations are in Tables 4-8, where binomial models

Table 3: Option value assessments for apple processing using binominal model

Parameter	Apple juice	Apple vinegar	Dried apples
OV* (€)	221,48	124,74	0,00
NPV_{SRO}	4.460,96	2.347,86	-885,76

Table 4: Asset valuation lattice for apple juice production by binominal model (for first 5 years of production)

Time (years)	0	1	2	3	4	5
OV (€)	3.349,33	4.521,12	6.102,88	8.238,03	11.120,17	15.010,66
		2.481,25	3.349,33	4.521,13	6.102,88	8.238,03
			1.838,15	2.481,25	3.349,33	4.521,13
				1.361,74	1.838,15	2.481,25
					1.008,80	1.361,74
						747,34

comprise two underlying lattice generation – asset and option value lattice

Table 4 indicates that that the possible project value after 5 years of production can be ranged from 747,34 € to 15.010,66 €, depending on favorable or unfavorable business circumstances.

Option value assessments for dried apples by binominal model for first 5 years of production result with value 0,00. In all cases, the most preferable alternative is apple juice production. The presented results showed that binominal models (Table 3, values of NPVSRO) in presented case further confirm the preliminary CBA results (Table 2), where dried apple production is from financial point of view for the farmer unacceptable.

Table 5: Option value assessments for apple juice production by binominal model (for first 5 years of production)

Time (years)	0	1	2	3	4	5
OV (€)	221,48	426,68	821,99	1.583,56	3.050,73	5.877,23
		0,00	0,00	0,00	0,00	0,00
			0,00	0,00	0,00	0,00
				0,00	0,00	0,00
					0,00	0,00
						0,00

Table 6: Asset valuation lattice for apple vinegar production by binominal model (for first 5 years of production)

Time (years)	0	1	2	3	4	5
OV (€)	2.226,19	3.005,04	4.056,38	5.475,54	7.391,21	9.977,09
		1.649,20	2.226,19	3.005,04	4.056,38	5.475,54
			1.221,76	1.649,20	2.226,19	3.005,04
				905,10	1.221,76	1.649,20
					670,52	905,10
						496,73

Table 7: Option value assessments for apple vinegar production by binominal model (for first 5 years of production)

Time (years)	0	1	2	3	4	5
OV (€)	124,74	240,31	462,95	891,87	1.718,19	3.310,09
		0,00	0,00	0,00	0,00	0,00
			0,00	0,00	0,00	0,00
				0,00	0,00	0,00
					0,00	0,00
						0,00

Table 8: Asset valuation lattice for dried apples by binominal model (for first 5 years of production)

Time (years)	0	1	2	3	4	5
OV (€)	1.297,66	1.751,66	2.364,49	3.191,73	4.308,38	5.815,71
		961,33	1.297,66	1.751,66	2.364,49	3.191,73
			712,17	961,33	1.297,66	1.751,66
				527,59	712,17	961,33
					390,85	527,59
						289,55

But it should be mentioned that it does not mean that financial weak project (i.e. production of dried apples) should be rejected immediately. And contrary, financial strong project (i.e. apple juice and vinegar production) should not be accepted and invested immediately. It should be taken into account the flexibility and possible options. In the further decision process, under other presumed input production parameters, a weak option values means that the farmer should hold the option of analyzed project investment, prepare some possible project scenarios and not to abandon the project instead.

CONCLUSIONS

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 apple 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 dried apples is not advisable for the analyzed 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.

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