Raport Badawczy

Research Report

RB/11/2002

Acceleration of Economic Growth by Technological Change and Knowledge Management

R. Kulikowski

Instytut Badań Systemowych
Polska Akademia Nauk

Systems Research Institute
Polish Academy of Sciences

POLSKA AKADEMIA NAUK

Instytut Badań Systemowych

ul. Newelska 6

01-447 Warszawa

tel.: (+48) (22) 8373578

fax: (+48) (22) 8372772

Kierownik Pracowni zgłaszający pracę:
Prof. dr inż. Roman Kulikowski

Warszawa 2002

Acceleration of Economic Growth by Technological Change and Knowledge Management

by

Roman KULIKOWSKI[(*)]

Abstract. The paper deals with methodology of knowledge management which is aimed at the acceleration of economic growth.

The methodology is based on the subjective utility concept, introduced by Kulikowski [1998], which enables one to estimate the present value benefits resulting from the technological change and the cost of change. It enables also to derive, in an explicite form, the optimum strategies connected with allocation of a budget among the research institutes and research projects. The support of negotiations, connected with joint ventures, between the research institutes and business organizations, based on Nash principle and subjective utility, is also presented.

Key words: economic growth, knowledge management, utility, present value, decision support, joint ventures, negotiations, research systems.

1. Introduction. The "new economy", based on information and communication technology (CIT), has increased the demand for educated labour (human capital), innovations and knowledge supported management, among the OECD countries (see Pilat [6]). The human capital became recently an important factor in the production growth. Physical (financial) investments expands, as well, renewing the existing capital stock and enabling the new technologies to enter the production processes. The knowledge, inducing the technological change, became on important driver of economic growth.

In order to enable the new economy to work it is necessary to develop a new methodology in production and knowledge management.

Such a methodology, starting from the neoclassical production function concept, is proposed in the present paper. That methodology enables one to derive the expected rate of return on financial & human capital investments and the risk impact on the utility of the innovative production projects.

By deriving the present value of the traditional (PV_T) and new (innovative) technology (PV_N) one can also derive the net benefits ($B = PV_N - PV_T - C_T$, where C_T is the cost of transformation, connected with technological change). Implementing the transformation, or a reform, with $B > 0$, one can avoid a resistance to change (in the form of workers strikes etc).

The methodology can be also applied to the budget allocation problems among the given number of research units (institutes) or research projects. The optimum allocation strategy, which takes into account the research risk and expected rate of return, can be derived in an explicite form.

(*) SYSTEMS RESEARCH INSTITUTE, POLISH ACADEMY OF SCIENCES, NEWELSKA 6, 01-447 WARSAW, POLAND

(INSTYTUT BADAŃ SYSTEMOWYCH PAN)

That methodology can be, as well, applied to the negotiations of joint, risky ventures, between the research and business organizations.

It should be also noted that the new methodology, based on the subjective utility concept, enables one to take into account the behavioral aspects, which are manifested e.g. in the processes of negotiation

2. Utility and value of technological change in production systems. Assume the production $X(t)$ (at time t) to be described by the neoclassic production function:

(1) $$X(t) = ce^{\mu t}\prod_{i=1}^{n}[X_i(t)]^{\gamma_i}, \quad \sum_{i=1}^{n}\gamma_i = 1$$

where

c, γ_i: given positive numbers,

$X_i(t)$: production factors, such as labour, capital, land etc. which (together with γ_i) specify the production technology,

μ: characterizes the neutral progress.

Introducing factor prices $\omega_i(t)$, $\forall i$, and the final product price $\omega(t)$ one can write (1) in the monetary from:

(2) $$Y(t) = \bar{c}(t)e^{\mu t}\prod_{i=1}^{n}[Y_i(t)]^{\gamma_i}, \quad \bar{c}(t) = c\omega(t)\prod_{i=1}^{n}[\omega_i(t)]^{-\gamma_i}$$

where $Y(t) = \omega(t)X(t)$, $Y_i(t) = \omega_i(t)X_i(t)$, $\forall i$.

Assuming that the last year net (with withdrawn dividends) earning E_1 is used for factors endowments, i.e. $\sum_{l=1}^{n} Y_i(t) = E_1$, one can find the optimum strategy $Y_i(1)\overset{\Delta}{=}\hat{Y}_i(1)$, $\forall i$, by solving the problem:

$$\max_{Y_i(1)\in\Omega} Y[Y_1,...,Y_n]; \quad \Omega = \left\{Y_i(1) | \sum_{t=1}^{n} Y_i(1) = E_1; Y_i(1) \geq 0, \ \forall i\right\}$$

where $E_1 = Y(0)[1-\rho R_0]$, where $Y(0)\rho R_0$ is the dividends value withdrawn from $Y(0)$ and R_0 is the rate of return $R_0 = [Y(0)-Y(-1)]:Y(-1)$ which yields

(3) $$\hat{Y}_i(1) = \gamma_i E_1.$$

The production function (2) can be also written in the incremental form

(4) $$\dot{Y}(t)/Y(t) = \bar{\mu} + \dot{\omega}(t)/\omega(t) + \sum_{i=1}^{n}[\dot{Y}_i(t)/Y_i(t) - \dot{\omega}_i(t)/\omega_i(t)]\gamma_i.$$

Introducing the notation

$$R_t = Y(t+1)/Y(t) - 1, \quad \delta\omega_t = \omega(t+1)/\omega(t) - 1, \quad \delta Y_{it} = Y_i(t+1)/Y_i(t),$$
$$\delta\omega_{it} = \omega_i(t+1)/\omega_i(t) - 1,$$

one can replace the continuous (in time) production model (4), by the discrete model, where the expected rate of return on the capital (P_1) invested becomes

(5) $$R_t = \mu + \delta\omega_t + \sum_{i=1}^{n}[\delta Y_{it} - \delta\omega_{it}]\gamma_i.$$

The model's unknown parameters μ, γ_i, $\forall i$, can be estimated by the well known econometrical methods, i.e. the least squares, which requires the minimization of the functional:

$$\overline{V}(\mu,\gamma)=\frac{1}{T}\sum_{t=-1}^{-T}[\widetilde{R}_t-\delta\omega_t-\mu-\sum_{i=1}^{n}(\delta Y_{it}-\delta\omega_{it})\gamma_i]^2\overset{\Delta}{=}\frac{1}{T}\sum_{t=-1}^{-T}e_t, \tag{6}$$

where $\widetilde{R}_t$, $\delta\omega_t$, $\delta Y_{it}-\delta\omega_{it}$ are the historical data, regarding the rates of return $(\widetilde{R}_t)$, factor and product prices $(\delta\omega, \delta\omega_{it})$ and factors rates (δY_{it}).

The necessary conditions of optimality: $\partial\overline{V}/\partial\gamma_i=0$, $\forall i$ and $\partial\overline{V}/\partial\mu=0$, yield a system of $n+1$ linear equations, which can be solved in order to find the model parameters estimators $\hat{\mu}$, $\hat{\gamma}_i$, $\forall i$. Then one can also find the square error value $\overline{V}(\hat{\mu},\hat{\gamma})$. The error $V=\overline{V}(\hat{\mu},\hat{\gamma})$, regarded in the ex ante sense, can be called the variance of the random variable $\widetilde{R}_t$.

It should be noted that when the residuals

$$e_t=\widetilde{R}_t-E\{\widetilde{R}_t\},\quad t=-1,-2,\ldots,-T$$

have equal normal distributions, i.e.

$$g(e_t\,|\,\mu,\gamma)=\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}(e_t/\sigma)^2},\quad \forall t,\quad \gamma\equiv\{\gamma_1,,\gamma_n\},$$

the likelihood function becomes

$$L(\mu,\gamma\,|\,\text{data})=\left(\frac{1}{\sqrt{2\pi}\sigma}\right)^n e^{-\frac{1}{2}\sum_1^n(e_t/\sigma)^2}.$$

One can show, see [1], that the maximum likelihood (*ML*) estimators of μ and γ are identical to the least square (*LS*) regression estimators, however the estimator of $\overline{V}=\sigma^2$ differs slightly. The *ML* estimator is $\hat{\sigma}^2=e^2/T$, where $e^2=\sum_{-1}^{-T}e_t^2$, while the *LS* estimator is $\hat{\sigma}^2=e^2/(T-(1+n))$. Of course, that difference is usually trivial unless the sample size T is small.

The scientific methodology is based on construction of models of reality which are supporting the inferences. The distance between the approximating model $g(x\,|\,\theta)$, where θ is a vector of estimable parameters, (such as μ, γ) and an ideal (true) model f of reality can be expressed by Kullback-Leibler index

$$I(f,g)=\int f(x)\ln\left(\frac{f(x)}{g(x\,|\,\theta)}\right)dx,$$

which can be interpreted (heuristically) as the information lost when g is used to approximate f.

The key result was, established by Akaike (see [1]), who found (under certain, technological conditions) that the maximized ln-likelihood is biased upwards as an estimator and

$$\ln(L(\hat{\theta}\,|\,\text{data}))-K=const-E_{\hat{\theta}}[I(f,\hat{g})],$$

where $\hat{g}=g(\cdot\,|\,\hat{\theta})$ and $\hat{\theta}$ is the *ML* estimator of the true value of $\hat{\theta}$,

K - bias equal approximately to the number of estimable parameters $(K = n+2)$.

Akaike introduced also an information criterion

$$AIC = -2\ln(L(\hat{\theta})x)) + 2K,$$

which for normally distributed residuals with constant variance becomes

$$AIC = n\ln(\hat{\sigma}^2) + 2K.$$

The first term $(n\ln(\hat{\sigma}^2))$ can be interpreted (heuristically) as a measure of lack of model fit, while the second term $(2K)$ as a penalty for increasing the size of the model. Using the AIC index one can resolve (by a trade off) the conflict between the model underfitting and overfitting that is fundamental to a principle of parsimony (see [1]). Employing that principle one can neglect in the production function (2) all the factors which do not contribute to the decrease of AIC, and consequently, to the model accuracy.

The estimator (5) can be used for the evaluation of the expected (ex ante) rate of return of the firm with the production function (2). Indeed the $\widetilde{R}$ (for $t=1$) can be regarded as the random variable with the expected value (5) and $\mu = \hat{\mu}$, $\gamma_i = \hat{\gamma}_i$, $\forall i$.

When the factor endowment strategy is optimum so by (3):

$\delta \hat{Y}_{i1} = E_1 : E_0 - 1$; $\forall i$; one gets the following estimator of expected rate of return

(7) $$R = \hat{\mu} + \pi + \delta E,$$

where $\pi = \delta\omega - \sum_{i=1}^{n} \gamma_i \delta\omega_i$, $\delta E = E_1 : E_0 - 1$,

$$E_0 = Y(-1)[1 - \rho R_{-1}],\ R_{-1} = Y(-1):Y(-2) - 1.$$

Then one can use the utility model, described in [3] (replacing E_1 by P and assuming $x = 1$):

(8) $$U = PRS^{1-\beta},$$

where

(9) $$S = 1 - \kappa\frac{\sqrt{V}}{R},$$

κ: subjective parameter, depending on the fear of bankruptcy (emotions quelling factor). Since the production generates each year $t \in [0,T]$ a cash flow $PR\rho$ so when $\rho = const$ one can derive the present value (discounted with the rate k within the planning horizon T):

(10) $$PV_T = PR\rho \sum_{t=1}^{T} (1+k)^{-t} + P(1+k)^{-T}.$$

When $T \to \infty$ one gets

(11) $$PV_\infty = PR\rho : k.$$

The discount rate can be derived (see [3]) by the formula

(12) $$k = [(1/R_F + 1)S^{1-\beta} - 1]^{-1},$$

where R_F - the risk free rate of return.

It is possible to observe that utility (8), as well as the present value (10) of a firm, increases along with R, i.e. along with the prices change indicator π as well as $\hat{\mu}$ and δE. In the opposite situation (i.e. when these parameters decrease) the utility U and the present value PV_T decline so the firm is on the way to bankruptcy.

In the first situation we have the so called growth firms. In the past decades e.g. Polaroid and IBM were growth firms because of technological breakthroughs that gave those corporations profitable market penetrating powers.

In the opposite situation we have the declining firms. Examples of declining firms include e.g. the manufactures of home-movie cameras after the 1980 when *VCR* machines became popular, or Polaroid after the invention of digital photocameras.

All these examples indicite that in order to survive, in the competitive world, the firm should be innovative (by exploiting the inventions created by science and technology) and, as well, it should constantly adapt to the changing production technologies.

The adaptation process is usually connected with factors transformation costs

$$C_T = \sum_{i=1}^{n} [\hat{\gamma}_{iN} - \hat{\gamma}_{iT}]P + C_a$$

where

$\hat{\gamma}_{iN}$, $\hat{\gamma}_{iT}$ - parameters of new and traditional technology,

C_a - additional cost, e.g. the social cost connected with employment reduction, resistance to change, strikes etc.

Denoting the present values of the new and traditional productions by PV_N, PV_T respectively, one can formulate the following principle of technological transformation benefits

(13) $$B = PV_N - PV_T - C_T \geq 0 .$$

According to that principle the transformation is beneficial, i.e. no financial reasons (resistance to change) exist, when the net benefit is nonnegative.

In order to derive PV_T one can use the estimation technique (7)-(11) and historical data on traditional activity.

In the case of PV_N the cross-sectional estimation technique based on short history data of the set of leading, (based on knowledge) firms within the same (as the traditional firm) area. The technological change can be regarded as a bench marking process, when the traditional firm is trying to follow the best examples set by the modern and leading firms and corporations.

EXAMPLE

Suppose the traditional firm employing labour and financial capital only is characterized by:

a. labour factor with $\hat{\gamma}_{1T} = 0.7$ and capital factor with $\hat{\gamma}_{2T} = 0.3$,
b. expected rate of return $R_T = 0.3$ and safety index $S_T = 0.6$.

Assuming $R_F = 0.1$, $\rho = 0.1$, $\beta = 0.5$, and the planning horizon $T \to \infty$, one gets by (12) (11):

$k_T = [11 \cdot \sqrt{0.6} - 1]^{-1} = 0.133$,

$PV_T = 7.521 \cdot 0.3 \cdot 0.1P = 0.226P$.

The new (based on knowledge) technology consists in replacement of a part of by high qualified workers, supported by the computerized system and it is characterized by:

c. labour factor with $\hat{\gamma}_{1N} = 0.4$, financial capital factor with $\hat{\gamma}_{2N} = 0.3$; knowledge (i.e. human capital reinforced by computerized systems, education etc.) factor with $\hat{\gamma}_{3N} = 0.3$,
d. expected rate of return $R_N = 0.5$; $S_N = 0.5$.

Then by (12) and (11) one gets

$$k_N = [11\sqrt{0.5} - 1]^{-1} = 0.148,$$

$$PV_N = 6.778 \cdot 0.5 \cdot 0.1P = 0.339P.$$

Assume the following costs of technological change:

1. Net labour force reduction cost $C_1 = C_a - (\hat{\gamma}_{1T} - \hat{\gamma}_{1N})P$; where $C_a = 0.2P$ - recompensation paid to the dismissed workers, so $C_1 = 0.2P - 0.4P = -0.2P$.
2. Net financial capital cost: $C_2 = (\hat{\gamma}_{2N} - \hat{\gamma}_{2T})P = 0$.
3. Cost of knowledge, i.e. the human capital and computerized support system cost $\hat{\gamma}_{3N} = 0.3P$.

Then the total cost of transformation becomes

$$C_T = 0.3P - 0.2P = 0.1P,$$

and the resulting benefit $B = (0.339 - 0.226 - 0.1)P = 0.013P$ is positive, so the transformation of production technology, for the firm analysed is beneficial.

The utility of the new technology

$$U_N = PR_N\sqrt{S_N} = 0.354P,$$

is also bigger then for the traditional technology:

$$U_T = PR_T\sqrt{S_T} = 0.232P.$$

It should be noted that the present methodology enables one to evaluate different technological transformation projects and economic reforms. It is possible, in particular, to evaluate the benefits of polish farming, resulting from the Poland access to European Union and the change of traditional to the modern (european) agriculture technology. It is also possible to evaluate the benefits resulting from cultivation of biomass and methanol production, which is used as a ecologically clean fuel in transportation and heating systems.

3. Knowledge management support in research system. The research institutes in Poland are financed by the Committee for Scientific Research (KBN) acting under the auspices of the Minister of Science. The Committee allocates the annual budget among the research institutes taking into account the institutes effectiveness, expressed by the number of professional publications, number of implemented projects, patents and production of highly qualified specialists (doctors of sciences, proffesors).

Allocating the budget among the set of institutes the committee takes into account also the relative importance of the institutes research program, according to the declared by the Minister of Science policy and preferences. The Minister of Science, realizing the Government policy, can for example give more preferences to ICT technology, which stimulates the growth of national economy.

The knowledge management support system should help the decision makers (on the central, as well as, on the research institutes level) to allocate the research resources (i.e. the budget, human capital etc.) in the most effective way [5].

In the present section one concentrates on the allocation of budget among the research institutes, taking into account the expected returns and the risk involving research activities.

Using the market productioin model (2) for the management support of the research institutes (which produce knowledge and are financed by the government) one has to assume that the product price ω is not regulated by the market but by the Minister of Science and $\rho = 0$, so

$$\delta E = \delta Y = Y(0):Y(-1) - 1 \stackrel{\Delta}{=} R_0 .$$

Then the expected rate of return for the research institute becomes

(14) $$R = R_0 + \hat{\mu} + \pi ,$$

where R_0 is the last year rate of return, $\hat{\mu}$ - historical trend parameter, and $\pi = \delta\omega - \sum_{i=1}^{n} \hat{\gamma}_i \delta\omega_i$ is the decision maker's (the Minister of Science) preference indicator. When $\delta\omega > \sum_{i=1}^{n} \hat{\gamma}_i \delta\omega_i$ the institutes research program is preferable and when $\pi < 0$ the preference is given to other programs.

Using the least squares technique for finding $\hat{\mu}$ and $\hat{\gamma}$ one can find the variance $V = \overline{V}(\hat{\mu}, \hat{\gamma})$ and find the probability of success of the research institute $p = [1 + V/R^2]^{-1}$.

Then the utilities of the n given institutes

(15) $$U_i(x_i) = PR_i S_i^{1-\beta} x_i^{\beta}, \quad S_i = 1 - \kappa\sqrt{1/p_i - 1}, \quad i = 1, \ldots, n$$

where $x_i = P_i / P$, part of total budget P allocated to the i-th institute; can be derived.

The optimum strategy $x_i \stackrel{\Delta}{=} \hat{x}_i$, $\forall i$, such that

$$U(\hat{x}) = \max_{x_i \in \Omega} \sum_{i=1}^{n} U_i(x_i), \qquad \Omega = \left\{ x_i \mid \sum_{i=1}^{n} x_i = 1, \; x_i \geq 0, \; \forall i \right\}$$

can be derived by the methodology described in [2]:

(16) $$\hat{x}_i = a_i^r : \sum_{j=1}^{n} a_j^r, \quad a_i^r = R_i S_i^{1-\beta}, \quad r = \frac{1}{1-\beta} \; \forall i$$

It should be noted that besides the budget $(P_i = \hat{x}_i P)$, received for financing the basic research, the institutes can apply to KBN for additional financing of the concrete projects characterized by the given cost $\overline{P}_j = \overline{x}_j \overline{P}$, $j = 1, \ldots, M$ and the utilities

(17) $$U_j(\overline{x}_j) = \overline{P} R_j S_j^{1-\beta} (\overline{x}_j)^{\beta}, \quad \forall j$$

which are given numbers.

In order to find the best portfolio of projects one can introduce the binary variable: $y_j = 1$, when the project is accepted and $y_j = 0$, when it is declined. Then the portfolio optimization problem can be formulated in the form of binary linear programming, i.e.

(18) $$\max_{y_j \in \Omega} \sum_{j=1}^{M} U_j(\overline{x}_j) y_j, \qquad \Omega = \left\{ y_j \mid \sum_{j=1}^{M} y_j \overline{x}_j \leq 1, \; y_j \in [0,1], \; \forall j \right\},$$

which can be solved by the known programming techniques.

The optimum portfolio consists of a number $m \leq M$ of projects, which are characterized by large $U_j(\overline{x}_j)$ and low cost $\overline{x}_j \overline{P}$.

Using the present methodology one can also construct a budget allocation support system for universities, where the education is the prevailing activity, supported by basic research.

One can also construct a support system for the postulated reform of existing research system in Poland which is aimed at achieving a concentrated (in the form of centers of excellence) research units. The reform can be successfully implemented when, according to the principle of technological transformation (13), it is beneficial. According to that principle the present value of the new system, based on concentration of dispersed research activities should be larger then the traditional system value and transformation cost involved.

4. Joint venture negotiation support. The main idea of an economy based on knowledge consists in promotion of cooperation between the research and applications. The cooperation, taking form of the so called joint ventures, according to the well known Nash principle, requires that the product of utilities of both cooperating partners (such as a research institute and a productive firm) is maximum.

In order to establish the joint venture project the negotiation between subjectively motivated partners should take place. In the classical works on negotiations, based on Nash principle (see e.g. Luce & Raiffa [5]) the explicite form of subjective utility function was unknown and it was not possible to analyse the impact of risk on negotiation strategy. In the present paper one can use, for that purpose, the utility concept (8), which takes into account the subjective parameters (κ, β), and derive the subjective utilities of the negotiating partners.

Then, introducing the negotiation variable y, the Nash principle boils down to the maximization of the function

(19) $$\phi(y) = [U_1(y) - U_{10}][U_2(y) - U_{20}],$$

where $U_1(y)$, $U_2(y)$ – the utilities of respective partners,

U_{10}, U_{20} – the utilities of status quo (when the cooperation is declined).

The utilities $U_1(y)$, $U_2(y)$ can be formulated using a simple cooperation model. For that purpose assume that at a research institute the idea of an invention has occured. In order to implement the idea (e.g. in the form of a patented prototype) the institute has to invest I_1 (in the form of financial & human capital). Then a joint venture project is negotiated with a large scale producer who expects, after investing I_2, to sell the invented product and get (yearly) the value $\$P_m$. Both parties are negotiating the split of the expected sailes on the parts: yP_m, $(1-y)P_m$, assigned to the institute and producer respectively, using as a support, the strategy $y \stackrel{\Delta}{=} \hat{y}$, such that $\max_y \phi(y) = \phi(\hat{y})$.

The utilities of both partners ($i = 1$ - the institute, $i = 2$ - the producer) become

$$U_1(y) = P_1 R_1(y) S_1^{1-\beta_1} (I_1 / P_1)^{\beta_1} = \bar{I}_1 R_1(y) S_1^{1-\beta_1}; \qquad \bar{I}_1 = P_1 \left(\frac{I_1}{P_1}\right)^{\beta_1}$$

$$U_2(y) = P_2 R_2(y) S_2^{1-\beta_2} (I_2 / P_2)^{\beta_2} = \bar{I}_2 R_2(y) S_2^{1-\beta_2}, \quad \bar{I}_2 = P_2 \left(\frac{I_2}{P_2}\right)^{\beta_2}$$

where

$$R_1(y) = yP_m : I_1 - 1 = ay - 1, \qquad a = P_m : I_1$$

$$R_2(y) = (1-y)P_m : I_2 - 1 = b - b_1 y, \quad b = P_m : I_2 - 1, \quad b_1 = P_m : I_2$$

Assuming $U_{10} = \bar{I}_1 R_F$; $U_{20} = \bar{I}_2 R_F$, the necessary condition of optimality:

$$\phi'(y) = U_1'[U_2(y) - U_{20}] + U_2'[U_1(y) - U_{10}] = 0,$$

where

$U_1' = a\bar{I}_1 S_1^{1-\beta_1}$, $U_2' = -b_1 \bar{I}_2 S_2^{1-\beta_2}$;

yields

$$(20) \qquad y \stackrel{\Delta}{=} \hat{y} = 0.5\left[1+\frac{I_1}{P_m}(1+R_F:S_1^{1-\beta_1}) - \frac{I_2}{P_m}(1+R_F:S_2^{1-\beta_2})\right].$$

Since $\phi''(y) = -2P_m^2 S_1^{1-\beta_1} S_2^{1-\beta_2} < 0$, the necessary condition is also sufficient for optimality.

It should be observed that the strategy (20) favours the institute when it invests more ($\bar{I}_1 > \bar{I}_2$) and his risk (expressed by $R_F : S_1^{1-\beta}$) is larger ($S_1 < S_2$). The larger risk of the institute (compared to the producer's risk $R_F : S_2^{1-\beta}$) can result from the combined (market & development risk) and the larger subjective factor κ_1, compared to the wealthy producer factor κ_2. Such a property of $\hat{y}$ strategy. based on the utility concept (8) with the subjective parameters (κ, β), enables one to include risks in negotiation support strategy.

EXAMPLE

Assume $R_F = 0.1$, $\beta_1 = \beta_2 = 0.5$, and $S_1 = 0.3$, $S_2 = 0.5$, $I_1 : P_m = 0.1$, $I_2 : P_m = 0.4$. Then by (20) one gets $\hat{y} = 0.331$. One can find also

$$R_1(0.331) = 0.331 \cdot 10 - 1 = 2.31 \quad \text{and} \quad R_2(0.331) = 0.673$$

Then $\quad U_1(0.331) = R_1(0.331) \cdot \sqrt{0.3}\,\bar{I}_1 = 1.265\bar{I}_1$

$$U_2(0.331) = 0.476\bar{I}_2.$$

If $\bar{I}_1 = 0.5P_1$, $\bar{I}_2 = 0.1P_2$ one gets $U_1 = 0.632P_1$, $U_2 = 0.048P_2$. It should be observed that for $I_1 = I_2$, $S_1 = S_2$ the strategy $\hat{y} = 0.5$ and $R_1(0.5) = R_2(0.5)$ so $U_2(0.5) : U_1(0.5) =$. $= \bar{I}_2 : \bar{I}_1 = P_2^{1-\beta} : P_1^{1-\beta} I^{\beta} = (P_2 : P_1)^{1-\beta}$. When $P_2 > P_1$ one gets $U_2(0.5) > U_1(0.5)$ so the strategy $\hat{y} = 0.5$ favours the wealthier partner.

The example shows that suggested negotiation strategy $\hat{y}$ depends much on the subjective parameters (S, β) and the wealth ratio $P_2 : P_1$ of joint venture partners. It favours that partner who is carrying larger expense and risk. The favour given to the wealthier partner may look unfair. However, the decision to participate in such a joint venture can be rationalized by showing that the utilities $U_i(\hat{y}) > U_{i0}$, $i = 1,2$. A similar rationalization argument can be applied when one participates in the unfair lottery or insurance (see [3]). The rationality (based on utility) enables the promotion and creation of joint ventures, between the research and business organizations, which in turn contribute to the growth of the economy.

REFERENCES

[1] K.P. Burnham, D.R. Anderson, *Model selection and multimodel inference,* Springer (1998).

[2] R. Kulikowski, *Portfolio Optimization: Two factors-utility approach,* Control and Cybernetics, No 3 Warszawa (1998).

[3] R. Kulikowski, *On general theory of risk management and decision support systems,* Bulletin of Polish Academy of Sciences, Ser. Techn. (this issue)

[4] R. Kulikowski, *URS methodology – a tool for stimulation of economic growth by innovations*. Bulletin of Polish Academy of Sciences, Ser. Techn. 50, No 1, Warszawa (2002).
[5] R.D. Luce, H. Raiffa, *Games and decisions,* New York, Wiley (1957).
[6] D. Pilat, *Making the „new economy" work,* Journal of Transforming Economic and Societies, Cracow University Economics & L. Koźmiński, Academy of Entrepeneurship and Management, Spring (2002