Croatian Operational Research Review
CRORR **5**(2014), 67–80

A new approach to developing and optimizing organization strategy based on stochastic quantitative model of strategic performance

Marko Hell[1] **and Dmitry Ershov**[2,*]

[1] *Faculty of Economics, University of Split*
Cvite Fiskovića 5, HR-21 000 Split, Croatia
E-mail: ⟨*marko.hell@efst.hr*⟩

[2] *Faculty of Applied Mathematics and Physics, Moscow Aviation Institute (National Research University)*
Volokolamskoe Shosse 4, RUS-125 993 Moscow, Russia
E-mail: ⟨*dmitreyyershov@mail.ru*⟩

Abstract. This paper presents a highly formalized approach to strategy formulation and optimization of strategic performance through proper resource allocation. A stochastic quantitative model of strategic performance (SQMSP) is used to evaluate the efficiency of the strategy developed. The SQMSP follows the theoretical notions of the balanced scorecard (BSC) and strategy map methodologies, initially developed by Kaplan and Norton. Parameters of the SQMSP are suggested to be random variables and be evaluated by experts who give two-point (optimistic and pessimistic values) and three-point (optimistic, most probable and pessimistic values) evaluations. The Monte-Carlo method is used to simulate strategic performance. Having been implemented within a computer application and applied to solve the real problem (planning of an IT-strategy at the Faculty of Economics, University of Split) the proposed approach demonstrated its high potential as a basis for development of decision support tools related to strategic planning.

Key words: strategic management, quantitative model of strategic performance, optimal resource allocation, Monte-Carlo simulation, expert evaluations

Received: October 27, 2013; accepted: February 18, 2014; available online: March 6, 2014

1. Introduction

Following A.D. Chandler [5], *organization strategy* can be defined as "the determination of the basic long-term goals and objectives of an enterprise and the adoption of course of action and the allocation of resources necessary for carrying out goals". In the process of developing and managing the strategy organizations use special decision support systems such as Business Intelligence (BI) and Corporate Performance Management (CPM) systems. A vast majority of applications built with BI and CPM platforms to date could be labelled as "descriptive". Their reporting and dashboarding capabilities are used to describe the dimensions and measures of business [18]. However, usage of more sophisticated applications for diagnostics,

*Corresponding author.

prediction, optimization and collective decision making (Social BI) will undoubtedly be a trend of the future.

Creation of advanced analytical systems for strategic management is directly connected with development of highly formalized methodological approaches to formulating and optimizing the strategy. During more than a semicentennial history of strategic management as a science many decision making techniques were developed (H. Minzberg et al. [15] single out ten strategic schools). Most of them have verbal character. Recommendations are usually given in form of a story rather than a step-by-step algorithm which is appropriate for incorporation in decision support system. Nevertheless, there are papers dealing with quantitative methods for making rational strategic decisions: R.F. Saen [17] developed a mathematical programming approach for strategy ranking; V. Wickramasinghe and S. Takano [23] used the analytic hierarchy process (AHP) in combination with SWOT-analysis to develop a marketing strategy for Sri Lanka tourism; T.W. Chien, C. Lin, B. Tan, and W.C. Lee [6] employed neural networks in conjunction with portfolio matrices to assist managers in evaluating and forming strategic plans. Decision support systems which can be used in the strategic planning process were suggested by S. Li [14] as well as by S. Subramoniam and K.V. Krishnankutty [19].

In order to formalize and operationalize the strategy R. Norton and D. Kaplan [11] developed the *Balanced Scorecard* (BSC) methodology. A number of mathematical models and frameworks were suggested based on this methodology. H. Kunz and T. Schaaf [12] proposed a method for a formal representation of the strategy which integrated current approaches in performance management. H. Huang [10] suggested the concept of an intellectual BSC knowledge-based system for strategic planning.

The *quantitative model of strategic performance* (QMSP) was proposed on the basis of BSC [9]. This model allows for solving the following three problems:

1) optimize the resource allocation among strategic initiatives;

2) evaluate overall strategic performance;

3) predict accomplishment levels of strategic objectives.

The QMSP is rather universal and can be used for planning one particular sphere of activity of an organization (e.g., development of IT). So, the model could be used as a basis for developing a formalized methodological approach to strategic planning. But it must be admitted that the QMSP is based on a number of artificial assumptions which limit practical usage of this model. A formal methodological approach to developing and optimizing organization strategy is proposed in the next section. This approach is based on the *stochastic quantitative model of strategic performance* (SQMSP) which eliminates limitations of the original model. A case example of using the developed approach in planning the strategy of a real organization (Faculty of Economics, University of Split) is given in Section 3. Finally, conclusions and directions for further research are provided in Section 4.

2. Proposed methodology

To facilitate a description of the proposed methodology an activity flow diagram was set up (see Fig. 1).

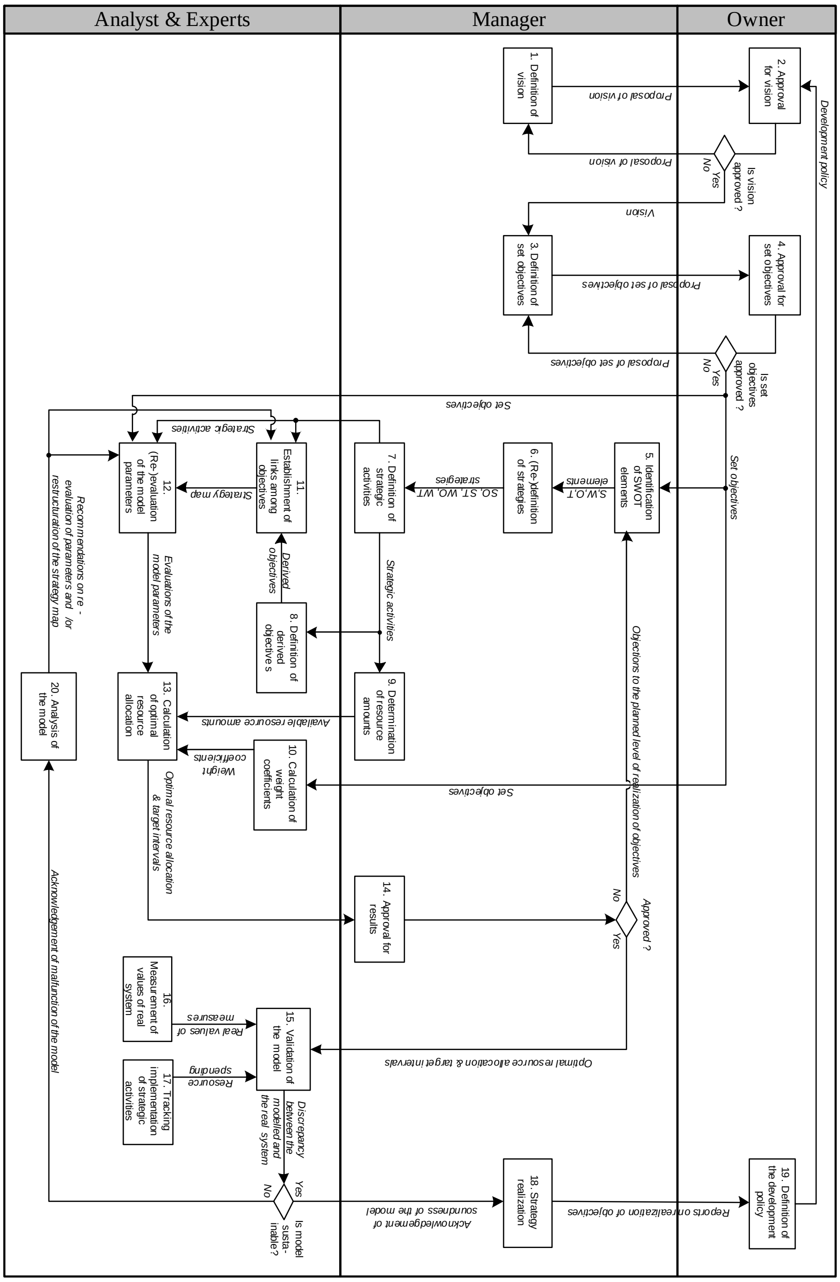

Figure 1: *Activity flow diagram for the proposed methodology*

It consists of the following elements: ***work posts***, describing functional roles (owner, manager, analyst and experts) included in the strategic planning process; ***activities***, representing a set of actions and decisions of the functional roles; and ***information flows*** that describe connections between activities*.

At the onset of the new strategic cycle, managers execute the ***definition of vision*** activity. Vision represents a brief qualitative description of the future state of organization [11, p. 40]. The management submits to the owner the *proposal of vision* for approval. Through the ***approval for vision*** activity, the owner compares the *proposal of vision* with the *development policy.* The owner approves the *vision* and forwards it to the management in charge of execution of the ***definition of set objectives*** activity. If the owner does not accept the *proposal of vision*, he/she needs to revise it.

The ***definition of set objectives*** leads to the shaping of the *proposal of set objectives.* Set objectives (SOs) are the main organizational objectives which describe the vision quantitatively. It is assumed that objectives are measurable, i.e. a numerical indicator (measure) with the target value is specified for each objective. For example, for an objective "Increase net profit of the organization" such indicator might be profit amount in euro with the target value that equals 20m € per annum after three years. An actual value of the indicator corresponding to the j-th objective ($j = \overline{1, l}$, where l is the number of set objectives) at the moment of time T, where T is a planning horizon, allows to calculate an accomplishment level (relative measure) of this objective:

$$x_j = \frac{I_j(T) - I_j(0)}{I_j^*(T) - I_j(0)},$$

where $I_j(T)$ is an actual value of the measure corresponding to the j-th objective at the end of the planning period, $I_j(0)$ is an initial value (As-Is) of the measure corresponding to the j-th objective, $I_j^*(T)$ is a target value (To-Be) of the measure corresponding to the j-th objective at the end of the planning period [9]. So, in our example, if profit amount is 10m € per annum after three years, then an accomplishment level of the objective "Increase net profit of the organization" will be equal to 0.5 or 50 %. If the current moment of time $t < T$, then the value of x_j is not known precisely, but it may be predicted. To do prediction, some formal model of strategic performance must be used. The proposed methodology is based on the quantitative model of strategic performance (QMSP) constructed in [9] which is modified to make it more appropriate for practical usage.

When executing the ***approval for set objectives***, the owner either accepts the *proposal of set objectives* or needs to revise it. Acceptance of the *proposal of set objectives* gives l main organizational objectives that the management will be using in a further procedure.

The next activity is the ***identification of SWOT elements*** which results in *S, W, O, T elements* (see [13]) that are used to execute the ***definition of strategies*** activity with the TOWS method (see [22]). Once the management has defined *SO, ST, WO, WT strategies*, the ***definition of strategic initiatives*** is carried

*In the explanations provided below, the information flows are given in the *italic* font style, whereas the activities are marked with both *italic* and ***bold*** font style (note that in Fig. 1 activities are not marked with any style in order not to worsen readability of the diagram).

out. Thus, the strategies are translated into *strategic initiatives* required for their implementation.

Then the analyst executes the ***definition of derived objectives***. For each *strategic initiative* he/she formulates an objective which will enable measuring productivity of the initiative implementation. Measures and target values for derived objectives (DOs) are specified, as they were specified for the set objectives. This is how the *derived objectives* are defined and thereby n organizational objectives (l set objectives and $n - l$ derived objectives) are acquired.

It is obvious that implementation of strategic initiatives requires spending resources. Let realization of all activities require s types of resources. The management executes the ***determination of resource amounts*** to specify vector $(R_1, R_2, ..., R_s)$ of available resource amounts.

To quantify resource consumption the set of technological coefficients r_{ij} ($i = \overline{1,s}, j = \overline{1,n}$) is used. Coefficient r_{ij} indicates an amount of the i-th resource that has to be spent on the initiative corresponding to the j-th objective in order to achieve the 100% level of the accomplishment of this objective (it is assumed that $r_{i,j \le l} = 0$). Traditionally, the set of coefficients $\{r_{ij}\}$ is referred to as technological coefficients because it is the way (in other words, technology) the resources are used, that determines how many resources are needed for the 100% accomplishment of objectives.

Available resource amounts may not satisfy all the needs, so the problem of optimal resource allocation arises. The set of allowable resource allocations is the set of matrixes $\mathbb{U} = (u_{ij})_{s \times n}$ for which the following conditions are satisfied:

$$\begin{cases} 0 \le u_{ij}, & i = \overline{1,s}, j = \overline{1,n}, \\ \sum_{j=1}^{n} u_{ij} = 1, & i = \overline{1,s}, \\ u_{ij} = 0, & \text{if } r_{ij} = 0. \end{cases}$$

Value u_{ij} is the share of the i-th resource which should be spent on implementation of the initiative corresponding to the j-th objective. To allocate resources an optimally modified QMSP is employed.

According to the model, the result of the strategy implementation can be measured by the weighted sum of accomplishment levels of the set objectives $I = \sum_{j=1}^{l} w_j x_j$, where $w_j \ge 0$ is a weight coefficient of the j-th objective. The ***calculation of weight coefficients*** activity serves to determine the coefficients w_j ($j = \overline{1,l}$). In the original QMSP, the weight coefficients proposed to assign were equal to $1/l$, but more rational approaches may be used in practice. For example, if $I_j(0) \ne 0$, the weight coefficients can be calculated by the formula:

$$w_j = \frac{|I_j^*(T) - I_j(0)|}{I_j(0)}$$

and normalized to the sum of 1 [20, p. 57]. The logic of this approach is rather simple: the greater the relative difference between the target and the actual value of the indicator, the more value assigned to the corresponding weight coefficient. Weight coefficients can also be obtained by the procedure of pairwise comparisons proposed by T. Saaty as part of the analytic hierarchy process (AHP) [16].

Following the BSC concept, which is the basis for building the model of strategic performance, execution of the ***establishment of links among objectives*** activity results in the determination of a strategy map (examples of strategy maps can be found in special catalogs such as [3] or case studies including [1, 2]). The strategy map can be presented as an oriented graph $\mathbb{G} = (N, K)$, where N is a set of vertices corresponding to strategic objectives and K is a set of edges defining cause-effect relationships between objectives. Let all vertices be enumerated from 1 to n, the first l vertices correspond to the set objectives and the last $n - l$ vertices to the derived objectives. An example of an abstract strategy map is shown in Fig. 2.

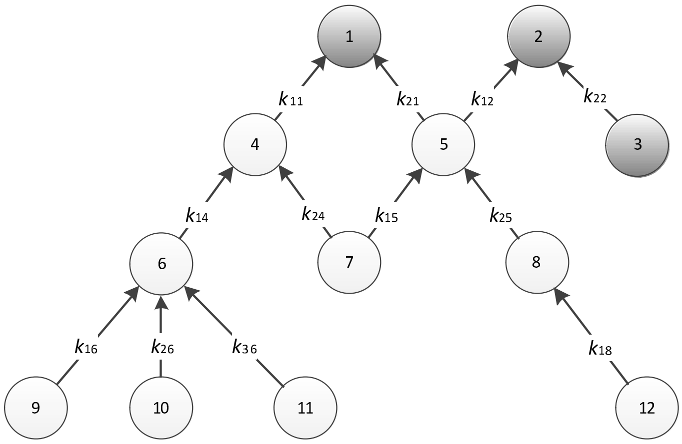

Figure 2: *An example of an abstract strategy map (SOs are marked with dark color; $n = 12$, $l = 3$)*

Let the i-th objective be referred to as subordinate to the j-th one if there is an edge $(i, j) \in K$. Let N_j $(j = \overline{1, n})$ be a set of numbers of the objectives which are subordinate to the j-th objective. Objectives belonging to N_j can be renumbered with local numbers $1, 2, ..., n_j$ $(n_j = |N_j|)$ relative to the j-th objective. Each edge $(i, j) \in K$ is assigned the coefficient $k_{\tilde{\imath}j} \geq 0$, where $\tilde{\imath}$ is the local number of the i-th objective relative to the j-th one. It is assumed that the coefficients of the edges directed to one edge are normalized to the sum of 1. According to the model, the accomplishment level of the j-th objective is bounded by the weighted sum of subordinate ones:

$$x_j \leq \sum_{\tilde{\imath}=1}^{n_j} k_{\tilde{\imath}j} x_i, j = \overline{1, n}.$$

Establishment of links among objectives implies only structuring of a strategy map, i.e. defining its edges. Weights are assigned to the edges in the next step. Thereby the *strategy map* turns out to be formulated.

The proposed methodology can be used for planning one particular sphere of activity of an organization, so strategic initiatives and derived objectives are specified only for this sphere. Set objectives which do not belong to the sphere under consideration (they can be referred to as external objectives) remain pendant in the strategy map (in Fig. 2 the third objective is external). For these objectives accomplishment levels x_j^{ext} ($j \in N^{\text{ext}}$, where N^{ext} is the set of indexes of external objectives) have to be assigned manually, while for the other objectives accomplishment levels are calculated through the procedure of strategic performance optimization.

Let technological coefficients, cause-effect relationship coefficients and levels of accomplishment of external objectives be referred to as parameters of the model. According to [9], parameters are specified in the following way: technological coefficients are determined precisely by the analyst; cause-effect relationship coefficients with the same second index are considered to be equal to each other; and accomplishment levels of external objectives are considered to be equal to 100%. These assumptions are artificial enough. We eliminate them considering that parameters of the model can be evaluated by experts.

It should be recognized that obtaining precise and at the same time reliable evaluations is a rather difficult problem. A high level of environmental uncertainty in long-range perspective as well as a novelty of considering the situation may not allow an expert to give precise evaluations of model parameters. In addition, evaluations received from various experts may differ. To overcome these obstacles we propose to use not precise, but three-point and two-point (interval) evaluations. During the procedure of ***evaluation of model parameters*** each expert directly evaluates minimum, most probable and maximal values of technological coefficients and levels of accomplishment of external objectives. So, two sets of three-point evaluations $\left\{\underline{r}_{ij}^p, \hat{r}_{ij}^p, \overline{r}_{ij}^p\right\}$ and $\left\{\underline{x}_j^{\text{ext}p}, \hat{x}_j^{\text{ext}p}, \overline{x}_j^{\text{ext}p}\right\}$ are specified ($p = \overline{1,e}$, where e is the total number of experts). Two-point evaluations of cause-effect coefficients $\left\{\underline{k}_{\tilde{\imath}j}^p, \overline{k}_{\tilde{\imath}j}^p\right\}$ can be obtained with interval AHP [8]. According to recommendations given in [21], it is assumed that values of parameters are random variables with the following density functions:

$$f_{k_j}(\cdot) = \sum_{p=1}^{e} c_p f_{k_j}^p(\cdot), f_{r_{ij}}(\cdot) = \sum_{p=1}^{e} c_p f_{r_{ij}}^p(\cdot), f_{x_j^{\text{ext}}}(\cdot) = \sum_{p=1}^{e} c_p f_{x_j^{\text{ext}}}^p,$$

where c_p is a coefficient of competence of the p-th expert, $f_{k_j}^p(\cdot)$ is a density function for uniform distribution of random point $k_j(\omega) = \big(k_{1j}(\omega), ..., k_{n_j j}(\omega)\big)$ on the surface of the polygon

$$Q_j^p = \left\{ (t_1, ..., t_{n_j}) \in \mathbb{R}^{n_j} \middle| \sum_{\tilde{\imath}=1}^{n_j} t_{\tilde{\imath}} = 1; \underline{k}_{\tilde{\imath}j}^p \le t_{\tilde{\imath}} \le \overline{k}_{\tilde{\imath}j}^p, \tilde{\imath} = \overline{1, n_j} \right\};$$

$f_{r_{ij}}^p(\cdot)$ is a density function for PERT-beta distribution of random variable $r_{ij}(\omega)$ on the segment $\left[\underline{r}_{ij}^p, \overline{r}_{ij}^p\right]$ with a mode equal to $\hat{r}_{ij}^p$; $f_{x_j^{\text{ext}}}(\cdot)$ is a density function for PERT-beta distribution of random variable $x_j^{\text{ext}}(\omega)$ on the segment $\left[\underline{x}_j^{\text{ext}p}, \overline{x}_j^{\text{ext}p}\right]$ with a mode equal to $\hat{x}_j^{\text{ext}p}$. According to [7], parameters of PERT-beta distribution with support segment $[a, c]$ and mode b can be calculated with the following formulae:

$$\alpha = \left(\frac{2(c + 4b - 5a)}{3(c - a)}\right)\left[1 + 4\left(\frac{(b - a)(c - b)}{(c - a)^2}\right)\right],$$
$$\beta = \left(\frac{2(5c - 4b - a)}{3(c - a)}\right)\left[1 + 4\left(\frac{(b - a)(c - b)}{(c - a)^2}\right)\right].$$

Since parameters of the model are random variables, the model can be referred to as a stochastic quantitative model of strategic performance (SQMSP).

To maximize the strategic performance the analyst should perform ***optimization of resource allocation***. Let all objectives be renumbered so that the following condition is satisfied: if $j < i$, then there is no way from the i-th vertex to the j-th vertex of the strategy map. Then at some resource allocation $U \in \mathbb{U}$ and fixed realization of model parameters $\{r_{ij}\}, \{x_j^{\text{ext}}\}, \{k_{\tilde{\imath}j}\}$ the accomplishment levels of objectives are calculated by the formula:

$$x_j = \min\left\{1, \min_i \frac{R_i u_{ij}}{r_{ij}}, \sum_{\tilde{\imath}=1}^{n_j} k_{\tilde{\imath}j} x_i, x_j^{\text{ext}}\right\}, j = \overline{n, 1}.$$

This formula expresses all constraints imposed by the original quantitative model of strategic performance proposed in [9]. It is important that x_1 is calculated first, x_2 is calculated second, ..., x_n is calculated last. Let resource allocation $U^* \in \mathbb{U}$ be optimal if

$$U^* = \underset{U \in \mathbb{U}}{\operatorname{argmax}}\, \mathbf{E}\left[\sum_{j \in N^{\text{set}}} w_j X_j(\omega, U)\right],$$

where $\mathbf{E}[\cdot]$ is the expectation operator, $X_j(\omega, Y)$ is the random accomplishment level of the j-th objective, N^{set} is the set of numbers of the set objectives. At given $U \in \mathbb{U}$ the value of $\mathbf{E}\left[\sum_{j \in N^{\text{set}}} w_j X_j(\omega, U)\right]$ can be calculated by the Monte-Carlo method (see [21, p. 45]), so some optimization algorithm that requires evaluation of only the objective function values can be used in order to find U^*. We propose to use the particle swarm optimization algorithm (PSO, see [4]) with a special representation of particles and their velocities. Let each particle be a matrix $Y = (y_{ij})_{s \times n}$ and its velocity a matrix $V = (v_{ij})_{s \times n}$. It is assumed that the share of the i-th resource spent on implementation of the initiative corresponding to the j-th objective is calculated by the formula:

$$u_{ij} = \frac{y_{ij}}{\sum_{p=1}^{n} y_{ip}}.$$

If $r_{ij} = 0$, then at each iteration of the PSO procedure y_{ij} and v_{ij} are assigned to 0. If on some iteration of the PSO procedure $y_{ij} < 0$, then y_{ij} is assigned to 0. The proposed approach allows us to eliminate the constraints $\sum_{j=1}^{n} u_{ij} = 1(i = \overline{1, s})$ which are satisfied automatically. The analyst obtains the *optimal resource allocation* U^* as an output of this procedure. Than by the Monte-Carlo method he/she can obtain target intervals for objectives' accomplishment levels $\left[\underline{x}_j, \overline{x}_j\right]$ and $\left[\underline{I}, \overline{I}\right]$, where a lower bound of each interval is the 5-th percentile and an upper bound is the 95-th percentile for the respective value.

In the next step, the analyst submits *optimal resource allocation and target intervals* to the manager for approval. If they do not satisfy the manager, then there are *objections to the planned level of realization of objectives* and ***identification of SWOT elements*** activity should be repeated so as to find a new element that will bring us closer to the desired state.

If this is not the case, the results are used in the process of ***validation of the model***. The *real values of measures* are obtained through the ***measurement of values of real system*** activity and *resource spending* is obtained through the ***tracking implementation of strategic initiatives***.

Validation of model activity determines the *discrepancy between the modeled and the real system*. The analyst formalizes model sustainability in the form of *acknowledgement of soundness of the model*. If *acknowledgement of soundness of the model* exists, then *optimal resource allocation and target intervals* for accomplishment levels of objectives are employed in the process of ***strategy realization***.

Results of the ***strategy realization*** process are submitted to the owner in the form of *reports on realization of objectives*. Based on the *reports on realization of objectives*, the owner executes a ***definition of the development policy***. The *development policy* is used in the ***approval for vision*** activity on the next cycle of strategic planning.

If the model is not satisfactory, *acknowledgement of malfunction of the model* is provided, after which it is necessary to conduct an ***analysis of the model*** in order to reveal *recommendations on re-evaluation of parameters and/or restructurization of the strategy map*. It should be noted that the reason for malfunctioning of the model may be caused by the changed environment. In this case, the strategy must be revised at a higher level, so new SWOT elements have to be specified and the planning process has to be repeated.

The methodology described in this section is favorably comparable with approaches proposed earlier (especially with an approach based on the original quantitative model of strategic performance) in that it uses stochastic simulation. An organization strategy as a rule is a novel long-term plan, so precise estimations of one expert cannot be considered trustworthy. The proposed methodology is designed to take into account imprecise estimations of many experts and improve reliability of results. Additionally, it provides ground for implementation of predictive and prescriptive analytical tools, because it allows prescription of optimal resource allocation and prediction of objectives accomplishment levels.

3. Case example

The proposed methodology was applied to develop and optimize the IT-strategy at the Faculty of Economics, University of Split (planning horizon was assumed to be two years).

At the beginning of the planning process the following vision statement was formulated and approved (Fig. 1 — Activities 1–2):

An internationally recognized organization (SO1) that generates new scientific discoveries in the fields of economics, business economics and tourism (SO2) and implements them into the economy (SO3) using modern educational standards (SO4) to produce fresh human resources and improve the existing ones(SO5).

Based on this statement, Activities 3–4 were executed, so five set objectives were specified (objectives SO2 and SO3 were assumed to be external). Then SWOT (Fig. 1 — Activity 5) and TOWS (Fig. 1 — Activity 6) analyses were performed to give eighteen strategic activities (Fig. 1 — Activity 7). According to Activity 9, resources of three types were assigned to implementation of the strategy, their total amounts were determined (see them in Fig. 3 below the legend; descriptions and measurement units for resources are not shown for reasons of privacy).

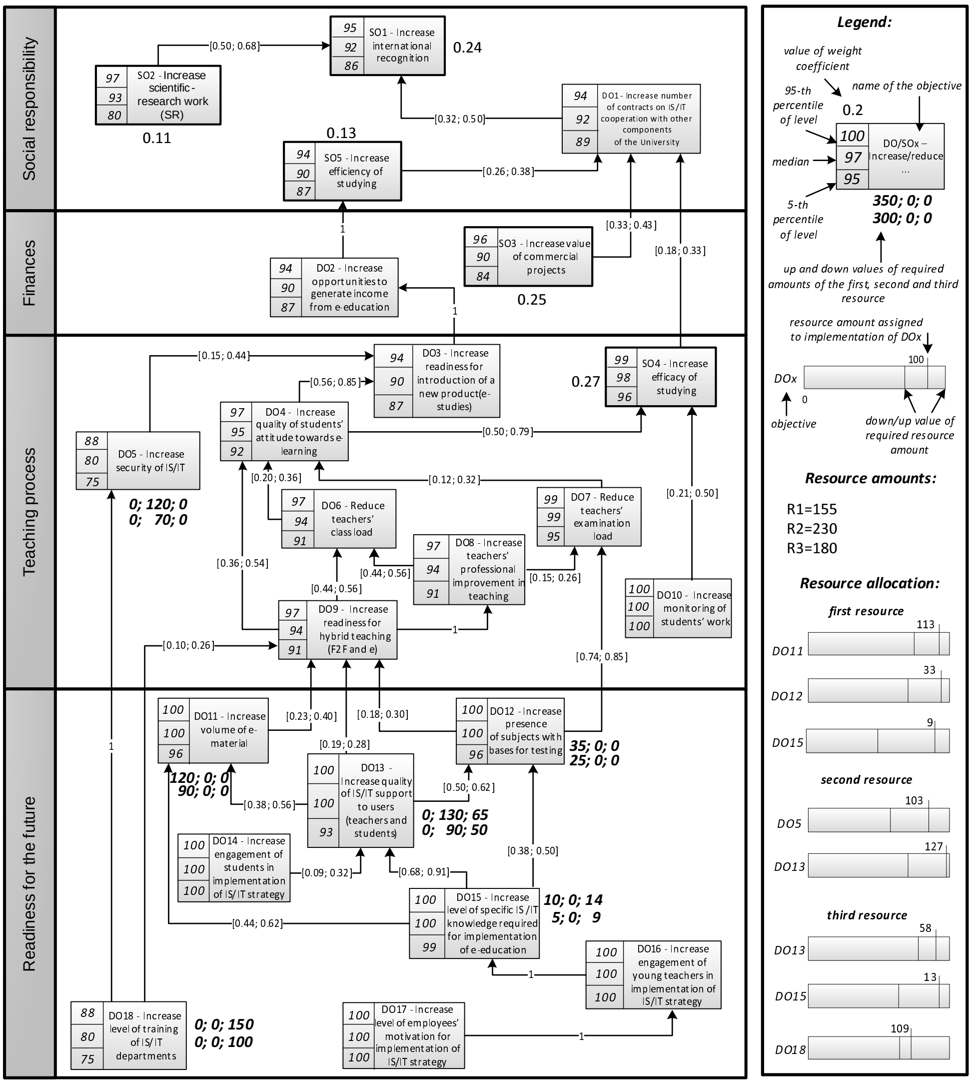

Figure 3: *IT-strategy map of the Faculty of Economics, University of Split*

For each strategic activity a derived objective with measure and expected value was formulated (Fig. 1 — Activity 8) whereby twenty-three strategic objectives were defined. According to Activity 10, weight coefficients of the objective function were calculated based on the difference between initial and planned values of corresponding indicators (they are marked beside the set objectives singled out with thick frames in Fig. 3).

Set and derived objectives were grouped into four perspectives and linked with cause-effect relationships (Fig. 1 — Activity 11). Thereby we obtained the strategy map presented in Fig. 3 (note that the set objectives are singled out with thick frames).

Activity 12 was implemented to give evaluations of model parameters. All evaluations were obtained by votes of five experts. Extreme evaluations of parameters are demonstrated in Fig. 3. Intervals assigned to the edges of the strategy map represent maximum and minimum possible values of cause-effect coefficients which can be generated in the process of Monte-Carlo simulation. For example, the edge (SO5, DO1) is assigned to the interval [0.26, 0.38], the edge (SO3, DO1) to the interval [0.33, 0.43] and the edge (SO4, DO1) to the interval [0.18, 0.33]. It means that the values 0.37, 0.35 and 0.28 can be generated for the edges (SO5, DO1), (SO3, DO1) and (SO4, DO1), respectively, but the values 0.4, 0.35 and 0.25 cannot, because 0.4 is greater than the maximum possible value for the cause-effect coefficient of the edge (SO5, DO1).

Having executed Activity 13 we calculated optimal resource allocation and target levels for objectives' accomplishment. Mean value of the result at calculated optimal resource allocation appeared to be equal to 93% (standard deviation 2.6%), the 5-th percentile was equal to 90% and the 95-th percentile was equal to 95%. Empirical cumulative frequency distribution for the value of the result is presented in Fig. 4.

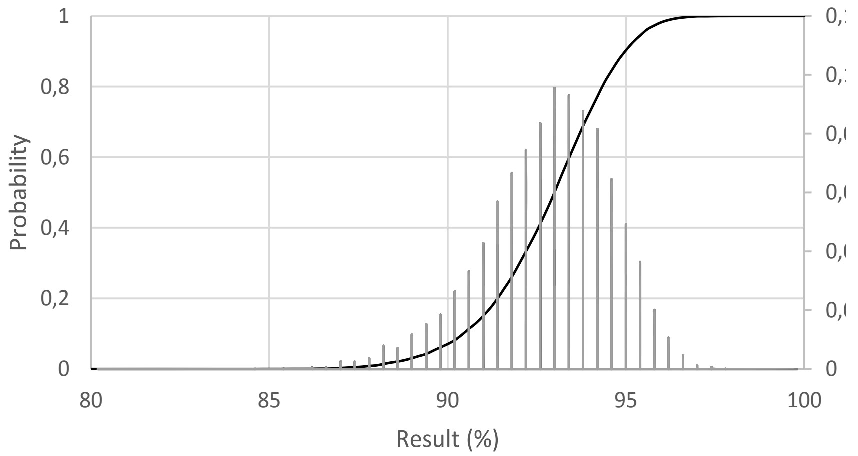

Figure 4: *Empirical cumulative frequency distribution and histogram for the value of the result*

Calculated optimal resource allocation (amounts of resources which have to be spent on achievement of each objective) is presented in Fig. 3. Fig. 3 also presents target levels for all strategic objectives. For example, the accomplishment level of the objective DO5 "Increase security of IS/IT" has the 5-th percentile equal to 75%, median equal to 80% and the 95-th percentile equal to 88%. It means that the accomplishment level of DO5 will belong to the interval [75, 88] with probability of 0.9, and it will be more than 80% with probability of 0.5.

Head of the Faculty Council was satisfied with the obtained results, so the developed strategy was approved (Fig. 1 — Activity 14). Activities 15–17 have been fulfilled and the model has shown its sustainability. The model is used to monitor and control implementation of the strategy developed (Fig. 1 — Activity 18). The obtained target levels are used as part of the motivation system. If after two years the accomplishment level of some objective is less than the lower bound of the respective target interval, then the person responsible for accomplishment of this objective will be penalized (he/she will lose part of the bonus). On the other hand, if the accomplishment level is greater than the median, then the responsible person will gain extra bonus.

4. Conclusions and further research

The paper proposes a formal methodological approach to strategic planning based on the usage of a stochastic quantitative model of strategic performance. This model was built by virtue of already "classical" approaches to strategic performance, the BSC and strategy maps, developed by R. Kaplan and D. Norton. The strategic planning process is connected with heightened uncertainty, so model parameters such as cause-effect relationship coefficients, technological coefficients and levels of accomplishment of external strategic objectives cannot be specified precisely. We suggest the method which enables obtaining their values in the form of three-point and two-point (interval) evaluations and uses them for solving the problem of optimal allocation of organization's resources and calculation of target intervals for objectives' accomplishment levels. Thus, the proposed approach is able to facilitate optimization of organizational strategic performance, which could be of special interest in the development of relevant strategic management analytic packages and other forms of managerial decision-making support.

Further research could concern the introduction of parameters describing implementation of strategic activities (e.g., maximal intensity of resource consumption, lag between accomplishing activity and reaching objective, preconditions fulfilment of which is necessary for starting implementation of activity, etc.) and usage of system dynamics in order to describe the developed strategy more precisely, optimize resource scheduling, obtain not static, but dynamic target intervals which would show planned objectives' accomplishment levels for each moment of time within the planning horizon.

Acknowledgement

The authors would like to thank two anonymous reviewers for their suggestions and comments.

References

[1] Amini, M.T., Bavil, S.K. (2011). Codification of the strategy map in small, auto-parts manufacturing companies (case study: Sahand Khordo Company of Tabriz). International conference on management (ICM 2011) Proceeding, 220–228.

[2] Anagnostopoulos, K.P. (2010). Strategic Plan in a Greek Manufacturing Company: A Balanced Scorecard and Strategy Map Implementation. International Journal of Business and Management, 5(2), 12–25.

[3] Best Practice Strategy Maps (2010). Palladium Group, Inc. http://goo.gl/tFrMre [Accessed on 22 October 2013]

[4] Bratton, D., Kennedy, J. (2007). Defining a Standard for Particle Swarm Optimization, Proceedings of the 2007 IEEE Swarm Intelligence Symposium (SIS 2007), 120–127.

[5] Chandler, A.D. (1962). Strategy and Structure, Boston, MA: MIT Press.

[6] Chien, T.W., Lin, C., Tan, B., Lee, W.C. (1999). A neural networks-based approach for strategic planning. Information & Management, 35, 357–364.

[7] Davis R. (2008). Teaching Project Simulation in Excel Using PERT-Beta Distributions. INFORMS Transactions on Education, 8 (3), 139–148.

[8] Ershov, D.M. (2013). Optimization of resource allocation in strategic performance management process. Vestnik MAI, 20(2). [in Russian]

[9] Hell, M., Vidačić, S., Garača, Z. (2009). Methodological approach to strategic performance optimization. Management, 14(2), 21–42. http://hrcak.srce.hr/file/74195 [Accessed on 22 October 2013]

[10] Huang, H. (2009). Designing a knowledge-based system for strategic planning: A balanced scorecard perspective. Expert Systems with Applications, 36(1), 209–218.

[11] Kaplan, R.S., Norton, D.P. (2008). The Execution Premium: Linking Strategy to Operations for Competitive Advantage. Harvard Business School Press.

[12] Kunz, H., Schaaf, T. (2011). General and specific formalization approach for a Balanced Scorecard: An expert system with application in health care. Expert Systems with Applications, 38(3), 1947–1955.

[13] Learned, E.P., Christensen, C.R., Andrews, K.R., Guth, W.O. (1965). Business Policy: Text and Cases. Homewood, IL: Irwin

[14] Li, S. (2007). AgentStra: an Internet-based multi-agent intelligent system for strategic decision-making. Expert Systems with Applications, 33, 565–571.

[15] Minzberg, H., Ahlstrand, P.B., Lampel, J.B. (2008). Strategy Safari: The Complete Guide Through the Wilds of Strategic Management. Financial Times/Prentice Hall.

[16] Saaty, T. (2008). Decision making with the analytic hierarchy process. Int. J. Services Sciences, 1(1), 83–98. Available at http://goo.gl/jGBbe [Accessed on 22 October 2013]

[17] Saen, R.F. (2009). A Mathematical Programming Approach for Strategy Ranking. Asia Pacific Management Review, 14(2), 109–120.

[18] Schlegel, K., Sallam, R.L., Yuen, D., Tapadinhas, J. (2013). Magic Quadrant for Business Intelligence and Analytics Platforms, Gartner.

[19] Subramoniam, S., Krishnankutty, K.V. (2002). An expert system for the selection of strategic planning technique. Kybernetes, 31(3), 550–560.

[20] Trahtengerts, E.A. (2003). Computer support of negotiations while harmonizing managerial decisions. Moscow. [in Russian]

[21] Vose, D. (2008). Risk Analysis: A Quantitative Guide. John Wiley & Sons.

[22] Weihrich, H. (1982). The TOWS matrix: A tool for situational analysis. Long Range Planning, 15(2), 54–66

[23] Wickramasinghe, V., Takano, S. (2009). Application of Combined SWOT and Analytic Hierarchy Process (AHP) for Tourism Revival Strategic Marketing Planning: A Case of Sri Lanka Tourism. Journal of the Eastern Asia Society for Transportation Studies, 8.