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Neuro Multiple Criteria Analysis System for University-Industry Partnerships

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Abstract

The EU RTD stresses the Europe 2020 objective that it "aims to support the development of a strong and sustainable industrial base able to innovate and compete globally". University-industry partnerships should be sustained for inspiring up-to-date RTD, and industry-driven antecedences should be reinforced. The positioning by these authors had a solid accent on university-industry partnerships over the entire course of the ASCENT project to increase societal resilience to disasters. Collaboration appointments can appear in numerous forms and dimensions (career fairs, business advisors and affiliates, placements, conferences and meetings, project and university initiative support, program improvement, scholar fellowships, joint life cycle collaboration, RTD projects and product/service development). The forms and stages of partnership will fluctuate depending on the micro-, meso- and macro-levels of the environment. A founder of behavioral economics, Nobel Prize laureate Daniel Kahneman, asserts that two categories describe our thinking: fast thinking (first system) and slow thinking (second system). The foundation of the first system consists of emotions, impulses and exaggerated optimism. The first system does not require any great efforts; it operates practically automatically. Meanwhile the second thinking system is slow and analytical with an ability to control behavior and thoughts. Based on this idea, the author of this article developed the Neuro Multiple Criteria Analysis System for University-Industry Partnerships.

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Keywords: University-Industry Partnerships, Multiple Criteria Analysis, Affective Computing, Neuro Decision Matrix

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1. Introduction

Lately these authors have been consistently making more efforts at rationalizing university-industry partnerships by considering the emotions and motivations of stakeholders. Positive as well negative emotions and motivations have an approximately equal effect on the efficiency of a university-industry partnership. Numerous scientists and practitioners have studied such a relation [1-9]. A brief analysis of this follows.

Scholars and practitioners [3-5, 8, 9] have analyzed the university-industry partnership through an emotional prism. For example, in the opinion held by [5], the best support for the requirements involved in the knowledge co-creation process at the multi-user Co-creation Centre for university–industry collaboration entails the place where individuals share feelings, emotions, experiences and mental models and the place where the knowledge-creation process begins. The main [5] findings are that the knowledge co-creation process requirements for university–industry collaboration at a Co-creation Centre are best where individuals share feelings, emotions and experiences. [10] compared the rankings of Turkish Universities obtained by the Scientific and Technological Research Council of Turkey's (TUBITAK) Entrepreneur and Innovative University Index (EIUI) with the rankings obtained by an analysis of the sentiments expressed in the social media messages by the related university's students, including graduate students. Sentiment analysis is the field of study that analyzes people's opinions, sentiments, attitudes and emotions on products, services, organizations, individuals, issues, events and topics. Sentiment analysis focuses on opinions expressing or implying positive or negative sentiments. [10] performed a sentiment analysis on the approximately 1,353,803 tweets of 57,321 followers from 50 universities of ranking interest thereby obtaining a new ranking of them. Later [10] conducted statistical tests on the compatibility of these two university rankings.

The university-industry partnership has also been deliberated from the perspectives of different emotions (trust, happiness and the like). [11] developed the wheel of emotions suggesting eight primary emotions grouped on a positive or negative basis: joy versus sadness, anger versus fear, trust versus disgust and surprise versus anticipation. [12] investigate how relational mechanisms facilitate trust formation in university–industry research collaborations (UICs) in three countries and contribute to the understanding of international similarities and differences in UICs by considering institutional factors, specifically, the strength and maturity of UICs in each country. The analysis of survey data from 618 recent UICs in the US, Japan and South Korea by [12] identifies the activities of innovation champions as serving like a critical trust building mechanism between firms and universities complementing initial trust formation through strength of contacts, partner reputation and contractual safeguards. [12] find that partner reputation and champion behavior are more important for trust formation in South Korea than in the U.S. and Japan indicating that, in "emerging UIC countries" where most firms and universities have little collaboration experience, reputation and the leadership by innovation champions are more important for trust formation in UICs than in "advanced UIC countries" with strong and mature UIC networks. The findings of [12] suggest, from a public policy perspective, that networks between firms and universities should be generally strengthened and collaboration partners should be provided with effective contractual safeguards to enhance trust formation among UICs. The clinical placement learning environment is a critical component of nursing education where Australian nursing students spend a minimum of 800 hours. Thus identifying components of successful clinical placements for undergraduate nursing students is therefore paramount. An assessment of nursing students' views of the learning environment during clinical placement with an emphasis on the pedagogical atmosphere reveals the importance of the leadership style of the ward manager and premises of nursing in the unit or ward. The study used Clinical Learning Environment, Supervision and a nursing teacher questionnaire to examine the perceptions of 150 final year undergraduate students in the clinical placement learning environment. Student nurses value a welcoming workplace, where staff and educators are happy to help and have a positive attitude to student presence at the wards [2]. [7] examine the dynamic nature of university–industry linkages (UIL). Thirty in-depth interviews conducted in Australia and Germany/the Netherlands provide evidence of the different phases through which UILs evolve and their respective measures of success. Communication, understanding, trust and people are universal drivers, yet managers must consider the variations in the nature of these factors to ensure successful UILs [7]. [7] study equips managers involved in technology transfer, innovation and commercialization with critical insights into developing effective relationships.

As stated by [13], motivation is the reason for people's actions, desires and needs and it is their direction for behavior, or what causes people to want to repeat a behavior. In line with [14], a motive is what prompts a person to act in a certain way, or at least develop an inclination for specific behavior. Emotion is often intertwined with mood, temperament, personality, disposition and motivation [15]. Emotion is often the driving force behind motivation, positive or negative [16]. According to other theories, emotions are not causal forces but simply syndromes of components, which might include motivation, feeling, behavior and physiological changes, but none of these components is an emotion. Nor is emotion an entity that causes these components [17]. Motivation and emotion are usually viewed as two psychological features that seemingly a share cause-and-effect relationship. Many psychologists believe that the link between motivation and emotion emerged due to three reasons. First, the arousal of emotion and motivation both activates or energizes behavior. Second, emotions often go together with motives. The common Latin root word of emotion and motivation, “movere” (to move) seems to imply the said reason. Third, it is typical for basic emotions to possess motivational properties of their own. For example, happiness motivates a person to achieve a better performance (explorable.com). A number of theories on psychology (approach motivation, avoidance motivation, achievement motivation, attribution theory) resiliently associate human motivation with emotions. There is a brief analysis of these theories. Approach motivation can be defined as when a certain behavior or reaction to a situation/environment is rewarded or results in a positive/desirable outcome. In contrast, avoidance motivation can be defined as when a certain behavior or reaction to a situation/environment is punished or results in a negative/undesirable outcome [13, 18]. Research suggests that, all else being equal, avoidance motivations tend to be more powerful than approach motivations. Because people expect losses to have more powerful emotional consequences than equal-size gains, they will take more risks to avoid a loss than to achieve a gain [18]. Achievement motivation is a drive that is developed from an emotional state. One may feel the drive to achieve by striving for success and avoiding failure. In achievement motivation, people would hope that they would excel in what they do and not think much about the failures or the negatives [19]. [20] applies the Attribution Theory and describes an individual's beliefs about how the causes of success or failure affect their emotions and motivations.

[1] investigate university-industry (U-I) innovation collaboration and propose a renewed and empirically tested conceptual approach to analyze it. The main contribution of this study is twofold: an interdisciplinary approach for analyzing U-I collaboration using a multiple case-study research design and the explanation of relevant preconditions – individual rather than institutional levels of motivation and absorptive capacity – as critical aspects that determine the likelihood of the success or failure of such collaboration [1]. Where the challenge lies is in bridging the divide between the academic and industry communities. This will require a change of mindset on both sides. It will also require an adjustment to the way in which academics are rewarded and how they and their institutions perceive their role within the national economy. Universities should not be viewed as applied R&D centers. Their resources are best allocated to education and undertaking research that commercial organizations will not or cannot do. Useful collaborative alliances between universities and industry can be forged. The critical ingredients are effective communications and an appreciation by both parties of the limitations, strengths and motivations of the other [6].

There are substantial studies carried out on the connexion between emotions and resilience [21-26]. As per the report of [27], people who demonstrate resilience are people with an optimistic attitude and positive emotionality and are, by practice, able to balance negative emotions with positive ones effectively. In the opinion held by [25], feeling positive emotions during stressful experiences may have adaptive benefits in the coping process of the individual. According to [26], a positive emotionality aids in counteracting the physiological effects of negative emotions; it also facilitates adaptive coping, builds enduring social resources and increases personal well-being. The [25] study was done on positive emotions in trait-resilient individuals and the cardiovascular recovery rate following negative emotions felt by those individuals. [25] showed that trait-resilient individuals experiencing positive emotions had an acceleration in the speed in rebounding from cardiovascular activation initially generated by negative emotional arousal, i.e., heart rate and the like.

[28, 29] investigated the university-industry partnership continuum spanning five stages: awareness (career fairs, interviews), involvement (industry affiliates, advisory programs, research grants, internships, software grants), support (student consultants, hardware grants, curriculum development, workshops and seminars, student organization sponsorships, philanthropic support, guest speaking/lectures), sponsorship (university initiative sponsorships, undergraduate research program support, graduate fellowships, collaborative research programs, outreach programs, support for proposals for education) and strategic partner (executive sponsorships, joint partnerships, state education lobbying, major gifts, business development). This research has also applied such a university-industry partnership continuum.

The purpose for this research was to develop the Neuro Multiple Criteria Analysis Methodology and System for University-Industry Partnerships.

2. Methodology

A Methodology for a Neuro Multiple Criteria Analysis System for University-Industry Partnerships (SUP) was being developed step by step as follows:

Stage I. A best practice description is written-up on university-industry partnerships in different countries that includes:

- A system of criteria characterizing university-industry partnership efficiency as established by relevant literature and expert methods
- A description based on this system of criteria in conceptual (textual, graphical, numerical etc.) and quantitative forms on the present state of university-industry partnership in different countries

Stage II. A comparison and contrast of university-industry partnerships in different countries are performed that include:

- An identification of global development trends (general regularities) in university-industry partnership
- An identification of university-industry partnership differences between developed countries
- A determination of the pluses and minuses of these differences
- Establishment of the best university-industry partnership practice for the ASCENT project based on actual conditions
- An estimation of the deviation between the knowledge that stakeholders have about best practices worldwide and their practices-in-use
- An analysis of existing information, expert and decision support systems

Stage III. SUP was developed based on above analysis.

Stage IV. Some general recommendations based on SUP are developed on how to improve efficiency levels for stakeholders.

Stage V Certain recommendations are submitted based on SUP to stakeholders. Each general recommendation proposed in Stage III contains several specific alternatives.

Stage VI A multiple criteria analysis based on SUP is performed on the components of university-industry partnership, and the most efficient version of the life cycle of university-industry partnership is selected. Next, obtained compatible and rational components of one type of a university-industry partnership are joined into a full, university-industry partnership process.

3. Neuro Multiple Criteria Analysis System for University-Industry Partnerships

According to [30], the study of cognition has historically excluded emotion and focused on non-emotional processes (e.g., memory, attention, perception, action, problem solving and mental imagery). Therefore, the research of the neural basis of non-emotional and emotional processes emerged as two separate fields: cognitive neuroscience and affective neuroscience. The distinction between non-emotional and emotional processes is now thought to be largely artificial, since the two types of processes often involve overlapping neural and mental mechanisms [31]. The analysis of information systems used in university and industry partnerships, which were developed by researchers and practitioners from various countries, and the above Methodology helped this author to develop the Neuro Multiple Criteria Analysis System for University-Industry Partnerships of his own. The System developed by the author differs from others in the use of new, original, multiple criteria analysis methods [32-37] and the object of the investigation. Researchers from various countries involved in the analysis of a university-industry partnership life cycle and its components (awareness, involvement, support, sponsorship, strategic partner) who are also handling the problems of their design did not touch upon the research object defined by this author, i.e., the life cycle of a university-industry partnership, the parties interested in the project and the micro, meso and macro environmental factors as an integral entity.

A Neuro Multiple Criteria Analysis System for University-Industry Partnerships was developed based on an analysis of existing information along with expert and decision support systems. This was accomplished to determine the most efficient versions of university-industry partnerships. This System consists of an Equipment subsystem, database, database management system, model-base, model-base management system and user interface.

The use of the Equipment subsystem aims for an assessment of the emotional state of stakeholders. This subsystem consists of a full set of equipment that the System needs to analyze a viewer's nonverbal information and assess the neurobiological response to the alternatives the person is viewing. The set includes the Microsoft Emotion API and a video camera, the QA5 SDK, Mirametrix S2 Eye-Tracker, Flir Thermo Cam B2, Enobio Helmet, Voice Stress Analysis Subsystem, Omron InteliSence M2-Basic and Extech MO270 along with a wireless pulse oximeter, wireless body thermometer, wireless smart gluco-monitoring system and Polar heart sensor h3. The Equipment subsystem assists in acquiring a great deal of multimodal data. The Database stores such data, which are used henceforth for the calculations in the Model-base.

The following tables constitute the System database:

- Initial data tables that consider general facts about the university-industry partnership
- Data tables on university-industry linkages (pre-linkage [agreement to work together], establishment [contract], engagement [delivery of project], advancement [ongoing partnership] and latent phase [future projects]) containing the evolved, considered university-industry linkages
- Tables assessing university-industry partnership life cycle solutions containing quantitative and conceptual information about alternative university-industry partnership life cycle solutions
- Tables assessing traditional and holistic engagements of university-industry partnership alternatives covering awareness (career fairs, site tours, industry ambassadors), involvement (industry affiliates or advisors, small grants, internships, work experiences), support (industry mentors, curriculum development and support, professional development workshops, student sponsorships, guest speakers), sponsorships (education initiative sponsorship, large grants, outreach programs) and strategic partner (joint partnership, longer-term joint projects, whole-school level involvement)
- Tables in a multi-alternative design providing quantitative and conceptual information on the interconnection of the processes, their compatibility and possible combinations as well as data on a complex, multi-alternative design of a university-industry partnership
- Microsoft Emotion API Affective Database
- QA5 SDK Emotions Database

The use of a database management system was to design the structure of a database and perform its completion, storage, editing, navigation, searching, browsing etc.

The efficiency of a university-industry partnership alternative is often determined by taking into account quantitative and qualitative factors. Therefore a model-base of the System should include models enabling a decision maker to perform a comprehensive analysis of the alternatives available and thereby make an accurate choice. The aim of the following model-base models is to perform this function:

- model for establishing the criteria weights
- model for developing the Neuro decision matrix
- model for designing a university-industry partnership employing multi-alternatives
- model for analyzing by multiple criteria alternatives the pre-linkage (agreement to work together), establishment (contract), engagement (delivery of project), advancement (ongoing partnership) and latent phase (future projects)
- model for analyzing by multiple criteria alternatives the awareness (career fairs, site tours, industry ambassadors), involvement (industry affiliates or advisors, small grants, internships, work experiences), support (industry mentors, curriculum development and support, professional development workshops, student sponsorships, guest speakers), sponsorships (education initiative sponsorship, large grants, outreach programs) and strategic partners (joint partnership, longer-term joint projects, whole-school level involvement)
- model for multiple criteria analyzing and setting priorities
- model for determining project utility degrees
- model for determining project market values
- model for determining project investment values
- model for providing recommendations

The above models are the basis for the ability of the System to make up to 100,000 university-industry partnership alternatives; perform their multiple criteria analysis; determine utility degrees and market and investment values and select the most beneficial alternative without human interference.

Table 1. Neuro decision matrix

Quantitative and qualitative information pertinent to alternatives									
Criteria describing the alternatives	*	Weight	Measuring units	University-industry partnership alternatives under comparison					
				1	2	…	j	…	n
University-industry partnership Database									
X_1	l_1	q_1	m_1	x_{11}	x_{12}	…	x_{1j}	…	x_{1n}
X_2	l_2	q_2	m_2	x_{21}	x_{22}	…	x_{2j}	…	x_{2n}
...	...	...	...	...	...	…	...	…	...
X_i	l_i	q_i	m_i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}
...	...	...	...	...	...	…	...	…	...
X_t	l_t	q_t	m_t	x_{t1}	x_{t2}	…	x_{tj}	…	x_{tn}
Emotional state data of a viewer while analyzing alternatives (Microsoft Emotion API Affective Database and QA5 SDK Emotions Database)									
Neutral, X_{t+1}	l_{t+1}	q_{t+1}	m_{t+1}	$x_{t+1\,1}$	$x_{t+1\,2}$	…	$x_{t+1\,j}$	…	$x_{t+1\,n}$
Happy, X_{t+2}	l_{t+2}	q_{t+2}	m_{t+2}	$x_{t+2\,1}$	$x_{t+2\,2}$	…	$x_{t+2\,j}$	…	$x_{t+2\,n}$
Sad, X_{t+3}	l_{t+3}	q_{t+3}	m_{t+3}	$x_{t+3\,1}$	$x_{t+3\,2}$	…	$x_{t+3\,j}$	…	$x_{t+3\,n}$
Angry, X_{t+4}	l_{t+4}	q_{t+4}	m_{t+4}	$x_{t+4\,1}$	$x_{t+4\,2}$	…	$x_{t+4\,j}$	…	$x_{t+4\,n}$
Surprised, X_{t+5}	l_{t+5}	q_{t+5}	m_{t+5}	$x_{t+5\,1}$	$x_{t+5\,2}$	…	$x_{t+5\,j}$	…	$x_{t+5\,n}$
Scared, X_{t+6}	l_{t+6}	q_{t+6}	m_{t+6}	$x_{t+6\,1}$	$x_{t+6\,2}$	…	$x_{t+6\,j}$	…	$x_{t+6\,n}$
Disgusted, X_{t+7}	l_{t+7}	q_{t+7}	m_{t+7}	$x_{t+7\,1}$	$x_{t+7\,2}$		$x_{t+7\,j}$		$x_{t+7\,n}$
QA5 SDK evaluation of emotional states with Subsystem, X_{t+8}	l_{t+8}	q_{t+8}	m_{t+8}	$x_{t+8\,1}$	$x_{t+8\,2}$		$x_{t+8\,j}$		$x_{t+8\,n}$
University-industry partnerships Database									
V_k				V_1	V_2	…	V_j	…	V_n

*- The sign + (-) indicates that a greater (lesser) criterion value corresponds to a greater (lesser) significance for stakeholders

One of the most important stages of a multiple criteria decision analysis involves the establishment of a system of criteria describing the alternatives, measurement units, weights and values. The university-industry partnerships to be shown relate directly to the quantitative and qualitative data of these alternatives by comprehensively describing the alternatives under consideration. The compilation of data for a neuro decision matrix is based on the Database and the emotional states established for a specific potential stakeholder while reviewing alternatives. Such data comprehensively describe the university-industry partnership alternatives for that stakeholder. The System captures Criteria $X_1 - X_t$ along with the information describing them (measuring units of the criteria $[m_1 - m_t]$, values $[x_{11} - x_{tn}]$ and weights $[q_1 - q_t]$) from the University-industry partnership Database. Then it also captures Criteria $X_{t+1} - X_{t+7}$ from the Microsoft Emotion API Affective Database (measuring units of criteria $[m_{t+1} - m_{t+7}]$, values $[x_{t+1\,1} - x_{t+7\,n}]$ and weights $[q_{t+1} - q_{t+7}]$ and Criterion X_{t+8} from QA5 SDK Emotions Database (measuring unit of the criterion$[m_{t+8}]$, values $[x_{t+8\,1} - x_{t+8\,n}]$ and weight $[q_{t+8}]$). This completes the compilation of a neuro decision matrix on a specific viewing stakeholder (see Table 1).

A model base management system can provide various models according to user needs. When a certain model is used (i.e., determining the initial weights of the criteria), the results of the calculations obtained become the initial data for some other models (i.e., a model for the multi-alternative design of a university-industry partnership project, a model for multiple criteria analysis and priority setting). Meanwhile the results of the latter, in turn, may become the initial data for some other models (i.e., determining a project utility degree and the market and investment values, providing recommendations etc.).

A Model base management system provides a user with a model base allowing him/her to modify the available models, eliminate the no longer needed ones and add new models linked with existing ones.

4. Conclusions

Emotions and motivations of interested groups are analyzed from different perspectives in an effort to make university-industry partnerships more effective [1-9]. According to [38], affective neuroscience is the study of the neural mechanisms of emotion. This interdisciplinary field combines neuroscience with the psychological study of personality, emotion and mood. The analysis of information and expert and decision support systems used in a university-industry partnership, which researchers and practitioners from various countries developed, and above Methodology helped this author to create his own Neuro Multiple Criteria Analysis System for University-Industry Partnerships. The systems developed by this author differ from others by the use of new original methods [32, 33] and by the object of investigation. Researchers from various countries involved in the analysis of a university-industry partnership life cycle and its components (awareness, involvement, support, sponsorship, strategic partner) did not handle the problems of their design and did not touch upon the research object defined by this author, which consists of the life cycle of a university-industry partnership, the parties interested in the project and micro, meso and macro environmental factors as an integral entity.

There is a compilation of data for a neuro decision matrix based on university-industry partnership alternatives, their attributes and valences as well as by the arousal, emotional state and physiological parameters of a stakeholder. Additionally there is the performance of a multiple criteria, neuro analysis. This is followed by the selection of the most personalized and effective university-industry partnership alternative from numerous alternative variants by considering the aforementioned neuro decision matrix and the features of a stakeholder. The basis for establishing the priorities, utility degrees and investment values of the variants under comparison consists of this neuro decision matrix and the application of methods for conducting multiple criteria analyses of projects, all developed by the authors of this article (Kaklauskas 2016). Thereby electronic negotiations are made possible.

Complex databases of a university-industry partnership life cycle and its stages were developed by providing a comprehensive assessment of alternatives from economic, technical, infrastructural, qualitative, technological, legislative and other perspectives. Based on the above complex databases, the developed System enabled a user to analyze university-industry partnership projects quantitatively (a system and subsystems of criteria and units of measure, values and weights) and conceptually (text, formula, schemes, graphs, diagrams, video tapes).

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