A New Heuristic Protocol for Strategy Selection Presented on the Basis of Examples of Former Underground Mines

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Abstract

Strategic planning and analysis often require that we make choices that are backed up with logical reasons. Such decision-making is difficult, as it involves many variables, both measurable and non-measurable. In some cases, a choice has to be made from among a dozen or several dozen variants, or more. It might be hard to determine which of these are the best and why.

This paper describes SWOT-AHP-PSS, an innovative approach developed to support decision-making as part of strategic planning. What is innovative about the SWOT-AHP-PSS protocol is the original combination of commonly known and used methods. SWOT-AHP-PSS assesses the probability of success for each of the pre-defined scenarios, and helps identify the key factors behind PSS. It can be useful for both simple and very complex decision-making.

Keywords: heuristic methods for strategy selection, SWOT, Analytic Hierarchy Process, Market Attractiveness, Market Position, probability of strategy success

Introduction

Strategic planning often requires that optimum choices be made. Such choices should be supported with logical reasons. The process of selection is difficult because the variables involved tend to be either non-measurable or difficult to measure. In addition, with multiple 'good' options on the table, it is hard to determine which of these are the best and why.

This paper presents a protocol for strategy selection I devised on the basis of three elements, namely the SWOT matrix, the Analytic Hierarchy Process (AHP) technique, and a method used for determining the probability of strategy success (PSS). Based on the names of its component elements, I refer to this protocol as SWOT-AHP-PSS. This article describes how this protocol could be used. And, last but not least, it demonstrates that this protocol could be useful for both simple and very complex decision-making.

SWOT-AHP-PSS

The SWOT analysis has been commonly known and used for more than five decades now. This method was developed on the basis of Force Fields with Driving Forces and Restraining Forces, as formulated by psychologist Kurt Z. Lewin [1]. The former are further sub-divided into strengths and opportunities, while the latter into weaknesses and threats. Strengths and Weaknesses constitute internal factors, which stem directly from the characteristics of a business or a project. On the other hand, Opportunities and Threats are external factors, which are presented by the environment external to a business or a project.

SWOT analysis is carried out to identify the key factors which determine the future of a business or a project. But there is a problem of how to quantify the individual factors in the analysis, and, consequently, how to rank them in terms of their priority. SWOT analysis itself can constitute the first step in strategic planning, which requires that each factor be identified and categorised as a Strength, a Weakness, an Opportunity or a Threat. The next stage, where the importance of each factor is determined, can refer to the Analytic Hierarchy Process (AHP) method, as developed by T. Saaty [2,3]. AHP was created to provide analytic support for decision-making, whether involving simple consumer choices or complex, multi-layer, corporate decisions.

As a multi-criteria technique for hierarchical analysis of decision-making problems, AHP combines elements of mathematics and psychology. With AHP, it is possible to break down the problem into smaller parts and ultimately rank the finite set of possible options. An optimum choice is made by reducing criteria through a series of pairwise comparisons, with the number of such pairs equal to $n(n-1)/2$. Ultimately, these comparisons make it possible to derive numerical values for the analysed elements. The pairwise comparisons follow the Saaty Scale from 1 to 9 (Table 1), where 1 means that both elements are equally important, and 9 means that one element is much more important than the other.

The assessments (aij) are put together in the form of an inverse symmetric matrix (Table 2). Its diagonal satisfies the condition aij=1 for i=j. This means that its diagonal elements are the assessments of the elements in relation to themselves.

The next step in the AHP method is to calculate the eigenvectors for the matrix. According to Saaty, there are four different ways of calculating these eigenvectors. One way is to multiply the elements in each row of the comparison matrix and to calculate the root with its degree equal to the number of elements in that row (see ri, Table 2). The produced results are then normalised one by one, by dividing them by their sum (see Wi, Table 2).

Following normalisation, eigenvectors constitute 'local values' of factors and reflect a relative hierarchy of importance for the considered factors.

Tab. 1. Pairwise comparisons and the Saaty Scale. Source: Own elaboration
Tab. 1 Porównania parami wg. skali Saaty'ego. Źródło: Opracowanie własne

Element A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Element B
Element B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Element C
Element C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Element A

Tab. 2. Calculating eigenvectors in a comparison matrix. Source: [4]
Tab. 2. Macierz porównań. Źródło: [4]

	A_1	A_2	A_3	r_i	W_i
A_1	1	a_{i1}	a_{i2}	$\sqrt[3]{1 \cdot a_{i1} \cdot a_{i2}}$	$\frac{r_{i1}}{\sum r_i}$
A_2	$\frac{1}{a_{i1}}$	1	a_{i3}	$\sqrt[3]{\frac{1}{a_{i1}} \cdot 1 \cdot a_{i3}}$	$\frac{r_{i2}}{\sum r_i}$
A_3	$\frac{1}{a_{i2}}$	$\frac{1}{a_{i3}}$	1	$\sqrt[3]{\frac{1}{a_{i2}} \cdot \frac{1}{a_{i3}} \cdot 1}$	$\frac{r_{i3}}{\sum r_i}$
				$\sum r_i$	$\sum w_i = 1$

For these calculations, one can use Expert Choice or Super Decisions programs [5]. In addition to the above-mentioned numbers, these programs will calculate the consistency ratio (CR), which reflects the inconsistency of the matrix, or, in other words, mismatch during the first step, when factors are subject to pairwise comparisons. CR may not be greater than 10% or otherwise it will mean that comparison results are unreliable, which, in turn, could suggest that the pairwise comparisons were random rather than conscious choices by experts. Pairwise comparisons can be made on several levels in the hierarchy.

Recently, a common approach is to use SWOT and AHP methods together, i.e., AHP is used to model the elements identified in the SWOT analysis as a hierarchy. Figure 1 shows the conceptual combination of SWOT and AHP. Their elements have been divided into two levels, Level I and Level II, with Local Priorities (LPA, LPB) identified for each level. By multiplying Local Priority values on both levels, global values are calculated.

The literature includes a number of studies which employ this method combination. Take for instance a paper by Alshomrani S. and Qamar S entitled "Hybrid SWOT-AHP Analysis of Saudi Arabia e-government"[9], which uses this method to build a hierarchy of the Strengths, Weaknesses, Opportunities, and Threats found in e-government applications, and to formulate a future development strategy. For this purpose, Alshomrani and Qamar transformed SWOT into TOWS. Similarly to calculations based on Market Attractiveness (MA) and Market Position (MP) indices, TOWS supports strategy development. This approach is by all means correct. However, the problem is that, with multiple variants, a separate strategy can be developed for each. With TOWS, it is difficult to specify which variant is preferable. But this can be achieved with PSS.

The method used to specify strategic directions and the probability of strategy success (PSS) is well-known and used together with SWOT. With PSS, SWOT analysis elements are assessed on the basis of the adopted scale, e.g., from 1 to 5, or from 1 to 10. Its results are then summed up for each group (∑S, ∑W, ∑O, ∑T) and used to calculate Market Attractiveness and Market Position [6,7].

Market Attractiveness (MA)

$$MA=(\sum O)/(\sum O+\sum T) \quad (1)$$

Market Position (MP)

$$MP=(\sum S)/(\sum S+\sum W) \quad (2)$$

With MA and MP calculated (values between 0 and 1), one can proceed to formulate a development strategy. See Fig. 2.

There are four types of strategies:

- max - max – takes advantage of Opportunities by using Strengths,
- min - max – overcomes Weaknesses to take advantage of Opportunities,
- max - min – uses Strengths to avoid or neutralise Threats,
- min - min – suggests that the project should be abandoned.

The final stage is to calculate the probability of strategy success (PSS)

$$PSS=(MA+MP)/2 \quad (3)$$

If PSS is above 0.5, this means that the strategy is likely to be successful, while results below 0.5 correspond to failure.

Possible application of my original SWOT-AHP-PSS protocol for former underground mines

To my knowledge, the available literature contains no solution similar to SWOT-AHP-PSS. The first and, so far, the only example of this protocol being used in practice was presented in a monograph by A. Wiktor-Sułkowska [8], who considered 16 possible strategy variants for former underground mining facilities. This set of possible variants was

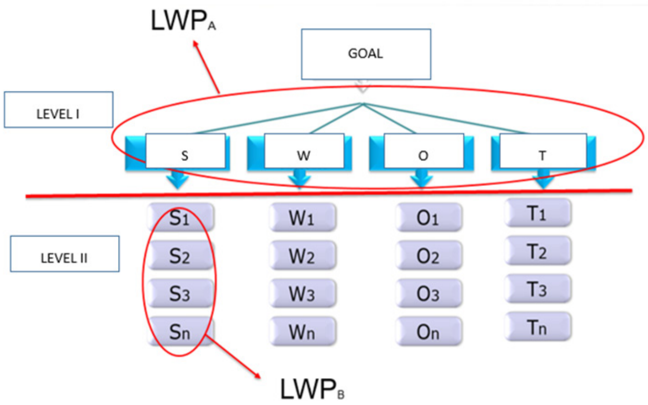


Fig. 1. Conceptual combination of SWOT and AHP. Source: Developed on the basis of [8]
Rys. 1. Schemat poglądowy dotyczący połączenia metod SWOT i AHP. Źródło: Opracowano na podstawie [8]

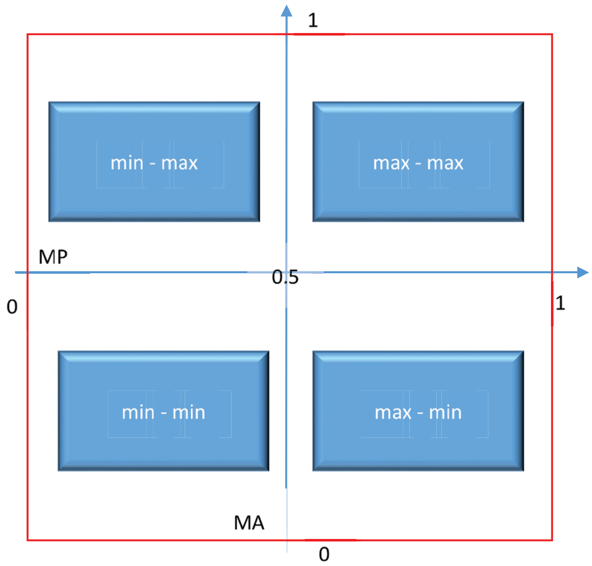


Fig. 2. Strategy formulation. Source: Own elaboration
Rys. 2. Formowanie strategii. Źródłó: Opracowanie własne

divided into two groups, i.e., based on the standard and alternative approaches to adaptation, respectively. The standard approach means adaptation of former underground mines for tourist, museum, health-resort, sports, event-organisation, or educational/training purposes.

On the other hand, the alternative approach involves adaptation of former underground mines for experimental purposes or as petroleum/gas/water/food storage, archives, hazardous or radioactive waste disposal sites, renewable energy sources, such as water power plants, or thermal energy sources.

Based on in situ surveys in Poland and abroad, the study [8] identified the key factors influencing the individual types of adaptation. These groups of factors were related to such categories as formal/legal, economic, socio-demographic, psychological, cultural, historical, political, environmental, technical, and spatial.

The factors were assigned to SWOT elements, i.e., Strengths, Weaknesses, Opportunities and Threats. Next, using AHP, the author identified local and global priority vectors for Ss, Ws, Os, and Ts. Based on global priority vectors, the study calculated Market Attractiveness (MA) and Market Position (MP) indices. These indices were then used to identify the preferable strategy for each of the adaptation scenarios (Fig. 2).

MA and MP indices were also used for calculating the probability of strategy success (PSS). Results are presented in Graph 1 below.

The results presented in Graph 1 above can be interpreted as follows:

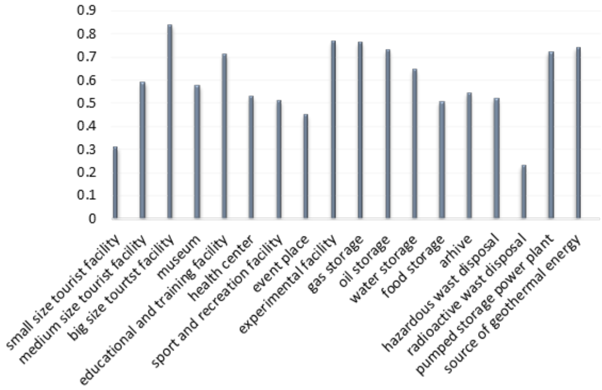
Success is very likely if former mines are adapted as (big) tourist facilities, experimental facilities, or gas storage.

Success is likely if former mines are adapted as educational/training facilities, petroleum storage, renewable energy sources (using heat trapped in underground rocks, underground water power plants), (medium-sized) tourist facilities, or museums.

A fifty-fifty chance of success is given for projects involving adaptation of such mines as health resorts, sports facilities, food storage, archives, or hazardous waste disposal sites.

Finally, failure is expected for the adaptation of former mines as event places, (small) tourist facilities, or radioactive waste disposal sites.

SWOT-AHP-PSS assessed the probability of success for each of the pre-defined scenarios, and helped identify the key factors behind PSS.



Graph 1. PSS indices for former underground mine adaptation scenarios. Source: Developed on the basis of [8]

Wykres 1. Prawdopodobieństwo sukcesu strategicznego dla poszczególnych sposobów adaptacji podziemnych wyrobisk. Źródło: Opracowano na podstawie [8]

Applying SWOT-AHP-PSS results to actual adaptation scenarios for former mines

Calculations show that success is likely to be achieved by “large” post-industrial underground mines if these are adapted as tourist facilities. Currently, both in Poland and in Europe, the largest and the finest example of such a facility is the salt mine in Wieliczka. Each year, this mine is visited by more than 1.7 million tourists. It is estimated that Wieliczka earns some PLN 70-80 million a year from its tourist services alone. For this adaptation, it has been the considerable historical and cultural value of the facility that contributed to its success. As a tourist facility, it provides up to several hundred jobs, and contributes to the local economy in general.

A fifty-fifty chance of success is estimated for adaptations of former mines as underground health resorts, sports facilities, or hazardous waste disposal sites. If implemented on an individual basis, the first two forms of adaptation would be more likely to fail than to succeed. In practice, however, such health resorts are often combined with former mine adaptations as tourist facilities or museums. This is also the case for the adaptation of mines as sports facilities (climbing, underground playing fields, etc.). An exception to this is the adaptation of a former mine as a sports facility used for diving. Currently, there is only one place in the world where diving in a former mine is legally available. This place is Kalkbergwerk Militz, Germany. But having a former mine adapted as a professional diving facility requires the development and maintenance of special safety procedures and standards. Moreover, mines adapted for such purposes can only be used by a small group of divers, which cannot possibly produce any major income.

Interestingly enough, the adaptation of a former mine as an underground hazardous waste disposal site also has fifty-fifty chance of success. On the one hand, such projects face public opposition, but on the other hand, these facilities are in demand. In Poland, there are several mines, which would meet the technical criteria for such adaptation.

Adaptation scenarios for which PSS is below 0.5 are doomed to failure. For example, the graph shows that the most abject failure (given Polish conditions) can be expected when a former mine is to be adapted as a disposal site for slightly or moderately radioactive underground waste. Such a poor assessment of the scenario is largely due to public opposition. Failure is also to be expected from small underground mines, which are to be adapted as tourist facilities. The detailed analysis showed that the costs of such undertakings would be higher than the possible income.

Summary

This article discussed the original protocol called SWOT-AHP-PSS. It explored how the protocol works and how it could be used. What is innovative about this approach is the combination of methods that are commonly known, but have never been used together. SWOT-AHP-PSS can be used for strategic analysis and decision-making to select from n variants. This protocol assesses the probability of success for each of the pre-defined scenarios, and helps identify the key factors behind PSS. It can be useful for both simple and very complex decision-making.

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Autorska, heurystyczna metoda doboru strategii planowania w kontekście doboru sposobu zagospodarowania wyeksploatowanych wyrobisk kopalń podziemnych

Planowanie i analiza strategiczna często wymagają dokonania wyborów opartych na logicznych podstawach. Takie podejmowanie decyzji strategicznych jest trudne, ponieważ obejmuje wiele zmiennych, zarówno mierzalnych, jak i niemierzalnych. Często należy dokonać wyboru jednego z wielu wariantów. Może być trudno określić, które z nich są najlepsze i dlaczego.
W niniejszym artykule opisano autorską metodę SWOT-AHP-PSS, jako innowacyjne podejście opracowane w celu wspierania procesu decyzyjnego w ramach planowania strategicznego. Nowością w tej metodzie jest oryginalna kombinacja powszechnie znanych i używanych metod. SWOT-AHP-PSS ocenia prawdopodobieństwo sukcesu każdego z predefiniowanych scenariuszy i pomaga zidentyfikować kluczowe czynniki stojące za prawdopodobieństwem sukcesu strategicznego. Metoda ta może być przydatna zarówno do prostego, jak i bardzo złożonego procesu decyzyjnego.

Słowa kluczowe: heurystyczne metody doboru strategii postępowania, SWOT, Analytic Hierarchy Process, atrakcyjność rynkowa, pozycja rynkowa, prawdopodobieństwo sukcesu strategicznego