Application of Artificial Intelligence Methods for Analysis of Material and Non-material Determinants of Functioning of Young Europeans in Times of Crisis in the Eurozone

Gawlik, Remigiusz

Cracow University of Economics, Poland

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Remigiusz GAWLIK
Cracow University of Economics

APPLICATION OF ARTIFICIAL INTELLIGENCE METHODS FOR ANALYSIS OF MATERIAL AND NON-MATERIAL DETERMINANTS OF FUNCTIONING OF YOUNG EUROPEANS IN TIMES OF CRISIS IN THE EUROZONE

INTRODUCTION

The study presents an analysis of possible applications of artificial intelligence methods for understanding, structuring and supporting the decision-making processes of European Youth in times of crisis in the Eurozone. Its main purpose is selecting a research method suitable for grasping and explaining the relations between social, economic and psychological premises when taking important life decisions by young Europeans at the beginning of their adult life.

The interdisciplinary approach to science, assuming inclusion of economic phenomena in the analysis of issues belonging to other domains of science, contributes to further development of economics. Thus, the foundations of the economy are being redefined, whereas the dogma of rationality of consumer behaviour no longer binds. The researchers depart from their former deliberations on mass production , they also no longer claim that they understand the character of consumers' preferences. The increased interest of economists in research instruments which employ artificial intelligence encourages them to use mathematical and IT tools to explain decision-making processes. This group of methods, based on fuzzy logic methodology offers the possibility of including into their research factors of a qualitative character (in addition to quantitative ones).

It is equally important to identify possible fields of implementation of the results of qualitative – quantitative analysis in economic and social practice. A benefit for the business could be the possibility of better adjustments to new trends and consumers' preferences. Social effects of the implementation should stem from supporting decision-making processes until facilitating professional and personal development of young people. Broadening of knowledge in this sphere will allow the responders to perform individual valuation of the material and non-material determinants of the quality of their life, which will eventually contribute to the growth of their life satisfaction. It will indirectly contribute to the increase of the overall level of satisfaction in the society.

1. DESCRIPTION OF RESEARCH SAMPLE

The target group of the analysis are young Europeans receiving education or training, those newly employed or counted among the NEET (*not in Education, Employment or, Training*) group (classified according to the definition of the International Labour Organization)[1]. The quoted report reveals worrying changes of a non-linear character which the young Europeans have been undergoing in recent years. According to the OECD data (2010), in 34 countries belonging to this organisation in 2008-2010, an increase of the average indicator of the number of NEET from 10,8% to 12,5% may be observed, with a significant growth tendency. At the same time, the analysis of employment ratios, such as the changes in unemployment of young people in time, the rate of unemployment among persons under 34 in comparison with the rate of unemployment among older employees, frequency of long-term unemployment among young people, percentage of NEETs in the whole population of young people in a given area, the age of getting one's first job and the length of the interim period between leaving school and getting a permanent job, or the first employment, shows a deteriorating situation for young Europeans[2].

The direct effect is a decrease of motivation and professional aspirations in the surveyed group, which, in connection with extension of the time of financial dependency on parents, produces wide-ranging social implications. Among them we may list an inability to support oneself, which delays the moment of getting married and starting a family, a drop of the consumers' purchasing power, problems with accessibility of qualified workers, a growing number of people unadjusted to the requirements of the labour market, etc. The target group of the research is characterized by growing level of concerns about maintaining their previous quality of life. The responders of the survey conducted among students from seven European countries, indicated two types of factors influencing the quality of life: material and non-material. Concerns about maintaining one's way of life concerned both. They referred to a small starting salary, the excessive burden of paying off student loans, the risk connected with self-employment, growing costs of living, decreasing income, uncertainty of a return on investments, problems with building up any savings and expected low retirement funds. The concerns over non-material determinants of life quality related to a

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[1]Report V: *The youth employment crisis: Time for action*, International Labour Organization, Geneva 2012, p. 17.

[2]*ibidem*, s. 18.

limited number of jobs, instability of work, being forced to work below one's qualifications, difficulty of harmonizing work with one's personal life, fear about the future, discomfort associated with a need to remain mobile, keeping friends, being away from the family and acquaintances, a boring or low paid job, information chaos and uncertainty about the social usefulness of one's occupation. The responders mentioned also disappointment at lack of direct connection between academic grades and professional prospects, and the incompatibility between the labour market and the opportunities of educational systems[3].

The area of the present research are decision-making processes determining the subjective level of satisfaction of young people. The elaboration of a general model of interdependencies between development alternatives, feelings and the environment of young Europeans, and their level of life satisfaction, should allow us to understand the principles determining a more effective allocation of resources at the stage of widely defined preparation of young people to independent functioning in the society. Resources here signify all of the upbringing, health care and educational effort "invested" in young people in order to help them find balance between their needs and aspirations, and the advantages for the society.

Thus, the principal research hypothesis assumes that: "sufficiently early identification of an individual hierarchy of values, considering material and non-material determinants of the quality of human life, constitutes the basis for conscious, rational career decision-making". For young people it provides a stable foundation for making life decisions and hence stimulates their personal and professional development and consequently increases the probability of obtaining equilibrium between all spheres of life, increasing satisfaction and the effectiveness of undertaken actions.

Upon completion of the obligatory education, young people are confronted with the choice of a further path of development. Some decide to continue studies at the university level, others prefer to complete vocational training, take practical courses and get certificates. Some decide to start working to earn their living, whereas others give up any professional career before they have even taken their first job. The complexity of the problem increases when we realise that the effects of decision-making process in the professional area has an impact on the private lives of decision makers. This dependence works in the opposite direction, too. Direct interviews with young Europeans prove that these decisions are not always conscious, following thoughtful reflection or an analysis of chances, gains, threats and costs. An additional difficulty is an overabundance of available information, which generates overwhelming information noise. In the discussed case it is by no means an advantage. It does

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[3]Gawlik, R., Kopeć, M. (red.), *Socio – Economic Implications of Global Economic Crises for European Youth. Summary Brochure,* EU DG Education and Culture, Erasmus Lifelong Learning Programme, Intensive Programme 2012. 2012-1-PL-ERA10-29001. Krakow University of Economics, Kraków 2012.

not increase the probability of arriving at possibly optimal final decisions[4]. An important cognitive value of the presented survey is the understanding of the nature of choices and establishing relations between the determinants that are taken into account by young people during early career decision-making. Namely these will be the condition of the decision environment, considered choice alternatives, and the final selection of one's individual way of personal and professional development.

Summing up, we may conclude that the target research group of the analysis are young Europeans whose socio-economic environment undergoes changes of a dynamic character. In effect, the development opportunities offered by the existing system of education and the state institutions become more and more limited. This forces young people to search for alternative strategies of survival, including adjustment, more intensive professional development, focusing on personal development, or adopting escapist strategies[5]. To become successful, they take part in numerous simultaneous, apparently unrelated decision-making processes, the determinants of which have one common feature – non-linearity and a fuzzy structure. This, in turn, confirms the purposefulness and the necessity to search for new tools for modelling these processes in turbulent environments.

2. THE NATURE OF DECISION-MAKING PROCESSES

The way humans make decisions can be compared to the functioning of a black box. The researcher may analyse the data at the input and output of the model, whereas the mechanism of processing the information remains out of the scope of his/her interest. The problem of making important life decisions may be viewed similarly. Instead of focusing on understanding the mechanism governing the decision-making process, the researcher should concentrate on factors shaping the environment in which the decision maker functions, and the individual determinants of the process. Hence, a research methodology aimed at creating a general model describing the processes of decision-making by young Europeans starting their professional career should contain an analysis of the individual preferences of each responder in feedback with its results.

The decision-making process consists of the following stages: "... *planning, generating alternatives, setting priorities, selection of the best strategy after several alternatives have been considered, allocation of assets, defining requirements, forecasting*

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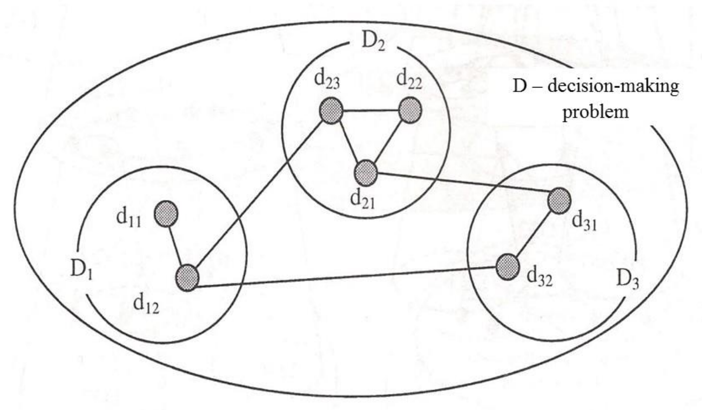
[4]Gawlik, R., Kopeć, M. (red.), *op. cit.*
[5]*ibidem.*

results, projecting systems, measuring efficiency, providing stability to the system, the optimizing and resolution of conflicts""[6].

Multi-criteria decision-making problems, like the one analysed here, can be divided into three types of structure: single-layer, hierarchical and fuzzy[7].

Chart 1: Decision-making problem with a single-layer structure



Source: Ostrowska, T., *Modelowanie sieciowych procesów decyzyjnych techniką AIDA*, "Komputerowo zintegrowane zarządzanie", Tom II, R. Knosala (ed.), Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2007, p. 171.

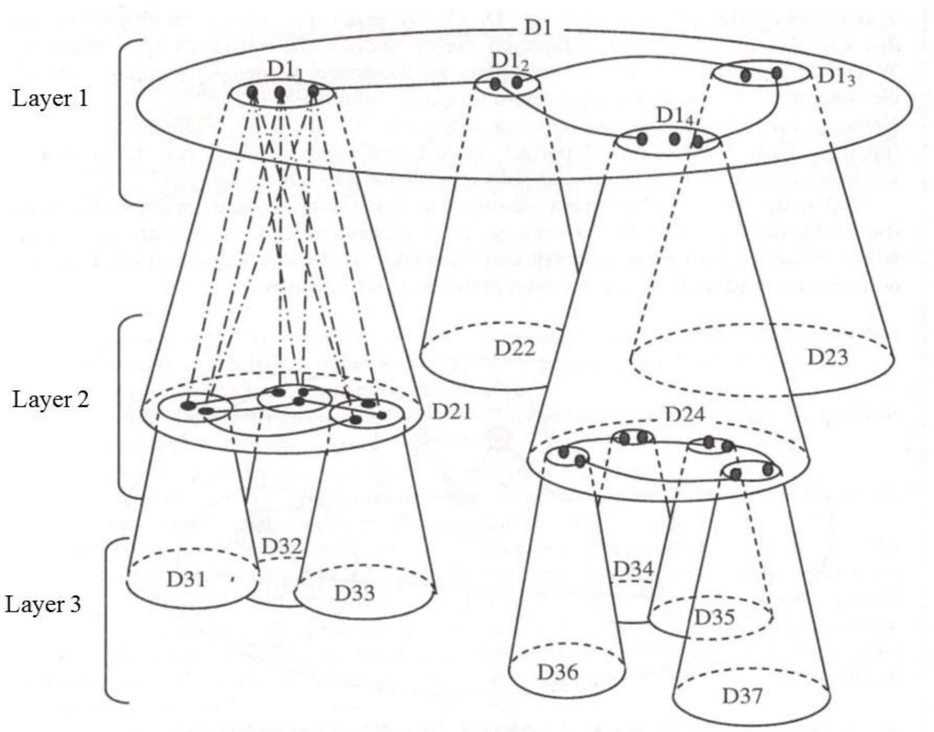
Chart 1 presents a scheme of a typical decision-making problem with a single-layer structure. D_i are the decision areas, and d_{ij} are the elementary decisions in the individual areas which eliminate each other within a single area. T. Ostrowska states that "*a decision-making system is a single-layer (flat) system when the decision-making problem is a close problem, which means that in the model of the process we consider only the relations of mutual elimination of the elementary decisions in the decision areas and between them, without considering relations with other decision-making problems*"[8]. This structure is not adequate in the analysed research task for several reasons. Firstly, in case of decisions made by young people at the onset of their adult life, one can clearly see that the decisions are made simultaneously in several spheres of life, hence there are mutual relations among decision-making problems. Moreover, these dependencies will weigh upon the quality of final

[6]Saaty, T.L., *The Analytic Hierarchy Process*, RWS Publications, Pittsburgh 1996, s. 5.
[7]Ostrowska, T.M., *Modelowanie sieciowych procesów decyzyjnych techniką AIDA*, „Komputerowo zintegrowane zarządzanie", Tom II, R. Knosala (ed.), Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2007, p. 171.
[8]*ibidem,* p. 171

decision. Thus, *the* system cannot be a single-layer one. Secondly, at this stage of research it is difficult to determine with certainty if the choice alternatives (d_{ij}) within a single decision area (D_i) necessarily have to eliminate each other. Thirdly, we may not dismiss the possibility that elimination of an elementary decision within one set will create the possibility to arrive at another elementary decision within another set (e.g. a decision on giving up work directly after studies may open a possibility to travel personal development**).**

Chart 2 presents the scheme of a decision-making problem of a hierarchical structure.

Chart 2: Decision-making problem with a hierarchical structure



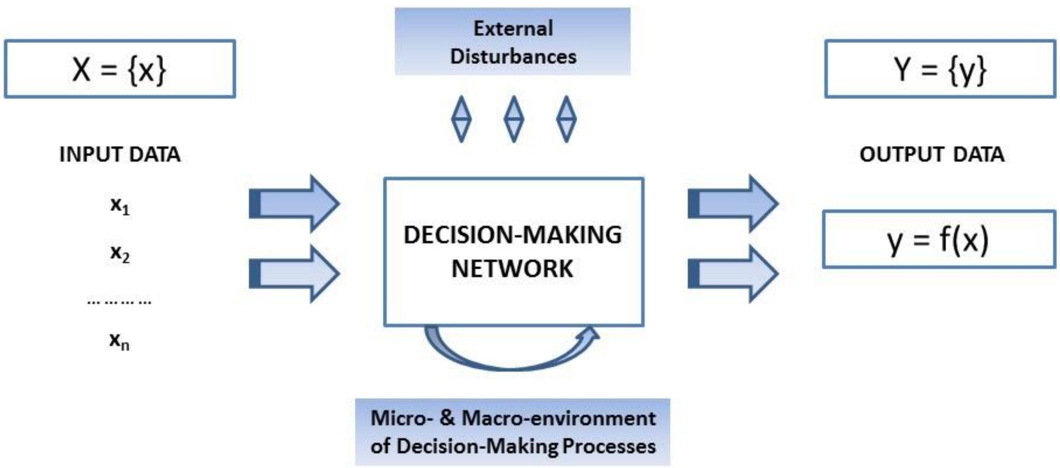
Source: Ostrowska, T., *Modelowanie sieciowych procesów decyzyjnych techniką AIDA*, „Komputerowo zintegrowane zarządzanie", Tom II, R. Knosala (ed.), Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2007, p. 171.

According to T. Krupa and T. Ostrowska "*the hierarchical structure of a decision-making process is characterized by layered placement of decision-making problems*"[9]. In systems of this type we may observe an interdependence among elementary decisions of higher layers D_{ij}, and the decision-making problems in the lower decision zones D_i. Only having considered all of the elementary decisions of the lower decision area, is one capable of making decisions at a higher level. This concerns every decision-making problem in a given area. The hierarchical structures require the employment of proper methods. The most important ones are presented in the next chapter of this chapter.

[9]Krupa, T., Ostrowska, T., *Model procesu decyzyjnego w systemie hierarchicznym*, „Komputerowo Zintegrowane Zarządzanie", Tom II, R. Knosala (ed.), WNT, Warszawa 2001, p. 8.

Decision-making problems with a fuzzy structure, also called network problems, are dependent upon the character of relations and interdependencies between individual agents of the system. It may be the cooperation (coordination) or rivalry (competition). These relations differ in their way of transferring information between individual elements of the system. Cooperation determines open transfer of information, thanks to which, every agent has similar knowledge, while rivalry leads to information disproportions during decision-making. The common element for both forms is non-linearity and discontinuity of the decision-making processes, the turbulence of the decision maker's environment, and continuous invalidity of earlier decisions. This encourages us to model decision-making problems with fuzzy structure using the mathematical instrumentarium adopted from technical sciences, namely artificial intelligence methods and more specifically neural networks. The general scheme of such a model is presented on Chart 3:

Chart 3: Research problem with a fuzzy structure



Source: own analysis based on Gawlik, R., *The Influence of Intergovernmental Organizations on Main Determinants of the Open Systems Model with Correlation Analysis Method Application*, "Organizations in Changing Environment. Current Problems, Concepts and Methods of Management", W. M. Grudzewski, I. Hejduk, S. Trzcieliński (ed.), IEA Press, Madison, WI, USA 2007, p. 90 – 102.

3. INTRODUCTION TO ARTIFICIAL INTELLIGENCE METHODOLOGY

In economic sciences the application of artificial intelligence methods, especially those based on fuzzy logic, is an innovative approach. However, limiting the description of the socio-economic reality exclusively to its quantitative determinants does not allow to adequately reflect the complex character of analysed phenomena. It is necessary to apply methods that would include the qualitative elements into led research. Only a complex approach, combining both types of determinants of the environment gives a chance to significantly expand this branch of knowledge. Thus, employment of mathematical instruments to analyse economic phenomena is justified. Application of such an apparatus for investigating socio-economic phenomena offers an opportunity to make a valuable contribution to economic research. This chapter is devoted to potential advantages and problems connected with use of artificial intelligence methods for these purposes. The presentation will include hierarchical structures and artificial neural networks. Due to their character, the single-layer structures will be ignored as the cases overly simplify analysed phenomena.

Among research methods useful for modelling of decision-making processes of a hierarchical structure, M. Dytczak and T. J. Wojtkiewicz list the Zero Unitarisation method, the Dematel method, Wroclaw taxonomy, Analytic Hierarchy Process and Analytic Network Process.[10]. P. Góralski and S. Pietrzak describe the Zero Unitarisation methods as "*one of the methods making possible standardization of the diagnostic variables by evaluation of the gap of an attribute. It is a universal method and may be used for standardization of various variables independent of their type, sign, size, unit"*[11]. Y. Yang, S. Shieh, J. Leu and G. Tzeng present the Dematel method as a tool for analysing and forming cause-effect relations among the criteria of evaluation[12], while Lin and Tzeng use it to construct the schemes of dependencies among gauges[13]. A. Ćwiąkała - Małys and W. Nowak maintain that "*the*

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[10]M. Dytczak, T. J. Wojtkiewicz, *Metody wielokryterialnego wyboru systemów monitorowania*, „Komputerowo zintegrowane zarządzanie", Tom I, R. Knosala (red.), Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2010, p. 398.

[11]Góralski, P., Pietrzak, S., *Ocena ryzyka kontynuacji działalności gospodarczej spółek ANR w aspekcie ich strategiczności oraz specyficznej funkcji rynkowej*, „Zeszyty Naukowe Uniwersytetu Szczecińskiego: Finanse, rynki finansowe, ubezpieczenia", no 47 (686), Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin 2011, p. 63.

[12]Yang, Y.P., Shieh, H.M., Leu, J.D. and Tzeng, G.H., *A novel hybrid MCDM model combined with DEMATEL and ANP with applications*. "International Journal of Operational Research", 5(3), 2008, p. 160 – 168.

[13]Lin, C. L. and Tzeng, G. H. *A value-created system of science (technology) park by using DEMETEL*. "Expert Systems with Applications", 36, 2009, p. 9683 – 9697.

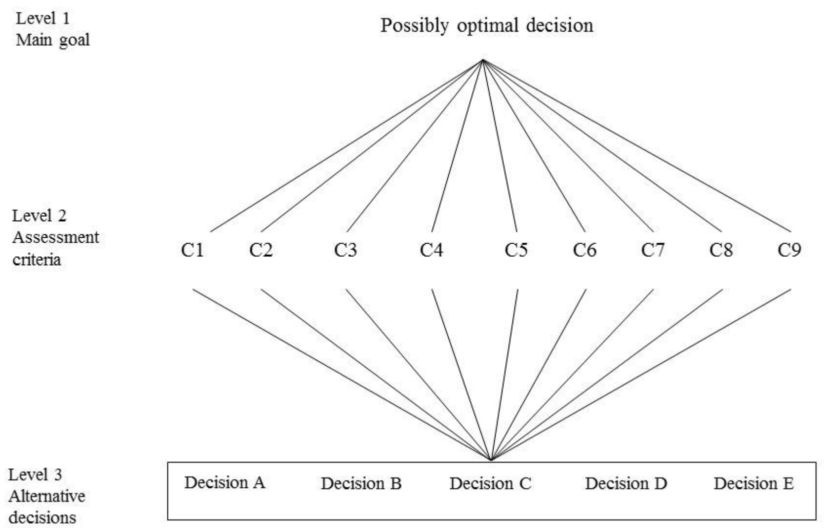
Wroclaw taxonomy (cluster analysis) is an analytical method used successfully for combining objects (variables) into groups which are uniform with respect to n-attributes (dimensions)"[14].

The methods listed above are useful only at some stages of construction of multi-criteria decision-making models. They do not provide a full picture of hierarchical decision structures, since each of them contains too many limitations, none of them can serve as the exclusive research method. On the other hand, the Analytic Hierarchy Process method may be used for modelling of multi-criteria decision-making problems in a more comprehensive way.

The Analytic Hierarchy Process (AHP) is a tool supporting decision-making accompanied by high uncertainty. Its employment seems most justified in situations when the decision maker faces a decision-making problem of extraordinary complexity. The AHP method may be used exclusively in cases when the structure of the problem may be presented in a hierarchical form, and the elements positioned higher in the hierarchy do not interact or influence other elements at the lower levels of the decision ladder. The Analytic Hierarchy Process should be taken into consideration wherever the optimum solution is selected from among many variants based on a set of subjective criteria (e.g. an important life decision) [15].

Chart 4 presents the levels of analysis of the decision-making problems in the AHP.

Chart 4: Decision-making with use of AHP method



[14]Ćwiąkała - Małys, A., Nowak, W., *Zarys metodologiczny analizy finansowej*, Wydawnictwo Uniwersytetu Wrocławskiego, Wrocław 2005, p. 58 – 65.

[15]Saaty, T.L., *Decision-Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*, 3rd Ed., RWS Publications, Pittsburgh 2000.

Source: own analysis based on Saaty, T.L., *The Analytic Hierarchy Process*, RWS Publications, Pittsburgh 1996.

They are reflected in the construction of the AHP method which can be divided into:

- the main goal level – the desired effect which should be produced by the analysed decision-making process;
- criteria and sub-criteria level, together with their determinants – is used for evaluation of the validity of the influence of the individual determinants of the process;
- decision alternatives – accessible choices which to various degrees bring the decision maker closer to arriving at the optimum decision for achieving the main goal[16]. Consecutive stages of method application were presented in other publications of the author[17].

If creation of a hierarchy of equivalent criteria proves difficult, then one should apply the Analytic Network Process method (ANP). ANP is not restricted by so many limitations and should be understood as supplementation of AHP for fuzzy decision-making problems. The principal advantage of ANP is the fact that it allows us to analyse how the individual factors influencing the process of decision-making interrelate (with one another), whereas AHP allows us to investigate the influence exclusively based on comparisons in pairs[18]. Thus, the quoted claim by M. Dytczak and T.J. Wojtkiewicz on the self-justifying application of the ANP method for analysing decision-making problems of a hierarchical structure, should be questioned.

The essence of the decision network is the fact that all of the components interact. Not only the elements constituting the network are considered, but also the relations among them, since these may have an impact on the effect of the decision-making process. Within a single network or sub-network, the elements are grouped in sets defined for each control criterion of the sub-system. Similarly to the AHP method, in ANP method expert evaluations are made, i.e. all combinations of relations between the elements and the groups are evaluated. Next, within every control subsystem, the results are synthesised considering advantages, costs,

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[16]Saaty, T.L., *The Analytic Hierarchy Process*, RWS Publications, Pittsburgh 1996, p. 5 – 6.

[17]Gawlik, R.,*The Influence of Intergovernmental Organizations on Main Determinants of the Open Systems Model with Correlation Analysis Method Application*, "Organizations in Changing Environment. Current Problems, Concepts and Methods of Management", W. M. Grudzewski, I. Hejduk, S. Trzecieliński (eds), IEA Press, Madison, WI, USA 2007, p. 90 – 102.

Gawlik, R., Teczke, J.,*The Influence of Non-Governmental Organizations on Main Determinants of the Open Systems Model with Application of the Correlation Analysis Method.* "Achieving Competitive Advantage Through Managing Global Resources". Fuxman, L., Delener, N., Elifoglu, H., Wankel, Ch., Abel, I. (eds.). New York: Global Business and Technology Association, New York, NY 2007, p. 728 – 735.

[18]Saaty, T.L., *The Analytic Network Process: Decision Making With Dependence and Feedback*., 2nd Ed., RWS Publications, Pittsburgh 2001.

chances and risk[19]. The next stage of synthesis is combining evaluations of all of the control sub-systems by means of multiplier (marginal) synthesis or additive synthesis[20].

The mathematical foundations of the ANP method are identical to those of AHP (basic scale of comparison, pair-wise comparison matrix, coherence test). It is necessary, however, to complement it by evaluation of the mutual influence of the criteria of level h_1 on an element of a different level h_n[21]. The effect of carrying out all coupled comparisons is the creation of vectors of priorities $W = (w_1, \dots w_n)$, which constitute columns of the supermatrix of the decision network. The number of levels C_h is: $h = \{ 1, 2, \dots n \}$. The number of elements at each level equals n_h and forms a set $E = \{ e_{h1}, e_{h2}, \dots e_{hh}\}$. If a given element does not influence another element, then its priority equals 0. A sample supermatrix of a decision-making matrix is presented below [22]:

$$W = \begin{array}{c} C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \overset{\begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array}}{\begin{bmatrix} W_{11} & W_{12} & \dots & W_{1n} \\ W_{21} & W_{22} & \dots & W_{2n} \\ \vdots & \vdots & \dots & \vdots \\ W_{n1} & W_{n2} & \dots & W_{nn} \end{bmatrix}}$$

Another supplementation of the AHP method which appears in the ANP is a hierarchy or a control network, which in the case of decision-making problems of economic nature consists, in most cases, of the following sub-systems: advantages – B, costs – C, chances – O, and risk R[23]. A complete analysis of the fuzzy decision-making process by means of the ANP method comprises 12 steps, which has been described in detail author's another publication[24].

Summing up, the ANP method constitutes a connection between modelling of the decision-making problems of a transparent hierarchy of criteria, and those of a fuzzy structure. The observed convergence stems from the common mathematical-logical base of the AHP and ANP.

R. Tadeusiewicz claims that the "*neural networks are a very refined technique of modelling, capable of reflecting extremely complex functions. In particular, neural networks are of a non-linear character, which significantly enriches the scope of their possible*

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[19]Motyka, S., *op. cit.*

[20]Zoffer, J., Bahurmoz, A., Hamid, M.K., Minutolo, M., Saaty, T.L., *Synthesis of Complex Criteria Decision Making: A Case Towards a Consensus Agreement for a Middle East Conflict Resolution*, "Group Decision and Negotiation", Vol. 17, No. 5, p. 363 – 385.

[21]Motyka, S., *Ocena skuteczności wprowadzania innowacji technicznych w przedsiębiorstwach przemysłu maszynowego*, doctoral dissertation, supervisor prof. zw. dr hab. inż. J. Gawlik, Politechnika Krakowska, Kraków 2007.

[22]Saaty, T.L., 2001, *op. cit.*

[23]*ibidem*

[24]Gawlik, R., *Zastosowanie metody Analitycznego Procesu Sieciowego do wspierania racjonalnych wyborów młodych Europejczyków*. „Unia Europejska w 10 lat po największym rozszerzeniu", Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, Poznań 2014 [w druku].

applications"[25]. At the same time, he points out that the human brain is a prototype of a research tool, being the artificial neural networks. The core of the method is a set of connections among neurons and synapses. The scholar states also that "*a neuron usually has an elaborate structure of multiple input gates (dendrites), combining signals form all of the body's inputs (perycaryon) and a carrier of output information leaving the cell as a single fiber (axon), multiplying then the effect of the neuron's work, which it is transmitting, and sending to numerous reception neurons via an intricate output structure (telodendron)*"[26]. The connections by which the axons communicate between the cells are synapses (filled with a neurotransmitter). Their role is not only transmission, but also modification of the conveyed signals and collecting data. In the artificial neural networks, the role of synapses boils down to multiplication of the input signals by assessment of the importance of their influence (weight), which are determined in the process of learning of the network. In application for analysing of the Multi-criteria decision models, it is the ability of self-teaching that determines the immense potential of neural networks. Equally important are possibilities of transmitting a signal from one synapse to many neurons simultaneously, and setting threshold levels for activating a given neuron. The former property reflects the complexity of simultaneous connections and feedback within one network; the latter prevents taking into consideration implications of criteria or markers of minor importance. Both constitute an incalculable value for the proposed research task.

In artificial neural networks "*the level of stimulation of a neuron is in fact nothing more than a linear function of the input values. The value of combined stimulation determined in such a way is modified by a sigmoid (S-shaped) function in order to define the neuron's response*"[27]. The network's response, called a "sigmoid cliff" is a plane of results of the first layer of the multi-layer perceptron and results from a juxtaposition of the above mentioned multilayer linear function and the single-layer sigmoid function. Learning of the consecutive layers of the multilayer perception is done by means of the values of orientation of the plane (cliff), its positioning in the coordinate system and the angle of inclination. These changes come from the changes of input weights and values of the threshold (border) parameters which is facilitated by modern calculating equipment – computers. R. Tadeusiewicz points out that the "*steep walls of the sigmoid 'cliff' correspond to high values of the weights*". This model, characteristic for a single neuron (in the case of the problem under scrutiny – a decision criterion) is copied for other layers of the network, which generates a multi-layer

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[25]Tadeusiewicz, R., *Wstęp do sieci neuronowych*. „Biocybernetyka i inżynieria biomedyczna 2000", M. Nałęcz (ed.), Tom 6: Sieci Neuronowe, W. Duch, J. Korbicz, L. Rutkowski, R. Tadeusiewicz (Vol. ed.), Akademicka Oficyna Wydawnicza Exit, Warszawa 2000, p. 4.
[26]*ibidem*, p. 10.
[27]*ibidem*, p. 23.

network[28] (here – a multi-criteria decision model). Graphically it is symbolised by a surface of a complex shape, consisting of terraces located higher and lower, inclined towards each other at various angles and connected by slopes of diversified steepness.

The process of learning of the network becomes possible only after defining the task which the network needs to learn, and the environment in which it is going to happen. This is achieved by assuming desirable and undesirable border conditions. In other terms, one may define which state of the network (the arrangement of terraces and slopes among them) is ideal, and which is unacceptable from the perspective of the decision-maker. The process of self-teaching of the network begins from a test of its natural preferences (accidental values of the neurons' weights are selected). Next, the proper process of self-teaching commences. The network's environmental conditions are changed many times by random adoption of values of the individual weights of the neurons. In effect of each *n-th* change the network reacts accordingly to its present knowledge, i.e. that obtained in the *(n-1)-th* round. The process continues until the moment when the predefined number of iterations has been reached (usually from several dozen to several hundred). Then, examination of the network takes place: the model has to provide the scores for all of the learned combinations. In practice, most often it is presented in the form of a monochromatic map of results, on which the extreme values are symbolised by black and white, whereas the intermediate values by various shades of grey[29].

4. ARTIFICIAL INTELLIGENCE METHODS AND THE RESEARCH PROBLEM

The character of the research problem suggests that the applicability of Zero Unitarisation, Dematel and Wroclaw taxonomy methods, is quite limited for the analysis of the multi-criteria decision-making processes referring to European Youth in times of post-crisis uncertainty. The diversity and variety of the criteria implies rather the necessity to use more advanced methods, making possible a simultaneous anticipation of a larger number of determinants of the decision-making process, such as the *Analytic Hierarchy Process* or the *Analytic Network Process*. In practice, in the modelling of discontinuous phenomena of little repeatability and predictability, the ANP method is most commonly applied as a supplement of the AHP method. Since the complexity of the ANP method is significantly higher than that of the AHP method, in each case it is worthwhile to determine whether expansion of the

[28] *ibidem*, p. 23.
[29] *ibidem*, p. 20 – 28.

analytical apparatus by the elements of sub-criteria and a supermatrix of the decision network is justified, the more so that an available alternative is neural networks.

Application of AHP and ANP is effective in case of a preliminary analysis of correlations between input and output variables, when trying to reveal possible hierarchical relations. Then one should answer the question: *what hierarchy of input data determines the occurrence of desirable output data?* However, since the decision-making process directed at increasing life satisfaction of the objects of the analysis is of a permanently discontinuous character (due to a turbulent decision environment), neural networks should be considered for elaboration of a general model.

The feature which suggests that artificial intelligence might become useful, and in particular the neural networks may be used for modelling decision-making processes among young people at the beginning of their professional career, is non-linearity of the analysed phenomena. The economists who employ the mathematical apparatus in their research are used to describing the world by means of linear modelling. In most cases this approach is rather justified, as the character of many economic phenomena is linear. Formulating prognoses concerning trends based on the preceding periods is thus made easier. Moreover, linear models may be easily optimised. Hence, it is relatively easy to analyse the impact of the input data on the desired output parameters. However, a linear description is a considerable simplification of the reality, in particular in the circumstances when we may observe a shortening of the trends' timeframes, accompanied by an accelerating course of events. In effect, the input data employed by the linear models get denser, thus, the probability of presenting an accurate prognosis decreases. Moreover, the prognosis would refer to a shorter period in the future. R. Tadeusiewicz remarks that "*the fastest and the easiest way to resolve these difficult and troublesome problems may be employment of the models created based on the neural networks (i.e. the models which without difficulty are capable of reflecting non-linear dependencies)*"[30].

The undeniable advantage of artificial neural networks is the ease of their application. We may assume that the models of non-linear relations, which describe the analysed phenomena, may be created with a relatively small engagement of the researcher. The network learns the mechanism of investigated dependencies on its own, by processing data, based on the input information and the type of network selected by the researcher. This is a consequence of the character of the method in question, which focuses the researcher's attention only on the interconnections among the input and output data in the model. The mechanism of generating results is no longer the researcher's concern. It is a great

[30]Tadeusiewicz, R., *op.cit.* p. 4

convenience, and at the same it shortens the time necessary for the preparation and execution of the whole research process.

An argument supporting employment of artificial intelligence for analysing socio-economic phenomena is the fact that other branches of science make use of this group of methods. We may mention technical sciences, biomedicine, biotechnology, physics, and others. R. Tadeusiewicz claims that "*it would be very difficult now to indicate at least one domain of science in which the network has not been used yet*"[31]. On the other hand, one can hardly ignore the fact that apart from the sphere of finance, economists are rather reluctant to use these tools as well as the mathematical support of decision-making processes, such as i.e. the Analytic Hierarchy Process. Hence, we should take the opportunity to turn the researchers' attention to innovative possibilities offered by the discussed group of research methods.

CONCLUSIONS

Recapitulating, we may state that for modelling of decision-making problems of a hierarchic structure, it makes sense to employ the Analytic Hierarchy Process. On the other hand, wherever it is hard to grasp a hierarchy of the decision criteria, it may be worthwhile to consider the application of Analytic Network Process. Whenever multiple criteria are not viewed as the only, key characteristic of the decision-making system, artificial neural networks might be used successfully. Their biggest value lies in the possibility of programming the network and its ability to learn, as well as being able to analyse multiple links and connections among the decision criteria simultaneously.

We should highlight the fact that the necessary, but not necessarily sufficient condition for success of application of artificial intelligence methods is a particular care at the stage of observation of the phenomena to be analysed. Obtaining results which accurately reflect the reality depends on proper selection of the input data for the model. Equally important is the choice of the type of neural network, which has to be adequate for the character of the phenomenon under scrutiny. Only a combination of these two conditions may open for a real possibility of applying the methods of artificial intelligence for investigation of socio-economic phenomena.

[31] *ibidem*, p. 6

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