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A system supporting financial analysis of an innovation project in the case of two negotiating parties

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A system supporting financial analysis of an innovation project in the case of two negotiating parties

by
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Abstract

The paper deals with cost - benefit - risk analysis of an innovation project. The analysis is considered in the case of two parties involved in the project realization, and negotiating joint venture contract. A model and a computer-based system are presented supporting the analysis and negotiation process. Some numerical results illustrating the problem discussed are included.

Key words: modeling, decision support, negotiations, innovations, financial analysis

1 Introduction

The paper develops a model of innovation activity in the case of two decision makers - two parties negotiating joint research project realization. It uses URS methodology presented in Kulikowski [1], [2], [3].

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Let a representative of a productive firm, called further investor, and a director of research institute are trying to sign a joint venture contract. The firm is going to cover cost of research on an innovative product to start selling the product in a given time. The contract should specify the participation of the parties in common cost and in profit but should also include risk that the project can fail. Each decision-maker has his own preferences and his own utility, as well as a different aversion to risk. An extension of the model presented in [1] is given including negotiated decision variables and quantities describing the project from the point of view of the investor and of the research institute. Some information regarding investment analysis and risk models useful in the model construction can be found in references [4], [5], [6], [7], [8].

A computer-based system including the model relations is proposed, to support the decision makers in cost - benefit - risk analysis of the project and to aid negotiation process leading to a consensus. The system supports overall analysis of the project, unilateral analysis made independently by each of the party and enables also derivation of a mediation proposal. Using the system each party can check how his return, profit, safety index (measuring risk) and other output quantities related to the project depend on negotiated decision variables such as: time of the project accomplishment, participation of the party in the cost and benefit. The information generated by the system allow each of the parties to understand better the nature of the problem, look for the decisions satisfying individual preferences. The parties can make conscious decision during negotiation process and sign joint venture contract.

The mediation proposal is based on the cooperative Nash [9] solution concept. It is derived by solving appropriate optimization problem. The optimization problem is formulated and the optimization procedure is included in the system.

An experimental version of the system has been constructed. Some numerical results illustrating options of the system are presented and discussed.

2 Model of innovation activities

Each project requires resources concentrated within time T to finish the investments and start selling an innovative product. Like in the model by Kulikowski [1], (see Fig. 1) we consider investment period of time $[0, T]$, harvesting time $[T, T_1]$, and we compare the investment cost to the cash flow within the harvesting period.

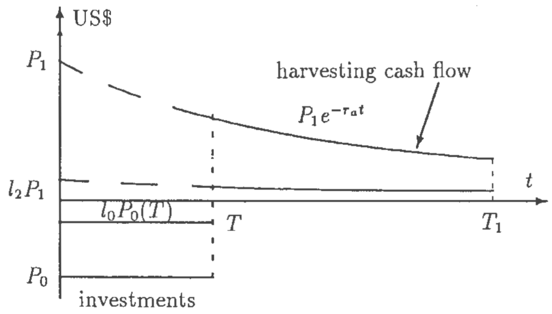

Figure 1:

Investment costs (present discounted value) of research project are described by

$$P_0(T) = \int_0^T P_0 e^{-rt} dt$$

and present value of cash flow within the harvesting period by

$$P_1(T, T_1) = \int_T^{T_1} P_1 e^{-r_a t} dt$$

where P_0 - denotes the investment costs flow per year, r - is a discount rate, P_1 - denotes the cash flow which could be obtained in the initial year, r_a - represents discount and "aging" of innovative product.

The project can succeed and we can calculate respective rate of return and profit, but there is also a risk that it will fail.

Two decision-makers are engaged in the project accomplishment: an investor and a research institute. Trying to formulate a decision-making problem in fair way, we assume that both the investor and the research institute should share the risk and the profit. Therefore it is assumed that they jointly participate in the investment costs and share the profit received.

The part $l_0 P_0(T)$ of the investment costs $P_0(T)$ is assigned to the research institute wheras the part $(1 - l_0)P_0(T)$ is assigned to the investor. The parameter l_0 is a decision variable, $0 < l_{0min} \leq l_0 \leq l_{0max} \leq 1$, where l_{omin} and l_{0max} define minimum and maximum part of the investment costs which can be assigned to the institute. The maximum part can be limited for example by a reserve fund of the institute. On the other hand it is assumed that the research institute can participate in the cash flow obtained in the harvesting period. A parameter $l_2 \in [0, 1]$ defines the share of research institute in the cash flow. Additionally it is assumed that the investor will place in a bank a deposit $l_1 P_0$ which will be paid as a premium to the research institute if the project will succeed. In the case of failure the deposit will be paid back to the investor. The parameters l_0, l_1, l_2, and the time T are considered as decision variables which are negotiated by the investor and the research institute. Output variables of the model are calculated as functions of these variables.

Two scenarios of the research accomplishment are considered:

success which can occure with probability $1 - p(T)$,

in this case the investor will obtain rate of return:

$R^u_{inv}(T, , l_0, l_1, l_2) = \frac{P_1(T,T_1)(1-l_2)}{P_0(T)(1-l_0)+l_1 P_0} - 1$,

while the research institute will receive the return:

$R^u_{res}(T, l_0, l_1, l_2) = \frac{l_1 P_0 + l_2 P_1(T,T_1)}{l_0 P_0(T)} - 1;$

failure – with probability $p(T)$,

the investor will obtain the negative rate of return
$R^d_{inv}(T, l_0, l_1) = -\frac{P_0(T)(1-l_0)}{P_0(T)(1-l_0)+l_1 P_0}$,
while the research institute will receive the negative return:
$R^d_{inv} = -1$.

As in Kulikowski [1] the probability p(T) of failure is evaluated under assumption that the research takes the form of x trials - tests, each taking basic period of time ΔT and characterized by the perceived probability of failure $1 - q$. Probability of success after x failures (according to Bernoulli scheme):

$$\overline{p}(x) = q(1-q)^x, x = 0, 1, 2 \ldots; 0 < q < 1.$$

with expected value $E(x) = (1-q)/q$

In the continuous case $p(T)$ is approximated by the function: $p(T) = \exp^{-T\tau_r}$, where $r_r = q/[(1-q)\Delta T]$ is a rate of research progress. The parameter $\tau_r = 1/r_r$ is called "breakthrough period". These parameters should be evaluated by experts for particular research project.

One can calculate expected quantities and measures of risk for the investor and the research institute.

The investor:

expected rate of return:

$$R_{inv}(T, l_0, l_1, l_2) = [1 - p(T)]R^u_{inv}(T, l_0, l_1, l_2) + p(T)R^d_{inv}(T, l_0, l_1)$$

variance:

$$\begin{aligned} \sigma^2_{inv}(T, l_0, l_1, l_2) &= [1 - p(T)][R_{inv}(T, l_0, l_1, l_2) - R^u_{inv}(T, l_0, l_1, l_2)]^2 \\ &\quad + p(T)[R_{inv}(T, l_0, l_1, l_2) - R^d_{inv}(T, l_0, l_1)]^2 \end{aligned}$$

safety index:

$$S_{inv}(T, l_0, l_1, l_2) = 1 - \kappa_{inv}\sigma_{inv}(T, l_0, l_1, l_2)/R_{inv}(T, l_0, l_1, l_2)$$

Value at Risk (VaR)

$$VaR_{inv}(T, l_0, l_1, l_2) = [P_0(T)(1 - l_0)]\kappa_{inv}\sigma_{inv}(T, l_0, l_1, l_2)$$

Research institute:
expected rate of return:

$$R_{res}(T, l_0, l_1, l_2) = [1 - p(T)]R^u_{res}(T, l_0, l_1, l_2) + p(T)R^d_{res}$$

Variance:

$$\begin{aligned} \sigma^2_{res}(T, l_0, l_1, l_2) &= [1 - p(T)][R_{res}(T, l_0, l_1, l_2) - R^u_{res}(T, l_0, l_1, l_2)]^2 \\ &\quad + p(T)[R_{res}(T, l_0, l_1, l_2) - R^d_{res}]^2 \end{aligned}$$

safety index:

$$S_{res}(T, l_0, l_1, l_2) = 1 - \kappa_{res}\sigma_{res}(T, l_0, l_1, l_2)/R_{res}(T, l_0, l_1, l_2)$$

Value at Risk (VaR)

$$VaR_{res}(T, l_0, l_1, l_2) = [P_0(T)l_0]\kappa_{res}\sigma_{res}(T, l_0, l_1, l_2)$$

Remarks: In the present model the research risk within the investment period is taken into account explicitely. The impact of operational and financial risks is expressed by means of discount r_a. In further extended version these risks will be treated explicitely also.

3 Mediation problem

According to the URS methodology [1], [2], [3] we assume that the investor and the research institute representative have utilities $U_{inv}(R_{inv}(T, l_0, l_1, l_2), S_{inv}(T, l_0, l_1, l_2))$ and $U_{res}(R_{res}(T, l_0, l_1, l_2), S_{res}(T, l_0, l_1, l_2))$ being functions of the expected return and the safety index respectively. Each party tries to select the decision variables T, l_0, l_1, l_2 maximizing its individual utility. Let us see that attainable values of the utilities U_{inv} and U_{res} belong to a set called further the agreement set and denoted by $\mathcal{S} \in R^2$, which is defined in the space of utilities of negotiating parties. The set is defined by the model relations. Particular points from the set can be obtained under unanimous agreement of the parties. The points are compared to a given "status quo" point $d \in R^2$. The status quo point defines utilities the parties can obtain when they do not decide to cooperate and realize jointly the research project.

The mediation problem consists in selection of a function $f(\cdot)$ defining a unique point $f(\mathcal{S}, d) = \hat{U} = (\hat{U}_{inv}, \hat{U}_{res}) \in \mathcal{S}, \hat{U} \geq d$, which could be jointly accepted by the parties. Nash [1] (1950) looking for the solution which could be accepted by two parties as fair has proposed a set of properties, called also axioms, the solution should fulfill. In the following the pair $(\mathcal{S}, d)$ is called the bargaining problem, and we will discuss the Nash properties of the solution to the problem.

Property 1. Independence of Equivalent Utility Representations.

Let a_k, b_k, be real numbers, $a_k > 0, k = 1, 2$, where the subscript $k = 1$ relates to the investor and $k = 2$ to the research institute. Let for the problem $(\mathcal{S}, d)$ we define the problem $(\mathcal{S}^1, d^1) : S^1 = \{y \in R^2 : \exists x \in \mathcal{S},$ such that $y_k = a_k x_k + b_k, k = 1, 2\}$, $d^1_k = a_k d_k + b_k, k = 1, 2$.

Then $f_k(\mathcal{S}^1, d^1) = a_k f_k(\mathcal{S}, d) + b_k$.

The property says, that the solution is invariant to affine transformations of utilities. any party can not benefit changing for example scale of his own utility.

Property 2. Pareto optimality.

For the problem $(\mathcal{S}, d)$ if elements $x, y \in \mathcal{S}$, and $x > y$, then $f(\mathcal{S}, d) \neq y$.

The property is called also as property of collective rationality. According to the property the solution will select an outcome such that no other feasible outcome is preferred by both the parties.

Property 3. Independence of Irrelevant Alternatives.

Let us consider two problems: $(\mathcal{S}, d)$ and $(\mathcal{T}, d)$, such that $\mathcal{T} \subset \mathcal{S}$. Let $f(\mathcal{S}) \in \mathcal{T}$. Then $f(\mathcal{S}, d) = f(\mathcal{T}, d)$.

It means that if an outcome generated by the solution $f(\mathcal{S}, d)$ belongs to a reduced agreement set $\mathcal{T}$, then it has to be also equal to the solution of the problem $(\mathcal{T}, d)$.

Property 4. Symmetry.

Let the problem $(\mathcal{S}, d)$ be symmetric, i.e. $d_1 = d_2$, and if a point $(x_1, x_2) \in \mathcal{S}$, then $(x_2, x_2) \in \mathcal{S}$.

Then $f_1(\mathcal{S}, d) = f_2(\mathcal{S}, d)$.

The property requires that the solution should not distinguish between the parties if the model does not. It means that if the parties have the same bargaining positions, they should have obtained the same utilities.

Analyzing the properties, we can see that they are formulated in a rational way, i.e. the negotiating parties thinking in rational way have no base to reject them.

Nash (1950) [8] assuming that the agreement set $\mathcal{S}$ is compact, close and convex has proved the following theorem.

Theorem

There is a unique solution possessing Properties 1-4. It is the function $f = F$ defined by

$$F(\mathcal{S}, d) = U^N = (U_1^N, U_2^N), \text{ such that } U^N \geq d,$$

and

$$(U_1^N - d_1)(U_2^N - d_2) > (U_1 - d_1)(U_2 - d_2), \forall U = (U_1, U_2) \in \mathcal{S} \text{ and } U \neq U^N.$$

In our case the mediation proposal based on Nash solution concept can be derived by solving the following optimization problem:

$$\max_{T, l_0, l_1, l_2} (U_{inv} - d_{inv})(U_{res} - d_{res}),$$

subject to the constraints:

$$U_{inv} \leq U_{inv}(R_{inv}(T, l_0, l_1, l_2), S_{inv}(T, l_0, l_1, l_2)),$$

$$U_{res} \leq U_{res}(Y_{res}(T, l_0, l_1, l_2), S_{res}(T, l_0, l_1, l_2)),$$

$$T \geq 0, l_0 \in [l_{0min}, l_{0max}], l_1 \in [0, 1], l_2 \in [0, 1],$$

where T, l_0, l_1, l_2 are decision variables, negotiated by the parties,
$U_{inv}(R_{inv}, S_{inv})$ defines investor utility as a function of his expected rate of return and safety index,
$U_{res}(R_{res}, S_{res})$ defines utility of research institute as a function of its expected rate of return and safety index.
Values $R_{inv}(T, l_0, l_1, l_2), S_{inv}(T, l_0, l_1, l_2), R_{res}(T, l_0, l_1, l_2), S_{res}(T, l_0, l_1, l_2)$ are defind by the model relations as functions of the decision variables.

4 Computer based system

Using the model presented above an experimental system has been constructed enabling cost - benefit - risk analysis of an innovation project.

The system has three general options.

The first one supports general analysis of the model. It is dedicated to the model analyst, who implements the model in the system, assumes model parameters and introduces data to the system. It enables analysis of output variables for assumed sequences of decision variables, required to check general consistence of the implemented model.

The second option supports unilateral analysis of the decision-making problem of each of the parties negotiating the contract. Each party can assume sequences of values for decision variables, can assume different values for parameters of utility functions and check sequences of output variables. Each party makes the analysis independently, without any interaction of the other party. Using the option the optimal decision variables can also be found maximizing utility of particular party. The optimum, useful in the analysis, can however not take into account preferences of the other party, and in general can be hardly accepted as a consensus. The analysis should allow each of the parties to learn and understand relations among decision and output variables, to understand its own preferences. After such an analysis the party will be better prepared for negotiations.

The third option enables generation of a mediation proposal. In this case for given parameters of utility functions of the parties, the system solves optimization problem mentioned before and calculates optimal values of decision variables and corresponding output variables of both the parties. This proposal is presented for joint analysis of both the parties and can be useful in finding the consensus.

Some results of experimental calculation made with use of the system are presented in the following tables and figures. According to the URS methodology the utility function of the investor is assumed in the form
$U_{inv} = P_0 R_{inv}(T, l_0, l_1, l_2) S_{inv}(T, l_0, l_1, l_2)^{1-\beta_{inv}}$,
and the utility function of the research institute has the form:
$U_{res} = R_{res}(T, l_0, l_1, l_2) S_{res}(T, l_0, l_1, l_2)^{1-\beta_{res}}$.

Assumed values of the model parameters are as follows: discount rate $r = 0.1$, aging rate $r_a = 0.2$, end time of the harvesting period $T_1 = 6$, research progress rate $r_r = 1.3$, $q = 0.4$, $\Delta T = 0.5$, $\tau_r = 0.75$, $P_1 = 4$, $P_0 = 1$; risk free return $R_f = 0.1$; status quo point $d_{inv} = 0$, $d_{res} = 0$.

Figures 2 and 3 illustrate unilateral analysis made by the investor. The investor has assumed constant decision variables $l_0 = 0.1$, $l_1 = 1$, $l_2 = 0.1$ and look at output variables for the time T changed since 1.0 till 4.5 years. Parameters describing the investor utility are assumed: $\beta_{inv} = 0.5$, $\kappa_{inv} = 0.8$, whereas in the case of the research institute $\beta_{res} = 0.5$, $\kappa_{res} = 1$. On the graphs generated by the system we can see how the output variables depend on the time T. In Fig. 2 an increasing cost of the project assigned to the investor and descreasing Value at Risk can be observed. The probability of success tends to 1. The profit has its maximum at the time $T = 2$. In Fig 3. we can see the curves of decreasing expected rate of return and decreasing variance. The safety index increases. The investor utility has its maximum at the time T equal to 2.75. In general the greater time of the project accomplishment results in an increased probability of success but in lower expected return and in lower variance. The time maximizing utility of the investor depends of course on his preferences and in particular on his aversion to risk represented by κ_{inv} parameter.

The figures 4 and 5 illustrate an analysis, which can be made by the research institute representative. Several output variables are presented as functions of the time T, namely: the costs assigned to by the institute, expected profit, probability of success, Value at Risk, rate of return, safety index and achieved utility. We can see that the utility has its maximum at the time T equal to 4.25.

Let us note that the investor and the research institute have different interests regarding the negotiated time T of the project accomplishment. The investor prefers the time (in this case equal to 2.75) maximizing his utility, but the research institute prefers the time equal to 4.25. If they have intention to undertake jointly the innovation project they have to find a compromise. Similar analysis can be made regarding other decision variables.

The mediation proposal derived by the system can support negotiation process and enable the parties to find the consensus. The mediation proposal is derived by solving the optimization problem mentioned before. It depends of course on the preferences of both the parties represented by parameters of the utility functions. In Table 1 a sequence of mediation proposal is presented for different values of κ_{inv} parameter changing from 0.8 till 1.2. At each value of the parameter the optimization problem has been solved, optimum decision variables: T, l_0, l_1, l_2, and output quantities have been derived. We can see the decision variables and the main output quantities: expected rate of return, safety index and utility of the investor as well as expected rate of return, safety index and utility of the research institute. Increasing value of κ_{inv} parameter results in increasing optimal time T of the project accomplishment. The optimum l_0 is on the lower band equal to 0.05 for the κ_{inv} less than 1, and on the upper bound equal to 0.3 for the greater values of κ_{inv}. The optimum l_1 and l_2 parameter has been derived and can be find in the table. Values of all the output variables are presented in the table.

This is of course only an example of the system output. Different results will be obtained for different model parameters and different

INVESTOR

Time	T	1	1,25	1,5	1,75	2	2,25	2,5	2,75	3
Investment costs	Costs	1,86	2,06	2,25	2,44	2,63	2,81	2,99	3,16	3,33
Expected profit	Profit	5,27	5,69	5,94	6,06	6,11	6,09	6,03	5,94	5,83
Success probability	1-p(T)	0,74	0,81	0,86	0,90	0,93	0,95	0,96	0,97	0,98
Value at Risk	VaR	2,93	2,60	2,28	1,97	1,69	1,45	1,23	1,05	0,89

Time	T	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00
Investment costs	Costs	3,50	3,66	3,81	3,97	4,12	4,26	4,40	4,54
Expected profit	Profit	5,71	5,58	5,45	5,31	5,17	5,03	4,90	4,76
Success probability	1-p(T)	0,99	0,99	0,99	1,00	1,00	1,00	1,00	1,00
Value at Risk	VaR	0,76	0,64	0,54	0,46	0,39	0,33	0,28	0,24

calculated for given

decision variables	I o = 0,10		I 1 =	1,00		I 2 =	0,10
parameters of utility	investor		beta =	0,5		kappa =	0,8
function	research institute		beta =	0,5		kappa =	1

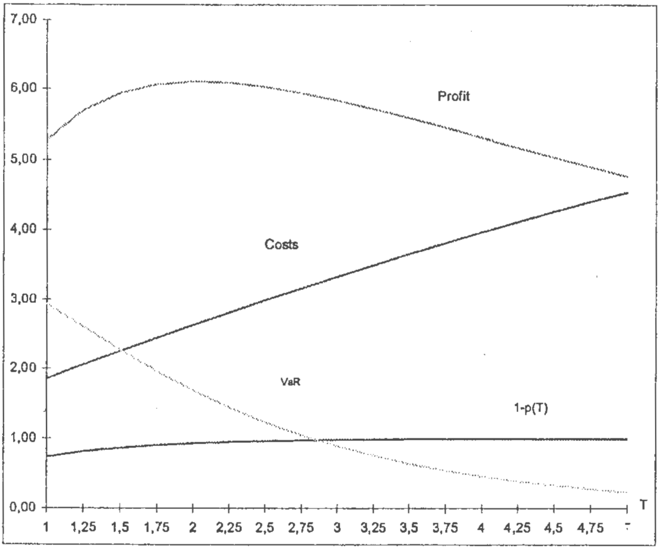

Figure 2:

INVESTOR

Time	T	1,00	1,25	1,50	1,75	2,00	2,25	2,50	2,75	3,00
Expected rate of return	R(T)	2,84	2,76	2,63	2,48	2,32	2,16	2,02	1,88	1,75
Sqrt(variance)	Sigma(T)	1,97	1,58	1,26	1,01	0,80	0,64	0,52	0,41	0,33
Safety index	S(T)	0,44	0,54	0,62	0,68	0,72	0,76	0,80	0,82	0,85
Utility	U(T)	3,51	4,19	4,66	4,98	5,19	5,32	5,38	5,39	5,37

Time	T	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00	5,25
Expected rate of return	R(T)	1,63	1,53	1,43	1,34	1,26	1,18	1,11	1,05	0,99
Sqrt(variance)	Sigma(T)	0,27	0,22	0,18	0,15	0,12	0,10	0,08	0,07	0,05
Safety index	S(T)	0,87	0,88	0,90	0,91	0,92	0,93	0,94	0,95	0,96
Utility	U(T)	5,32	5,25	5,17	5,07	4,97	4,87	4,76	4,64	4,53

calculated for given

decision variables	I_o = 0,10	I_1 = 1,00		I_2 = 0,10
parameters of utility function	investor	beta = 0,5		kappa = 0,8
	research institute	beta = 0,5		kappa = 1

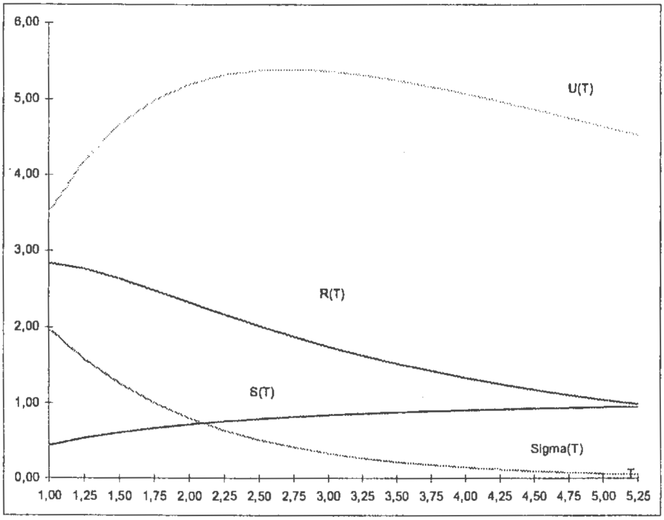

Figure 3:

Research Institute

Time	T	1,00	1,25	1,50	1,75	2,00	2,25	2,50	2,75	3,00
Investment costs	Costs	0,10	0,12	0,14	0,16	0,18	0,20	0,22	0,24	0,26
Expected profit	Profit	1,40	1,53	1,62	1,68	1,71	1,73	1,74	1,74	1,74
Success probability	1-p(T)	0,74	0,81	0,86	0,90	0,93	0,95	0,96	0,97	0,98
Value at Risk	VaR	0,90	0,64	0,56	0,48	0,41	0,35	0,30	0,26	0,22

Time	T	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00
Investment costs	Costs	0,28	0,30	0,31	0,33	0,35	0,36	0,38	0,39
Expected profit	Profit	1,73	1,72	1,71	1,70	1,68	1,67	1,65	1,64
Success probability	1-p(T)	0,99	0,99	0,99	1,00	1,00	1,00	1,00	1,00
Value at Risk	VaR	0,19	0,16	0,13	0,11	0,10	0,08	0,07	0,06

calculated for given

decision variables	I_o = 0,10		I_1 = 1,00		I_2 = 0,10
parameters of utility function	investor		beta = 0,5		kappa = 0,8
	research institute		beta = 0,5		kappa = 1

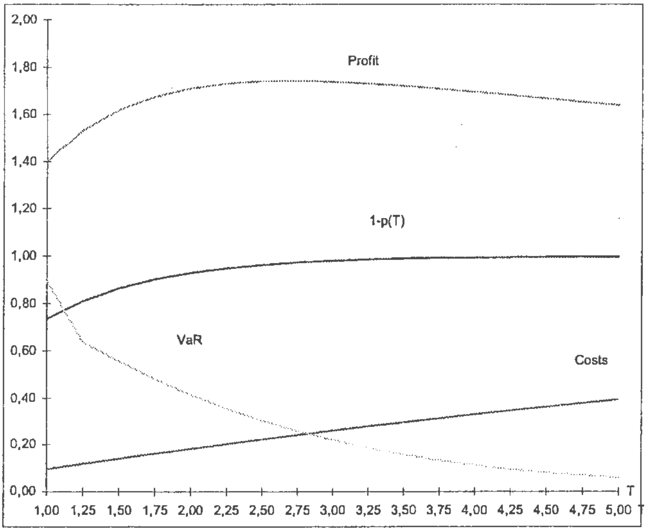

Figure 4:

Research institute

Time	T	1,00	1,25	1,50	1,75	2,00	2,25	2,50	2,75	3,00
Expected rate of retur	R(T)	14,75	13,05	11,63	10,45	9,45	8,60	7,87	7,25	6,71
Safety index	S(T)	0,36	0,48	0,57	0,64	0,70	0,74	0,78	0,82	0,84
Achieved utility	U(T)	0,84	1,06	1,22	1,34	1,43	1,49	1,54	1,57	1,60

Time	T	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00
Expected rate of retur	R(T)	6,24	5,83	5,46	5,14	4,86	4,60	4,37	4,17
Safety index	S(T)	0,87	0,89	0,90	0,92	0,93	0,94	0,95	0,96
Achieved utility	U(T)	1,61	1,62	1,62	1,62	1,62	1,62	1,61	1,60

calculated for given

decision variables	I_o = 0,10		I_1 = 1,00		I_2 = 0,10
parameters of utility	Investor		beta = 0,5		kappa = 0,8
function	research institute		beta = 0,5		kappa = 1

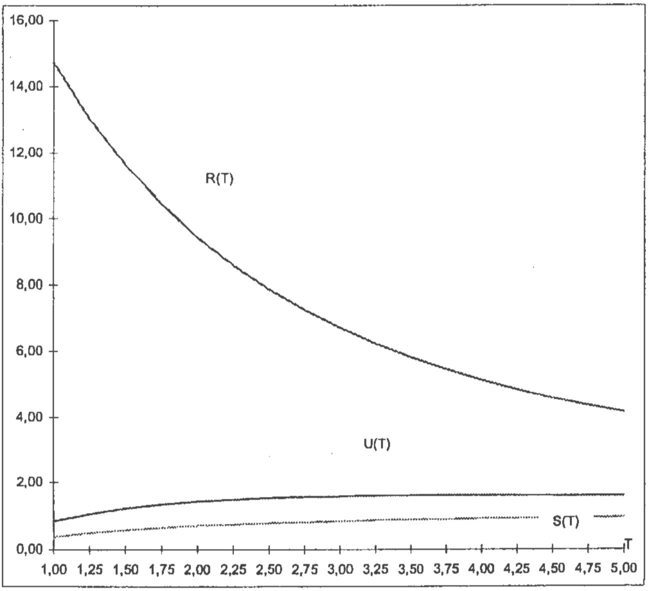

Figure 5:

Table 1:

OPTIMIZATION RESULTS

Nash solutions for different parameters kappa of investor

Investor

Changed parameter	kappa_i	0,8	0,9	1	1,1	1,2
	beta_i	0,5	0,5	0,5	0,5	0,5
Research institute						
	kappa_r	1	1	1	1	1
	beta_r	0,5	0,5	0,5	0,5	0,5
Optimum results	I0opt	0,05	0,05	0,3	0,3	0,3
	I10pt	1,578	1,578	1,500	1,500	1,500
	I2opt	0,228	0,225	0,300	0,298	0,297
Time	Topt	2,91	2,97	3,02	3,07	3,12
research costs	Po(T)	2,53	2,57	2,61	2,64	2,68
deposit	Deposit	1,58	1,58	1,50	1,50	1,50
cash flow	P1(T,T1)	5,14	5,02	4,91	4,80	4,69
Investor						
Cost in case of success	Po_s(T)	3,9787	4,0168	3,3248	3,3508	3,3770
Cost in case of failure	Po_f(T)	2,4009	2,4392	1,8248	1,8509	1,8772
Success return	Ru(T)	1,0088	0,9964	1,1805	1,1680	1,1554
Failure return	Rd(T)	-0,60	-0,61	-0,55	-0,55	-0,56
Success probability	1-p(T)	0,9794	0,9809	0,9822	0,9833	0,9844
Failure probability	p(T)	0,0206	0,0191	0,0178	0,0167	0,0156
Expected rate of return	R(T)	0,9757	0,9657	1,1497	1,1393	1,1288
	Sigma(T)	0,2288	0,2197	0,2288	0,2202	0,2118
Value at Risk	VaR	0,7283	0,7942	0,7608	0,8117	0,8584
Safety index	S(T)	0,8124	0,7953	0,8010	0,7874	0,7748
Achieved utility	U(T)	3,4989	3,4594	3,4210	3,3874	3,3552

Research institute

Cost in case of success	Po_s(T)	0,1264	0,1284	0,7820	0,7932	0,8045
Cost in case of failure	Po_f(T)	0,1264	0,1284	0,7820	0,7932	0,8045
Success return	Ru(T)	30,1487	29,4497	4,8832	4,7818	4,6828
Failure return	Rd(T)	-1,0000	-1,0000	-1,0000	-1,0000	-1,0000
Success probability	1-p(T)	0,9794	0,9809	0,9822	0,9833	0,9844
Failure probability	p(T)	0,0206	0,0191	0,0178	0,0167	0,0156
Expected rate of return	R(T)	29,5081	28,8672	4,7783	4,6854	4,5943
	Sigma(T)	4,4205	4,1711	0,7785	0,7401	0,7035
Value at Risk	VaR	0,5586	0,5355	0,6088	0,5871	0,5659
Safety index	S(T)	0,8502	0,8555	0,8371	0,8420	0,8469
Achieved utility	U(T)	3,4381	3,4278	3,4189	3,4105	3,4014

Calculation of Nash solution

Optimum time	Topt	2,9132	2,9674	3,0203	3,0708	3,1220
Utility of investor	U_i	3,4989	3,4594	3,4210	3,3874	3,3552
Utility of research institute	U_r	3,4381	3,4278	3,4189	3,4105	3,4014
Product		12,0296	11,8579	11,6962	11,5527	11,4127

assumptions about the parties' utilities. Using the system also other graphes can be generated presenting how the mediation proposal depends on other parameters of the utility functions.

5 Final remarks

In the paper a simple model enabling cost- benefit - risk analysis made by two parties (an investor and a research institute) negotiating joint realization of an innovation project. To support the analysis a computer-based system is proposed. Using the system each party can independently analyze expected output variables describing the project and look for the decision variables satisfying his preferences. A mediation proposal can be also generated based on Nash cooperative solution concept. The mediation proposal is derived by solving appropriate optimization problem formulated in the paper. The proposal fulfills a set of reasonable properties, and presented to the parties can support the negotiation process.

The presented approach utilizes Kulikowski's [1], [2], [3] URS methodology, in which given utility functions of the parties are assumed. We assume that the utility functions approximate only real preferences of the parties. Therefore parameters of the functions have to be evaluated, and because the functions are in general non-stationary, the evaluation process has to be repeated during the analysis. In further work an appropriate module enabling utility evaluation will be constructed and included in the system. The presented outputs of the system have been derived for the utility functions of the Cobb-Douglas form. Also different types of utility function can be assumed in the model, for example CES function, and used in the system calculations. In the future works also alternative approach based on multicriteria analysis and interactive solution concepts to bargaining problem proposed by Krus [10] will be developed.

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