

Methods for Scenario Development

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This paper is devoted to scenario development process and methods which are used at different stages of it. Stages of identification of system's key variables, driving forces and their possible states, assessment of influence, generation of scenario configurations, and analysis of these configurations are described; some methods for these stages are proposed.

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Introduction

Scenario development is a tool which can be used for strategy generating or testing, for exploration of system's states in the future and other purposes. This approach includes consideration of different visions of future — scenarios. Scenario is a coherent description of alternative hypothetical futures that reflect different perspectives on the past, present, and future development, which can serve as a basis for action [1].

Scenario analysis is used in many different spheres: for countries and cities, big corporations, by international organizations and in other cases [2–5].

Many methods for scenario development process were proposed during scenario analysis evolution [1, 6–8]. But mostly of them are qualitative and aren't based on any mathematical theory. Consistent description of all scenario development stages is usually absent or is incomplete. So in this article author proposes some quantitative methods which can be effectively used at different stages of scenario development process.

Scenario development process

Figure 1 shows proposed by author sequence of the stages of scenario development process and methods in each of them.

In the next paragraphs main of these stages and methods will be shortly described.

Key variables, driving forces and their states identification

Key variables are the system's internal characteristics, which should be mutually independent and should fully describe system under study. Key variables identification can be done using different methods like structural analysis [6], expert's methods [8] and so on. For identify quantitative system key variables author proposes to use SWOT-analysis. To use this method first of all the set of system quantitative characteristics should be determined — $\{I_k^i, k \in [1..K]\}$. Secondly peer group for system should be formed. Such group is formed of objects which are similar with studied one and for which the same quantitative characteristics are known — $\{I_k^j, k \in [1..K]\}$ — the set of characteristics for j country from peer group, J — number of countries in peer group. At the next step the sets of strengths and weaknesses for system should be determined by comparison and determining deviation Δ_j for each characteristics using formula:

$$\Delta_j = (I_j^* - \frac{\sum_{k=1}^K I_j^k}{K}) / \frac{\sum_{k=1}^K I_j^k}{K} \quad (1)$$

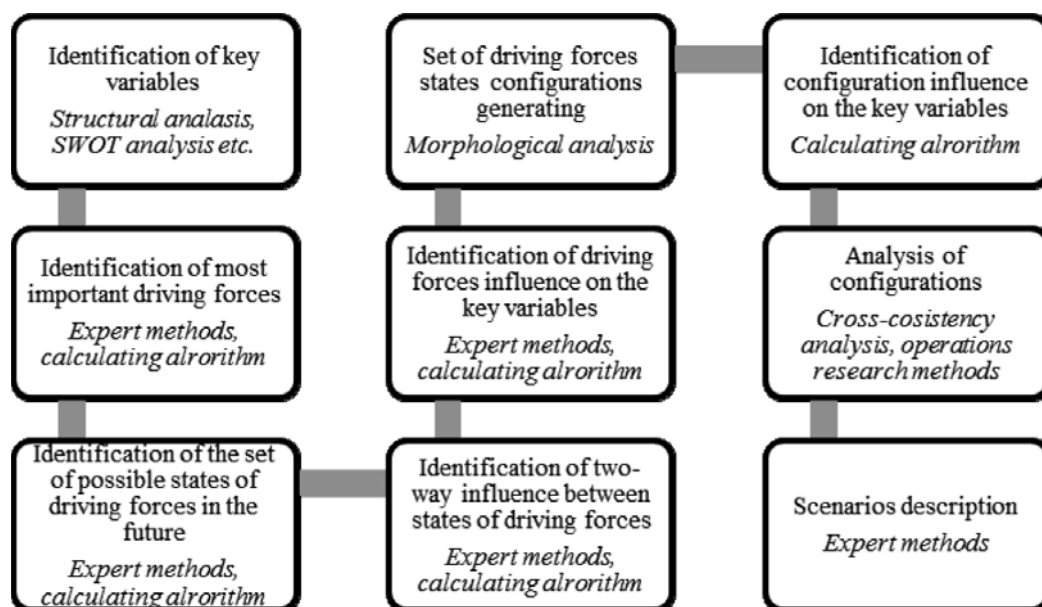


Fig. 1. Stages of scenario development process.

Accordingly to following rules characteristics should be classified: characteristics with Δ_j in boundary $[-\infty; -b_j]$ are weaknesses for system, with Δ_j in boundary $[b_j; \infty]$ are strengths for system, and with Δ_j in boundary $[-b_j; b_j]$ are neutral characteristics, the value of b_j is given by analyst of research. Result of this stage is the set of key variables (weaknesses and strengths) for system — $\{k_v, i \in [1..N]\}$. For example, for country and cities its sustainable development indices can be used as a basis for weaknesses and strengths identification [11]. Usage of SWOT-analysis for key variables identification is described in detail in [9–10].

Driving forces for system under study are the factors of external environment and can be of social, economic, ecological, political, technological and other types. For driving forces identification methods of expert evaluation can be used. The main driving forces should have strong influence on the system and their future states should be uncertain. So, the big amount of driving forces obtained from experts $\{DF_j, j \in [1..M]\}$ should be classified using such criteria as uncertainty — $U\{DF_j\}$ — and influence — $Infl\{DF_j\}$. First of all for each driving force the measure of their future state uncertainty and the measure of their influence on the system are identified by each expert. Secondly aggregated value of these parameters are calculated — $U(DF_j)$ and $Infl(DF_j)$, and the generalized characteristics — Importance — for each driving forces are calculated by formula:

$$\text{Importance}\{DF_j\} = \frac{U\{DF_j\} + Infl\{DF_j\}}{2} \quad (2)$$

In the result of this stage the set of driving forces for system under study should be formed — $\{DF_j, j \in [1..m]\}$.

In the period of future for which scenarios are being developed, driving forces can acquire some of their possible states. The set of possible states is identified by experts for each driving forces. As a result of this stage the set of possible states in specified period of time for each driving forces should be formed — $\{DF_j^k, k \in [1..q_j], q_j \in N\}$, where q_j is quantity of possible states for driving force DF_j in the future.

Influence determination and generation of configurations for scenarios

Hypothetically, in the future each driving force can acquire any of their possible states. So to explore all space of possible futures it is needed to construct all possible configurations of driving forces' states in the future. Useful and effective tool for such task is morphological analysis [12]. To implement procedure of morphological analysis let's represent our objects as following common terms for morphological analysis:

- driving forces as characteristics parameters of system,
- possible future states of driving forces as a set of values of characteristic parameters,
- all possible configurations of driving forces states as a morphological space.

So, according to morphological analysis procedure one can generate all possible configurations of driving forces' states in the future. But some of these configurations can be internal inconsistent. To reduce morphological space and exclude inconsistent configurations cross-consistency analysis should be conducted. To do that, experts should fill in matrix as in Table 1.

Table 1. Cross-consistency matrix.

States of DF/ States of DF	DF_1^1	...	$DF_j^{k_i}$...	DF_L^M
DF_1^1					
$DF_1^{k_p}$			$Cons(DF_j^{k_i}, DF_1^{k_p})$		
DF_L^M					

Where: $DF_j^{k_i}, DF_1^{k_p}$ — possible states of driving forces DF_j and DF_p
 $Cons(DF_j^{k_i}, DF_1^{k_p})$ — consistency of two states between two different driving forces, which is measured using the scale [0..1], where 0 — is consistent, 1 — is inconsistent. Values between 0 and 1 can be used in cases of partial consistency.

After such analysis all inconsistent configurations can be excluded from the morphological space. Or, in case of using values between 0 and 1, researcher can set a threshold level (for example, all configurations which contain two states with $Cons > 0,6$ should be excluded).

Still the quantity of configurations in this space usually remains quite big, often, few hundreds of thousands. The formula for calculation of the quantity of elements in morphological space is $\prod_{j=1}^M N_j$, where: N_j — is general quantity of states of DF_j , M — is quantity of driving forces in the research.

As a result of previous stage the set of vectors which consists of driving forces states are obtained: $\{DF_1^{k_1}, \dots, DF_j^{k_j}, \dots, DF_M^{k_M}\}$.

Development of scenario space and their analysis

In our research scenario is formalized as a two-part vector:

$$\text{Scenario: } (\{DF_1^{k_1}, \dots, DF_j^{k_j}, \dots, DF_M^{k_M}\}; \{kv_1, \dots, kv_N\}) \quad (3)$$

First part of this vector is the result of previous step of driving forces states configurations generating, the second is the vector of new key variables values which they gain under the influence of vector in the first part.

In more simple case in the future each key variable can have positive, negative or neutral dynamics. And each set of driving forces states can influence on each key variable by one of this manner. One of approaches for influence identification is consecutive assessment of each configuration from previous step influence on each key variable. This approach is very laborious because of quantity of configurations. The other approach consists of identification of influence of each driving force states to each key variable and identification of interrelationship between driving forces states to calculate their total influence. So, the first part of scenario-vector consists of

states set, the second one consists of the values of key variables' dynamics.

Further analysis of space of such objects can be done using some criterion for first or second parts. For example, all scenarios with the identic second part can be found; all scenarios with negative dynamics of some of key variables can be found, positive dynamics scenario can be located and so on.

Conclusions

Thus, in article the sequence of stages and methods for theme are proposed. Most of methods are quantitative and give more objective results. Using described process of scenario development researcher can explore all space of possible configurations of future. Important point in such approach is possibility to find really interesting and surprising scenarios. Because, the probability of each scenario in this research is considered to be equal, researcher isn't limited by the variants that seem to only be possible at current period of time. Many times in human history the most significant influence was caused by sudden events. So, scenario development approach can be useful in the case of flexible strategy development and of course, to widen horizons and see more different variants.

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