

Received March 7, 2019, accepted March 25, 2019, date of publication April 9, 2019, date of current version April 19, 2019.

Digital Object Identifier 10.1109/ACCESS.2019.2909812

The Influence of Social Capital on Knowledge Management Maturity of Nonprofit Organizations – Predictive Modelling Based on a Multilevel Analysis

RADMILA MIKOVIĆ¹, BRANKO ARSIĆ², ĐORĐE GLIGORIJEVIĆ³,
MARIJA GAČIĆ⁴, DEJAN PETROVIĆ¹, AND NENAD FILIPOVIĆ⁵

¹Faculty of Organizational Sciences, University of Belgrade, 11000 Belgrade, Serbia

²Faculty of Science, University of Kragujevac, 34000 Kragujevac, Serbia

³Computer and Information Sciences, Temple University, Philadelphia, PA 19122, USA

⁴Research and Development Center for Bioengineering, 34000 Kragujevac, Serbia

⁵Faculty of Engineering Sciences, University of Kragujevac, 34000 Kragujevac, Serbia

Corresponding author: Radmila Miković (radmila.mikovic@gmail.com)

ABSTRACT Nonprofit, nongovernmental organizations (NGOs) are important development actors that operate in ecosystems of multi and cross-sector stakeholders in order to reach the most vulnerable social groups of people. Having this in mind, our goal was to explore to what extent their social capital influences their knowledge in order to propose a model that could optimize their knowledge management maturity through social resources embedded into their structure. Therefore, we focused on NGOs from the European Union and the Western Balkans operating in the international development and cooperation sector. We first conducted a survey among 215 NGOs and then cross-checked the received data through desk research and in-depth interviews. We utilized collected structured data and devised a binary classification model capable of discriminating high level from the low level of knowledge management maturity in NGOs, and multi-class classification model for estimating the actual category of knowledge management maturity which can simulate the real connection among social capital and existing knowledge management maturity. Our findings provide valuable data to the NGO management, regardless of where the NGO comes from, of the number of employees it has, and the number of projects it runs. The mathematical models based on neural networks used in this paper show with high accuracy what the knowledge management maturity level (for each output) is in case there exists prior information about social capital (inputs).

INDEX TERMS Social capital, knowledge management maturity, nonprofit organizations, predictive modeling.

I. INTRODUCTION

Nonprofit, nongovernmental organizations (NGOs) are key developmental actors, worth over \$1 trillion a year globally, with over 19 million paid workers, countless volunteers and the authority to manage funds worth billions of US dollars annually while implementing development aid projects [1]. In 2014, only humanitarian aid sector encompassed some 4,480 operational aid organizations with

combined humanitarian expenditures of over \$25 billion and roughly 450,000 professional humanitarian aid workers in their ranks [2]. NGOs respond to global emergencies where states are unable or unwilling to act; they propel the emergence of new norms in an age of interdependence among states, evoking policy decisions; and they challenge the traditional power structure of international relations theory [3].

However, although their organizational structure allows them to operate on a highest level and with significant independence, achievements of NGOs look rather disappointing to policy makers. Facing internal and external pressures,

The associate editor coordinating the review of this manuscript and approving it for publication was Fabrizio Messina.

it by using their organizational social capital more efficiently in order to reach more durable solutions for complex developmental issues NGOs should respond to. Also, we expect that our work will contribute to the theory of social capital and knowledge management having in mind that it is one of rare papers that investigates these two phenomena through the lens of their mutual power dynamics in the nonprofit and nongovernmental sector.

The remainder of our paper is organized into six sections. In Section 2 we give a brief overview of key theoretic findings from the literature based on which we conceptualized our research framework. In Section 3 we provide some global information about the dataset used in this study and describe in detail the input and output variables giving some basic statistics. In Section 4 we describe artificial neural networks as a classification tool and provide the rationale for its application in our research. In Section 5, we discuss the results achieved through the proposed approaches and compare our results with three different baselines that can be relevant for this study. Finally, we conclude our study and discuss drawbacks of the current approach and provide suggestions for future work in Section 6.

II. THEORETIC OVERVIEW OF SOCIAL CAPITAL AND KNOWLEDGE MANAGEMENT MATURITY

A. SOCIAL CAPITAL

The term social capital first occurred in community studies emphasizing the importance of networks of strong personal connections which have developed over time and which represent the essence of trust, cooperation and collective action in such communities [11]. The concept started being implemented for researching a broad range of social and economic phenomena from human capital [12], economic performance of a company [13], geographic regions [14], to nations [15]. The key premise of the social capital concept is that networks are a valuable resource which enables to its members mutual recognition and long-term obligation which is the result of the feeling of gratitude, respect, friendship or institutionally guaranteed rights belonging to the members of the family, class or school [16]. Although all authors agree that the relation is important for social activity, the consensus has still not been reached on a precise definition of social capital. Thus, some authors limit the term only to the structure of the relations in the network [13], while others, like Putnam and Bordieu, also talk about potential resources that can be approached through the network. Like physical capital, referring to physical assets, or human capital, referring to ownership of people, social capital, according to Putnam, refers to the relations between individuals-social networks, norms, reciprocity and trust developing from them [17].

Given that our paper is exploratory-oriented considering internal and external social capital of the organization and knowledge management maturity as a key precondition for efficient management of NGOs, we adhere to the definition of social capital as a sum of actual and potential resources built into the network, available through the network and

generated by the network of links between individuals or social units [18]. In our paper we analyze two types of social units, one from the perspective of links created between individuals and teams within an organization (intraorganizational level of analysis), and the other from the perspective of links created between organizations within a network (interorganizational level of analysis). Putnam considers these two types of social units as “bonding” and “bridging” [17]. For him, bonding social capital refers to creation of a core within one organization; it embraces and creates strong ties between groups of people sharing common characteristics. Actually, it is about an inner need to create exclusive identities and homogeneity of the group, which makes people in the organization devoted to continual acting and often going beyond the limits given by job description. On the other hand, bridging social capital refers to connecting with the core of other organizations; it creates strong ties with other groups and individuals outside its core social network. Organizations which have high level of this type of social capital include people from different social groups. This ability of the organization to reach other influential people and groups which are out of its essential network makes the difference in the sense of an organization’s ability to generate greater and stronger support and trust for what it does.

Following the social capital theories of weak ties [19], which explains the strength of social connections, structural holes [20], which explains the pattern of relations, and social resources [21], which explains the nature of resources incorporated in the social network, we have focused on the social capital structural, relational and cognitive dimensions [18] analyzing their key elements in NGOs. Therefore, within the i) *structural dimension* which explains the general pattern of relations between participants, i.e. who you reach and in which way you reach them [20], we have addressed the presence or the absence of network ties between participants [22], that is, open [23] and closed ties [24], network position [23] and structural equivalence [18]. Within the ii) *relational dimension* which describes the nature of the relations developed through human interactions over time [26], we have addressed intensive and long-term communication [27], trust [15], closeness [29], reciprocity, norms and sanctions [23] and obligations and expectations [20]. Within the iii) *cognitive dimension*, which refers to resources providing shared representations, interpretations, and systems of meaning among network members [29], we have addressed shared narratives [30], common values, vision and goals [31]. With the development of the knowledge network concept, scientific community started studying the iv) *nodal dimension* of networks. Nodal dimension is characterized by diversity of network contacts [32], power [33], [34], capacity to receive and transfer knowledge [35], and depth of knowledge [36].

B. KNOWLEDGE MANAGEMENT MATURITY

Knowledge is a valuable, rare, imperfectly imitable and nonsubstitutable resource that leads an organization to the sustainable competitive advantage [37]. For decades now,

TABLE 1. Descriptive data for sample specific data of surveyed ngos with respect to their location.

	Location	N	Mean	Std. Deviation	Std. Error Mean
Years of duration	EU	129	23,53	16.250	1.431
	WB	86	13,14	7.065	,762
Number of full-time staff	EU	129	125.87	448.413	39.481
	WB	86	7,55	10.585	1.141
Number of part-time staff	EU	129	179.28	685.926	60.866
	WB	86	20,69	47.665	5.201
Number of realized projects	EU	129	2,32	1.166	,103
	WB	86	1,90	,958	,103

organizations have proactively engaged in knowledge management hoping to improve performance through better management of what they know. A number of knowledge management theories have been identified in a close review of the literature. [38] find that the knowledge management theory in general splits into two trains of thought. The first one is found to be more people-oriented, while the second one is more technology-oriented. However, overall, in the broadest sense, knowledge management is defined as the ability to leverage knowledge for achieving organizational goals [39]. Although many organizations worldwide are introducing knowledge management practices, there is no generally acknowledged methodology for assessing where the organization stands, compared to its competitors [40].

Our approach to project knowledge management maturity started with the assumption that knowledge has its own lifecycle and that, therefore, we need to manage it in accordance with the stages it goes through. The research conducted by [41]–[43] and [44], systematize the following key stages and elements of knowledge management: creation (or innovation), acquisition (or collection, transformation and accumulation of tacit into explicit knowledge), dissemination (or transfer of explicit knowledge and share of tacit knowledge) and usage (or application, usefulness of knowledge management tools, standardization of knowledge, data storing and prevention of loss, simplicity of knowledge usage).

The extent to which an organization consistently manages the above said stages and effectively uses its knowledge is defined as a knowledge management maturity [45]. In other words, knowledge management maturity describes the position of an organization when it comes to its knowledge management and what it can improve in order to be competitive at the market. [46]. To that end, knowledge, organization and information technology are systematized as key prerequisites that influence an organization's knowledge management maturity [40].

Within *knowledge*, the following dimensions are particularly important: i) accumulation, both internal and external, through internalization or externalization [47], ii) utilization of the (existing) knowledge in an organization [45], iii) sharing of knowledge both formal and informal [48], and iv) ownership, that is, the accessibility of knowledge [49]. Within *organization*, the following dimensions are particularly important: i) people & organizational climate, that is,

the importance of knowledge for an organization and the extent it invests into it through trust, creativity, team work and collaboration among employees [50], and ii) processes through which an organization integrates knowledge management activities, invests and makes them sustainable [51]. Within *information technology*, the following dimensions are particularly important: i) capturing knowledge, both explicit and tacit, with information technology tools [52], and ii) usage of IT tools that provide good quality of information, increase user satisfaction and facilitate knowledge usage and accessibility [53].

For a summarized presentation of theoretic concepts we referred to, see Table A in the online supplement accompanying this paper.

III. METHOD

In this section, we first provide some global information about dataset used in this study. Then, the input and output variables are described in detail giving some basic statistics.

A. NGO SAMPLING

As shown in Table 1, our sample consists of 215 surveyed nonprofit, nongovernmental civil society-based organizations (NGOs) in the European Union (EU) and the Western Balkans (WB) that implement international and local development projects aimed at improving the quality of life of marginalized groups of people. The reason we have chosen NGOs from these two regions lies in the fact that we wanted to assess to what extent the contextual and developmental differences that NGOs from these regions are faced with might influence the phenomena we examined. While the EU region is characterized as economically and socially developed, with (internationally) experienced, resourceful and networked NGOs, the WB region is stuck by slow democratic changes, corruption, unemployment and fragile peace, and (local) NGOs striving for the European perspective and better future for those least privileged. We speak about differences typical for North–South socio-economic and political divide, with the North usually defined as the richer and more developed and the South as the poorer and less developed region. These differences are determined by critical parameters (economic, political, regulatory and social) that either promote or restrict NGO evolution and are essential for understanding the nonprofit sector in any country [54].

Casey further argues that these parameters trace the contours of cultural frames—(Neo)Liberal, Corporatist, Social Democratic, Emerging, Developing and Authoritarian—that inform our understanding of how nonprofit sectors operate under diverse political, economic, and social conditions and allow observers to situate the dynamics of the nonprofit sector of any country in the broader context of other similar polities. In order to familiarize the wider IEEE audience with the heterogeneous nature of NGOs we will provide a summary of Casey's key critical parameters that constitute these cultural frames and influence the NGO evolution. Liberal frame, typical for the USA, UK, Australia and Canada, is characterized by high income, democratic and pluralist politics, high level of contracting of public services to nonprofits, philanthropic provision of collective goods and services supplement lower level of government services, high tax incentives for charitable donations by individuals and corporations, and strong culture of philanthropy and high trust in nonprofits. Social Democratic frame, typical for the Scandinavian countries, is characterized by high income, state-centered delivery of public services and collective goods, low barriers to sector entry, limited incentives for donations for individuals and corporations, high participation in expressive and recreational nonprofits and philanthropy often focused on international causes. Corporatist frame typical for Continental Europe such as Germany and Belgium, is characterized by high income, dominant subsidiary and pillarized relations between political and social actors, low barriers to sector entry, tax incentives for donations by individuals but more restricted incentives for corporations and long history of philanthropy and cooperative structures. Emerging frame typical for post-socialist countries of Central and Eastern Europe and Eurasia, postmilitary dictatorships of Central and South Americas as well as post-authoritarian regimes in Africa and Asia is characterized by middle income, democratic, incomplete transition to liberal, corporatist, or social democratic models, recently established processes for sector entry and incentives for donations according to emerging model, limited capacity to enforce regulations, small but growing nonprofit sector, growing local philanthropy, but low trust in nonprofit capacity, and concerns about corruption, instability if there is withdrawal of international funding. Developing frame typical for countries with lowest GDP and weak human assets located all around the globe (Balkans, Africa, Central and South America, Post-Soviet states, etc.) is characterized by low income, democratic or semi-authoritarian politics, low level of public services (many supported by international aid), philanthropy implemented by international nonprofits, medium to high barriers to incorporation of indigenous organizations, limited capacity to enforce regulations, high incidence of funding by foreign donations, tension between indigenous and international nonprofits, low trust in all public and nonprofit institutions due to concerns about corruption. Authoritarian frame typical for North Korea, China, Central African Republic, etc. is characterized by low-middle-high income, limited rights

of association and assembly, high barriers to incorporation of independent organizations, nonprofits restricted to “nonpolitical” activities, membership in regime-sponsored organizations and dissident nonprofit sector in exile.

This patchwork of contextual comparisons argued by Casey provides the reader with considerable insight to the evolution of the nonprofits and a useful framework for studying nonprofit sectors around the world. However, we have to be aware that countries may have elements of different frames, and it is certainly likely to have a dynamic nonprofit sector that is moving between the frames. This is exactly reflected in our sample – EU as a region with predominantly developed, corporatist and social democratic countries, and WB with predominantly emerging and developing countries. This is why we believe that our sampling approach makes our findings valuable not only for the NGOs that operate in the EU and WB regions but also to all NGOs that work globally and in the similar contexts.

The NGOs we surveyed come from 28 EU national platforms that bring together around 2,000 EU CSOs [55], 47 international networks that gather around 2,000 EU NGOs [56], and 1,000 WB CSOs working actively in the field of international and local cooperation and development [57]. The surveyed NGOs are both very young and mature organizations. While the youngest organization surveyed was only 1 year old and the oldest 98, majority of them operate between 10 and 20 years. In regard to the financial capacities, the surveyed NGOs run both small- and large-scale projects which at the end of the year is reflected in their annual turnover. Locally based organizations are more prone to small scale projects (5-10 per year) and grants (up to 100 000 euros) while international organizations operate with large-scale projects (over 20 per year) worth millions of euros. The cumulative number of the surveyed NGOs is shown in Fig. 2, as well as the number of their full-time staff.

The surveyed NGOs vary a lot in regard to the number of people who participate in the work of the organization and type of their engagement. While smaller local organizations have only a couple of full-time paid staff, there are international organizations that employ locally and internationally over 4000 people. However, apart from officially employed staff, it is important to mention that the surveyed NGOs rely in their work also on their constituencies, that is, members and volunteers of their organizations and that this number sometimes surpasses 5000. Descriptive sample-specific data in respect to the surveyed NGOs location, number of realized projects, years of duration, number of full-time and part-time staff, are shown in Table 1.

B. DATA COLLECTION

In our research we used surveying, desk analysis and in-depth interviews as key methods. The key instrument used for the survey was a questionnaire. In order to create the questionnaire, we have first consulted the presently available key theories and definitions of social capital and knowledge management maturity. Based on these findings (described in

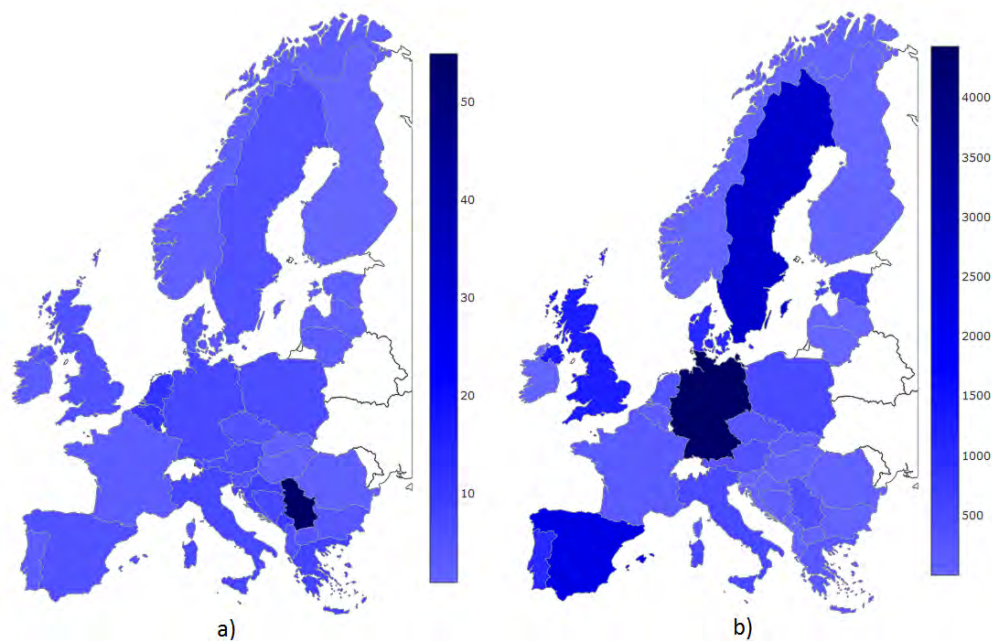


FIGURE 2. Cumulative number of a) surveyed NGOs and b) full-time staff.

the Section 2 of this article), we have determined the key dimensions and elements of social capital and knowledge management maturity (variables) and used them to form the questions. Additionally, social capital elements such as respect, power based on results and power based on influence have been subsequently added, due to the particularities of nonprofit industry operations, which the survey, later, proved to be true. Therefore, these three items we consider as additional value to this research. All examined variables, with their labels used throughout the paper, are presented below in Table 2. Notice that all variables related to intraorganizational level have prefix “wo”.

The questionnaire was composed of 59 questions encompassing control, dependent (social capital) and independent (knowledge management maturity) variables. It was based on the Likert scale (1-5) and was tested by 10 NGOs prior to being presented to the sample in order to establish and remove any deficiencies that could compromise the quality of the gathered information. The survey was done electronically through “SoGoSurvey” allowing access from all electronic devices (computer, laptop, notebook, tablets, and cell phone). The platform also allowed us to export all data to a software used for processing and analyzing results. As far as the statistical processing of data gathered in the survey is concerned, the authors used descriptive statistics (measures of central tendency and percentage). In order to establish the importance of differences between continuous variables, we used t-test for independent samples, ANOVA or Mann-Whitney and Kruskal-Wallis test. Chi-squared test was used to establish the importance of differences between categorical variables. In order to establish correlations between

the examined variables, we used Pearson or Spearman correlation coefficient.

Desk analysis involved gathering, interpreting and analyzing NGOs’ documents such as statutes, registrations, annual work reports, annual financial reports, projects, reports on organizational capacities and development requirements, etc. The goal was to refine and validate the results gathered through survey, but also to provide additional understanding on how the NGOs establish and nurture their organizational social capital and manage knowledge.

In-depth interviews, as the third method, helped us better triangulate the collected data. The goal of in-depth interviews was to confirm and deepen the knowledge of facts gathered during the survey and desk analysis, as well as to clarify potential questions opened by the survey. The in-depth interviews were conducted via Skype with 10 NGOs from different sectors and regions that participated in the survey, that is, with 10 project/program managers with at least five years of top management experience and three years of work for the same NGO. Ten in-depth interviews were sufficient to confirm our survey findings as well as to collect the additional qualitative data. Diversity of the interviewed NGOs helped us better understand different contexts and perspectives under which NGOs operate, while the sound experience and expertise of the interviewees helped us better understand how NGOs use their social capital in the context of knowledge management and identify how our neural network models could help them perform better. The average duration of an interview was 1 hour. Due to privacy reasons we do not disclose the schedule and identity of our interviewees.

TABLE 2. Input and output variables.

INPUT VARIABLES	OUTPUT VARIABLES
SAMPLE-SPECIFIC VARIABLES	KNOWLEDGE MANAGEMENT MATURITY
O - Management structure of the organization	KA - Knowledge accumulation
O1 - Geographic location of the organization	KU - Knowledge usage
O2 - Scope of work of the organization/prevaling activity	KS - Knowledge sharing
SOCIAL CAPITAL (inter/intra - organizational levels)	KO - Knowledge ownership
S1/woS1 - Number of ties (network openness)	POC - People and organizational climate
S2/woS2 - Number of direct ties (network closeness)	P - Processes
S4 - Network position (central)	CK - Capturing knowledge
S5 - Structural equivalency	IT - Usage of IT tools
R1a/woR1a - Strength of ties (intensity of communication)	
R1b/woR1b - Strength of ties (longevity of ties)	
R2/woR2 - Closeness of actors	
R3/woR3a, 3b, 3c - Trust (individuals, teams, organization)	
R4/woR4 - Respect	
R5/woR5a, 5b - Reciprocity (individuals, teams)	
R6/woR6a - Norms (and respecting the norms)	
woR6b - Sanctions	
R7/woR7a, 7b - Obligations and expectations (individuals, teams)	
K1/woK1 - Common vision and goals	
K3/woK3 - Common organizational values	
K5/woK5 - Common narrative	
N1 - Diversity of network contacts	
N2a/woN2a - Power (material/immaterial resources)	
N2b/woN2b - Power (achieved results)	
N2c/woN2c - Power (level of influence)	
N3/woN3 - Capacity for receiving/transferring knowledge	
N4/woN4 - Depth of knowledge	

TABLE 3. Scope of work – the main type of activity of ngo (215 in total).

Scope	Frequency	Percentage
Culture, media & education	20	9,3
Environment & wellness	26	12,1
International cooperation & development	44	20,5
Local development	36	16,7
Philanthropy & humanitarian efforts	21	9,8
Social services & sensitive groups	41	19,1
Civil society & voluntarism	27	12,6
SUMMARY	215	100,0

C. INPUT VARIABLES

1) SAMPLE-SPECIFIC VARIABLES

In the following paragraphs we provide some basic statistics of the collected data for sample-specific, categorical variables across Scope, Management Structure and Location.

In regard to Scope (see Table 3), the surveyed NGOs are nonprofit and nongovernmental associations of citizens and

foundations implementing local and international development projects and programs aiming to improve the overall social, political and economic contexts that directly influence the quality of life of people, especially those who live on the social margin (youth, children, women, elderly, disabled, etc.). These NGOs are partners to a number of state and non-state actors due to their natural bridging role between the decision and policy makers and final beneficiaries, that is, versatile groups of citizens. Networking provides NGOs a chance to access different knowledge, to innovate and share. However, it is not clear to what extent they manage their knowledge efficiently through their social capital, that is, what the level of their knowledge maturity is.

In regard to Location, the surveyed NGOs are located 60% in the EU (out of which most of them come from Belgium –11, Greece –8, Croatia –8, Germany –7, Italy –7, etc.) while 40% are located in the WB (Serbia, Montenegro, North Macedonia, Albania, Bosnia and Herzegovina). While majority of the EU based NGOs are gathered around CONCORD – European Federation of

Humanitarian and Development NGOs as well as Social Platform, operating in over 200 development states, the WB based NGOs are gathered around Balkan Network for Development of the Civil Society. These were exactly the sources through which we approached the surveyed NGOs.

In regard to Management Structure, majority of the surveyed NGOs (53%) that are of pure voluntary and activist nature often apply rather loose than formative management structure. NGOs (37.2%) whose operations are project based, in order to organize their workflow efficiently apply some form of structure with clear division of roles among project team members with manager of the organization usually positioned as a project manager, too. NGOs (9.8%) that run long term and large-scale international projects and programs, are with formal organizational structure and defined systems and processes.

2) SOCIAL CAPITAL AS INPUT VARIABLES

Survey attributes are typically discrete data measured on a Likert scale, although they can be also categorical and continuous. The options provided in our five-level Likert item are Strongly Disagree, Disagree, neither Agree nor Disagree, Agree and Strongly Agree.

a: INTERORGANIZATIONAL LEVEL OF SOCIAL CAPITAL

When it comes to the elements of the external social capital i.e. the relationships that the surveyed organizations establish with other organizations inside a network (interorganizational relations), the 21-question scale showed a satisfactory level of internal consistency with Cronbach alpha at $\alpha = 0.815$, split-half (Spearman-Brown coefficient) reliability at 0.816 and average correlation of items with overall score at $r = 0.58$. To see how NGOs evaluated their external social capital, see Table B1 in the online supplement accompanying this paper.

In order to assess whether some independent variables should be kept as control ones in later analyses, they have been compared as to what extent the NGOs external social capital differs one from another in relation to the location and scope of their work. Only a couple of minor differences related to reciprocity, power, capacities to receiving/transferring knowledge, network position and diversity of network contacts have been noticed. For the differences in social capital of the organization (interorganizational level) pursuant to the location (EU vs. WB) and the scope of work, see Tables B2 and B3 in the online supplement accompanying this paper.

b: INTRAORGANIZATIONAL LEVEL OF SOCIAL CAPITAL

When it comes to the elements of internal social capital i.e. the relationships that organizations establish through individuals and teams (interpersonal and intraorganizational relations), the 23-question scale showed a satisfactory level of internal consistency with Cronbach alpha at $\alpha = 0.925$, split-half (Spearman-Brown coefficient) reliability at 0.883 and average correlation of items with overall score at $r = 0.59$. To see how NGOs evaluated their internal social capital,

see Table C1 in the online supplement accompanying this paper. Out of 23 questions only 3 related specifically to teams (R3b - trust, R5 - exchange of resources, R7b - obligations and expectations), since the nature of civil society sector makes it very hard to separate individuals from teams. Namely, the same individuals are often a part of different teams or, it may happen that certain individuals represent an entire team by performing several functions at the same time. All results relating to teams are identical to the results relating to individuals, which proves that these two levels are hard to differentiate. Therefore, later analyses merge interpersonal and intraorganizational levels into a single intraorganizational level that encompasses all relations within an organization established through individuals and teams.

In order to assess whether some independent variables should be kept as control ones in later analyses, there has been a comparison as to what extent the NGO internal social capital differs one from another in relation to the location and scope of their work. There have been noticed only a couple of minor differences related to strength of ties, closeness of actors, common narrative, vision and goals, and reciprocity. For differences in social capital of the organization (intraorganizational level) pursuant to the location (EU vs. WB) and the scope of work, see Tables C2 and C3 in the online supplement accompanying this paper.

The correlation matrix between input variables is presented in Fig. 3. It can be noticed that there are no strong correlations between input and output variables (marked fields). There are only a few values larger than 0.6. These strong correlations exist between input variables which belong to the same category of social capital. For example, $\text{corr}(\text{woR3a}, \text{woR3b})$ is equal to 0.797, or $\text{corr}(\text{IT}, \text{KO})$ is equal to 0.604. The marked part in the Fig. 3 is related to correlations between input and output variables. The analysis of correlations shows that there are no clear linear dependencies between input and output variables, yet literature suggests them as good predictors of knowledge management maturity (see the references in Table A).

This is why in this study we propose a non-linear approach for predicting acquired knowledge that captures information from input variables and accurately predicts knowledge management maturity. The neural network is able to learn nonlinear mappings from the input to the parameters of the output distribution.

3) KNOWLEDGE MANAGEMENT MATURITY AS OUTPUT VARIABLES

The variables related to the knowledge management maturity are previously described in Subsection 2.2, while their labels are given in Table 2. When assessing knowledge accumulation, usage, sharing and ownership we were specifically interested to assess the extent to which NGOs: 1) possess sufficient knowledge and information necessary for their operations, 2) knowledge and information are at disposal to all employees and partners, 3) people in organization exchange experiences and transfer concrete knowledge with

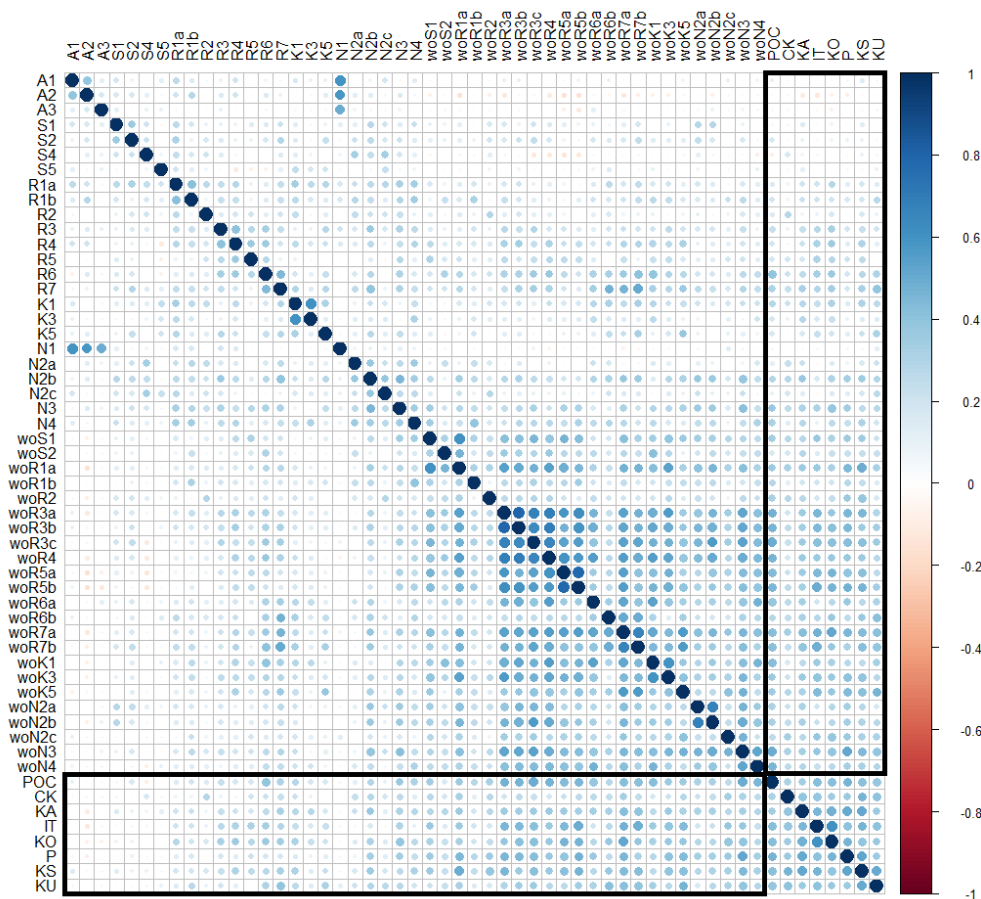


FIGURE 3. Correlation matrix between all input (inter and intraorganizational levels – prefix “wo”) and output variables. The marked area is related correlation between input and output variables.

their colleagues and 4) obtain easy and fast access to the technical/expert knowledge. When assessing people organization and climate, processes, capturing knowledge and usage of IT tools, we were specifically interested to assess the extent to which NGOs: 5) recognize knowledge as their intellectual capital enhancing trust, creativity, team work and collaboration among employees that entice knowledge sharing and learning, 6) dedicate time and efforts in developing and integrating knowledge management practices into the work processes, 7) invest into information acquisition and development of necessary knowledge, and 8) possess tools that allow easy access to quality of information enticing thus user satisfaction, usage and accessibility. Below, we give histograms of all output variables we use in our models (Fig. 4).

IV. ARTIFICIAL NEURAL NETWORKS AS A CLASSIFICATION TOOL

The process of data classification attempts to predict, for each observation in a population, which class an individual belongs to. In the multi-classification task the classes are independent of each other. Artificial neural networks (ANNs) are widely applied non-linear methods for modeling of complex relationships between variables in social sciences, either for

regression or classification tasks [58]. The ANN system can be organized in several layers, such as: input layer, one or more hidden layers, and one output layer. The best architecture (the number of hidden layers, the number of neurons and appropriate activation function) is achieved based on trial-and-error approach, since ANN method is still regarded as a “black-box” i.e. it is difficult to understand the exact relationship between the input and output data. These numbers are changing during training process until the satisfactory behavior of the ANN is obtained. However, using just one hidden layer is advisable due to the problems with local minima [59]. Weights of neurons are determined by means of a learning rule that updates them during the network training. However, due to non-uniqueness of a global minimum and the existence of (possibly) many local minima, the model revealed by the network is non-stable. Thus, neural network usefulness for social research is limited because they present only prediction results, while not providing insight into what features affected prediction the most. Here, our task was to create the ANN which can model multi-task binary class and multi-class classification problem.

Let us assume that we are given a set C of NGO’s surveying records, where each NGO record p_n has an outcome c_n^k ,

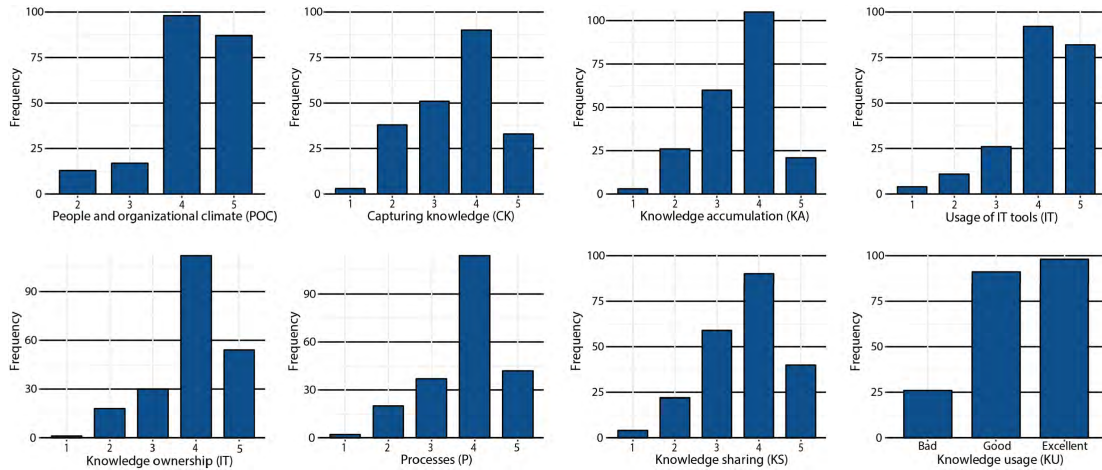


FIGURE 4. Output histograms.

for each output (dependent) variable k from Table 2. Final layer is used for scoring of classes and *sigmoid function* is used for binary classification and *softmax* for multiclass classification, which provide scores c_n^k . The response variables represent category of level of knowledge (1-5) for multi-class classification task, and it is binarized as positive class for the knowledge management maturity level of 4 or 5, according to the scale, vs. those whose knowledge management maturity is evaluated as 1 through 3.

For the multi-task binary classification task, we choose logistic loss function for each output k to optimize the model:

$$L_k = \sum_{i \in |C|} \left(\sum_{n: c_n^{k,i}=1} \log p_n + \sum_{n: c_n^{k,i}=0} \log (1 - p_n) \right)$$

where $|C|$ is the set of possible classes that depends on whether we want to split NGOs into two groups of higher and lower knowledge level (binary classification) or want to predict actual knowledge level/category (multiclass classification). The architecture of the knowledge management maturity prediction model by using social capital is presented in Fig. 5.

In our experiments hidden layer consists of 100 neurons with *tanh* activation function. *RMSPROP* optimizer is used to minimize loss, with 0.001 starting learning rate, and batch size of 256 examples. Other MLP activation functions for hidden neurons and learning parameters were also combined, but we obtained similar or worse statistical performance.

A variable where the number of observations belonging to one class is significantly lower than those belonging to the other classes is called an imbalanced output. In this situation, the predictive model developed using conventional machine learning algorithms could be biased and inaccurate. For unbalanced multi-category classification, our model involves the classes weighting such that certain classes in output variable are penalized in objective function. For classification problems, we use stratified 10-fold cross-validation, in which the folds are selected so that each fold contains roughly the

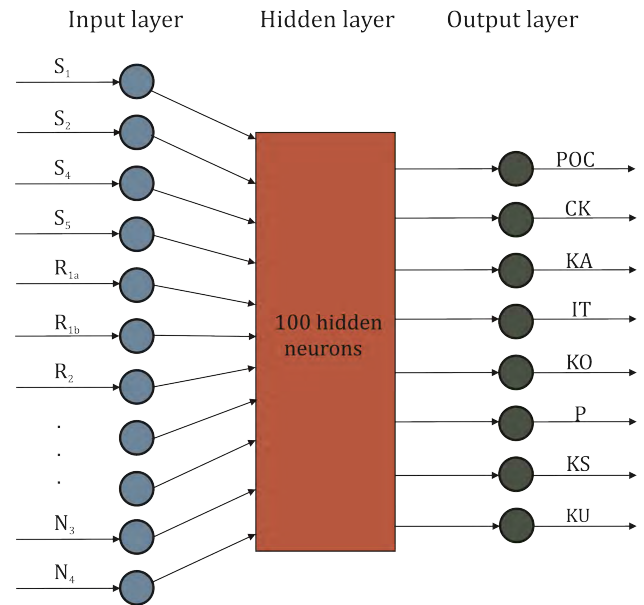


FIGURE 5. General architecture of the established ANN.

same proportions of class labels. The goal of cross-validation is to test the model's ability to predict new data that were not used in estimating it. This also gives us an insight on how the model will generalize to an independent dataset and model overfitting problem.

Finally, in the experiments we evaluate the quality of predictions when using previously described dataset. Simultaneously, we compare results obtained by using proposed neural network architecture with two baseline models: naive classifiers based on dataset statistics and logistic regression model (*LogReg*) for binary and multi-task classification.

V. RESULTS AND DISCUSSION

In this section we report the performance of the proposed approaches for the level of knowledge management maturity prediction tasks as binary and multi-class classification

problems in terms of Accuracy (simple ratio of correctly classified examples), F1-score (conveying balance between the precision and the recall) and area under receiver operating characteristic curve (ROC AUC) [60] that accounts for different values of threshold for logistic scores and best captures the overall performance of the models. Also, we compare our results with three different baselines that can be relevant for this study. We aim to answer the following research questions:

Research Question 1: How do the proposed models perform for the task of identifying high level of knowledge management maturity vs. low?

In order to simulate current standard for predicting knowledge management maturity, we employ median as a naïve baseline predictor. Using the mean or mode of outputs provided results of similar quality. Table 4 shows the results for binary-classification task obtained by using median for each output variable. We do not measure AUC for median predictor as it has no logistic threshold value.

TABLE 4. The results of the single task binary classification for the median of output.

	F1-score one	Accuracy
POC	0.63	0.54
CK	0.42	0.58
KA	0.28	0.51
IT	0.64	0.57
KO	0.49	0.47
P	0.42	0.46
KS	0.68	0.57
KU	0.47	0.58

TABLE 5. The results of the binary classification task for the logistic regression and neural network models.

	F1-score one		Accuracy		AUC	
	LogReg	NN	LogReg	NN	LogReg	NN
POC	0.81	0.84	0.87	0.91	0.67	0.80
CK	0.63	0.66	0.73	0.77	0.60	0.69
KA	0.61	0.62	0.71	0.73	0.59	0.67
IT	0.74	0.77	0.86	0.87	0.66	0.77
KO	0.78	0.83	0.83	0.86	0.62	0.76
P	0.75	0.81	0.83	0.86	0.76	0.84
KS	0.68	0.75	0.76	0.78	0.70	0.79
KU	0.39	0.43	0.44	0.45	0.28	0.38

Further, to evaluate performance of modeling linear dependencies of inputs and knowledge management maturity we applied logistic regression model and directly compared it to the proposed neural network model. Table 5 shows the results of single task binary classification when logistic regression and neural network are used for each output, separately. As a reminder, logistic regression measures the relationship between the categorical dependent variable and one or more independent variables by estimating probabilities using a logistic function.

It can be observed that the proposed NN approach outperforms naïve approach in 7 out of 8 tasks. The improvements of the NN approach against naïve approach range from 11% to 37% in accuracy. Compared to the linear model,

the improvements range from 2% to 6% in accuracy and 9% to 14% in AUC, outperforming the linear model consistently across all targets and metrics. Both logistic and neural network models underperformed to naïve baseline when predicting KU high vs. low level of this knowledge management maturity factor. To address the nonconsistency, we propose a task-sharing setup where models will predict high or low level of knowledge management maturity considering all of the knowledge management maturity factors and not per factors.

TABLE 6. The results of the multi-task classification with logistic regression and multi-layer.

	F1-score one		Accuracy		AUC	
	LogReg	MLP	LogReg	MLP	LogReg	MLP
POC	0.82	0.84	0.91	0.92	0.71	0.82
CK	0.67	0.71	0.68	0.70	0.67	0.71
KA	0.65	0.72	0.70	0.72	0.67	0.73
IT	0.81	0.82	0.87	0.87	0.70	0.79
KO	0.83	0.85	0.87	0.86	0.74	0.80
P	0.75	0.82	0.84	0.85	0.74	0.79
KS	0.72	0.81	0.73	0.79	0.72	0.83
KU	0.78	0.86	0.96	0.97	0.60	0.79

Table 6 presents the predictive performance on multi-task classification. First, we observe improvements across all metrics for both models, providing evidence of suitability of such setup. In the task-specific setup, predicting the KU target was much more accurate (lift of 41% in AUC for neural model) when the models were able to share parameters across the knowledge management types. Once again, neural model consistently outperforms all baselines across all metrics. The multi-task setting has obtained the best performance across all metrics, obtaining high accuracy and AUC values that are task-specific and may be used with higher confidence for estimation whether future knowledge maturity will be high or low.

Research Question 2: How do the created NN models perform for the task of identifying exact category of knowledge management maturity (classes are the level of knowledge management maturity)?

We further evaluate our model as best performing one on the task of predicting exact level of knowledge maturity for each knowledge management maturity factor. This setup is posed as a multiclass classification task, where classes are levels of knowledge management maturity.

Take into consideration that in this part of experiments, output variable KU (knowledge usage), which represents cumulative information, is factorized into three categories: bad, good and excellent. Also, for the multi-classification task all observations which have value of 1 in any of outputs POC, CK etc. are treated as a noise, thus 4 records out of 215 are removed. This is also the reason for absence of Class 1 in the results. The reason why NGOs gave so small scores is the result of either being prone to lack of impartial estimation of their organizational capacities or poor understanding of knowledge management process and practice.

TABLE 7. Accuracy.

	Class 2	Class 3	Class 4	Class 5
POC	0.97	1	0.86	0.88
CK	0.96	0.95	0.82	0.94
KA	0.98	0.87	0.82	0.99
IT	0.99	0.96	0.87	0.92
KO	1	0.94	0.89	0.92
P	0.99	0.98	0.93	0.96
KS	0.99	0.92	0.91	0.98
	Bad	Good	Excellent	
KU	0.98	0.89	0.91	

TABLE 8. ROC AUC.

	Class 2	Class 3	Class 4	Class 5
POC	0.88	1	0.89	0.92
CK	0.95	0.91	0.83	0.90
KA	0.98	0.88	0.85	0.99
IT	0.99	0.91	0.92	0.96
KO	1	0.83	0.91	0.94
P	0.99	0.98	0.95	0.95
KS	0.99	0.94	0.93	0.98
	Bad	Good	Excellent	
KU	0.93	0.92	0.93	

Results summarized for accuracy and AUC over independent 10-fold cross-validation experiments are provided in Tables 7 and 8, respectively.

It can be noticed that the results obtained with the multi-class classification model are better than the results obtained with the binary classification model. This typically occurs when there are a lot of features that specifically identify a certain category, while that might not be the case if all instances of categories 1 till 3 and 4 till 5 are summarized together. The improvements of the averaged neural model for multi-classification task against neural model for binary classification range from 10% to 19% in AUC. Compared to the neural model for binary classification, the improvements range 7% to 21% in accuracy, outperforming the binary neural model consistently across all targets, except for the KU output for which accuracy is decreased by about 4%.

The suggested neural network architecture can be very beneficial for the efficient work of NGOs. Based on the neural network models, NGO management can assess with high accuracy the level of their knowledge management maturity based on their internal and external social capital and make a data driven decision where and when to invest in their social relations in order to decrease their knowledge management deficiencies. In other words, neural network models we suggest may help NGOs that operate in the complex contexts with optimization of the mutual integration of organizational social capital and knowledge management maturity for the purpose of more effective work.

Our in-depth interviews and desk analysis reveal that NGOs are in need of both traditional knowledge (technical, general and specialist) and modern management skills (such as project crowdfunding, digital campaigning, project adaptation, etc.) as well as methods of learning (hubs, labs, job shadowing, mentoring, internships, etc.). Lack of resources

(talented workforce, expert based partnerships, IT and digital equipment, etc.) has been identified as the most serious obstacle for NGOs to acquire the missing knowledge and skills. Also, failure to transfer the existing individual knowledge and skills to organizational repositories, to transform them into the organizational and network knowledge and make them easily and always accessible to all people in the organization. Most of time this is because NGOs are more prone to ad-hoc (from project to project) than strategic knowledge management practices. Social capital of the organization still has not been recognized as a mechanism through which the existing knowledge may be innovated, the missing acquired, the acquired disseminated and used. NGOs do tend to build teams and create networks and alliances with other similar NGOs; they use the synergy of their project results and knowledge to create space for new project solutions that can be presented to donors. NGOs also do tend to create cross-sector partnerships with governmental and business stakeholders with aim to push for sustainable changes. However, most of time their investment in socializations (number of links and networks) exceeds the value brought by their creation (i.e. number and quality of projects and impact made). Similar to the finding of [61], the growth of cross-sector social capital has provided NGOs direct access to decision makers with the potential to influence their norms and values but these partnerships have not yet resulted in notable improvements in the overall performance of the supply chains they are embedded in. To that end, with neural network models, we help NGOs understand the basic principles of knowledge management and what specific internal and external social capital interventions should be deployed for the purpose of their more mature knowledge acquisition, creation, dissemination and usage and eventually more successful project and organizational management.

A neural networks shortcoming is that it cannot provide information on what concrete dimension or element of internal or external social capital influences more or less concrete knowledge management maturity factor. However, if some of the knowledge management maturity factors should be improved, the correlation matrix, shown in Fig. 3, provides a valuable information about the most influential input thus indicating the sensitive place for possible advancement. Artificial neural network architecture we propose confirms mutual links between social capital and knowledge management maturity and attributes to key theoretical standpoints. In general, similar to the finding of [62], our research also confirmed that social capital is a significant enabler of knowledge management initiatives, knowledge management processes and outcomes on the organizational level. More specifically, our findings confirmed that open ties (structural dimension) are the main prerequisite for creating knowledge because they offer access to different and new ideas while closed ties (structural dimension) are ideal for knowledge exchange because the ties between participants are strong and deep [24]. Strong ties (relational dimension) help with building trust and reciprocity (relational dimension)

between individuals, which hinders opportunism and increases expectations (relational dimension) from the cooperation [63] which further increase individual awareness on accessing knowledge and readiness to invest in transferring, receiving and using knowledge [64], influence adopting innovations [65], knowledge transfer and the creation of organizational knowledge [66]. Norms (relational dimension) reinforce trust and long-term contractual obligations mediating project collaboration and performance [67]. Common narrative, organizational goals and values (cognitive dimension) facilitate interpretation and simplify semantic systems between participants [29]–[31] which encourages accumulation and usage of knowledge. Knowledge depth (nodal dimension) of the receiver and source, increases motivation and ability to transfer, receive knowledge and innovate [68]. The bigger the absorption capacities (nodal dimension), the better the quality of knowledge transfer as well as the ability to use knowledge transfers in order to create new knowledge [69]. Finally, power (nodal dimension) derived from organizational role encourages adoption and implementation of innovations [33].

VI. CONCLUSION

Our paper examined social capital and knowledge management maturity of nonprofit, nongovernmental organizations in the European Union and the Western Balkans in order to explore the influence of social capital on the knowledge management maturity of NGOs that operate in the complex contexts, as well as to search for a model that could optimize their mutual integration for the purpose of more effective work. Our research utilized collected structured data and devised a binary classification model capable of discriminating high level from low level of knowledge management maturity in NGOs, as well as multi-class classification model for estimating the actual category of knowledge management maturity factors which can simulate the real connection among social capital and existing knowledge management maturity.

Our paper is of both practical and theoretical value. In terms of practical contributions, the models we propose are the mathematical models based on neural networks that can show to NGO management with high accuracy what the knowledge management maturity level (for each output) is in case there exists prior information about social capital (inputs) regardless of where the NGO comes from, of the number of employees it has, the number of projects it runs, etc. The findings of this research provide valuable data to the NGO management about the state of their knowledge management maturity and how to develop it through more efficient usage of organizational social capital. Given that NGOs operate in ecosystems of multi stakeholder and cross sector contacts, it is of great importance to learn that social links influence their knowledge management maturity and what model to use that could optimize their knowledge management maturity through social resources embedded into their structure. This will help NGOs more efficiently reach

the most vulnerable populations in need and provide sustainable solutions for a number of developmental issues affecting their life. In terms of theoretic contributions, we applied predictive modeling to explore interrelationships between social capital and knowledge management maturity in nonprofit industry. Our research is the very first study that applied neural network approach in examining and modeling the knowledge management maturity based on social capital of nonprofit organizations. It also confirmed that social capital influences knowledge management maturity, which is something that was prevalently examined in the profit industry. To that end we may say that our research is of direct value to the theories of social capital (structural, relational and cognitive dimensions) and knowledge networks (nodal dimension) adding new body of knowledge explicitly related to nonprofit industry, to the theory of knowledge management adding new models of knowledge management maturity based on social capital of the organization and to the theory of neural network adding its' applicability in testing the social theories and multi-disciplinary concepts.

On the other hand, our research also faces certain limitations. First, the neural network, as a non-linear method, cannot provide information on what concrete dimension or element of internal or external social capital influences more or less concrete knowledge management maturity factor. Therefore, it would be interesting to continue searching for the most proper method that would also provide answers to these research questions with the equal level of accuracy we managed to provide with the neural network method. Second, we examined a specific type of the nonprofit industry, i.e. non-governmental organizations whose characteristics are different from other nonprofit organizations such as state and local government, political parties, unions and universities that also belong to the nonprofit industry, but operate under different missions, values and goals. Therefore, it would be useful to conduct more similar researches in other types of nonprofit industry and sectors. Finally, the territory covered by this research refers to Europe. Although, we managed to cover it through the EU and the WB using the analogy of more and less developed regions based on which we claim that our findings may be applicable in other similar world contexts, it would be useful to conduct the same research across different geographic regions in order to reach comparable data and draw more consistent conclusions.

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RADMILA MIKOVIĆ received the B.A. degree (Hons.) in philology and the M.A. degree in management specialist from the University of Belgrade. She is currently pursuing the Ph.D. degree in management with the Faculty of Organizational Sciences, University of Belgrade, Serbia. She was a Management Consultant providing development and management services to nonprofit and nongovernmental organizations operating in the international development and cooperation sector worldwide for 20 years. As an Academic Researcher, she is significantly focused on examining the role of evaluation in the organizational learning and assessing the extent to which organizational social capital influences organizational knowledge management and overall performance.



BRANKO ARSIĆ received the M.Sc. degree in mathematics and computer science from the Faculty of Science, University of Kragujevac, Serbia, in 2008, where he is currently pursuing the Ph.D. degree in mathematics and computer science with the Department of Mathematics and Informatics. He is currently a Teaching Assistant with the Department of Mathematics and Informatics, Faculty of Science, University of Kragujevac. His research interest includes application of spectral graph theory in computer sciences along with semantic model development and tools for large scale integrative data mining of the Internet social networks.



ĐORĐE GLIGORIJEVIĆ received the B.Sc. degree in information systems and technologies from the Faculty of Organizational Sciences, University of Belgrade, Serbia, in 2013, and the Ph.D. degree in computer and information sciences from Temple University, Philadelphia, PA, USA, in 2018. He is currently a Research Scientist with the Yahoo! Research Group, Oath Inc. His research interests include large-scale machine learning and data mining, with applications in healthcare and computational advertising.



MARIJA GAČIĆ received the master's degree in module finance and accounting from the Faculty of Economics, University of Kragujevac, and the Ph.D. degree in business economics from the Educons University, Sremska Kamenica, Serbia, in 2016. She is currently a Researcher with the Research and Development Center for Bioengineering (BIOIRC), Kragujevac, and a Teaching Assistant with the Technical Engineering College of Vocational Studies in Trstenik. Her research interests include management in research organizations, project finances, and knowledge management. She has authored and coauthored more than 12 papers, published in journals and referent conferences.



DEJAN PETROVIĆ received the Ph.D. degree. He is currently a Full Professor and the Head of the Department for Specialized Management Disciplines, Faculty of Organizational Sciences, University of Belgrade, Serbia. He is also a Visiting Professor with the Faculty of Economics in Ljubljana/Slovenia and with the Faculty of Economics in Podgorica/Montenegro. He had a teaching cooperation with Radford University, Radford, VA, USA, and L'Ecole Central from Paris. He is a member of the International Project Management Association (IPMA), and South-East Europe Project Management Network and Academy of Management, USA. His scientific research interests include project management, knowledge management, project knowledge management, strategic management, and management of investment and changes.



NENAD FILIPOVIĆ received the Ph.D. degree. He is currently a Full Professor with the Faculty of Engineering Sciences and the Head of the Center for Bioengineering, University of Kragujevac, with rich experience in computer simulation. He is also a Research Associate and a Consultant with Harvard University, USA, and a Rector of the University of Kragujevac. He has authored and coauthored 11 textbooks and five monographs in English, over 170 publications in peer reviewed journals, over 10 software solutions for modeling with finite element method and discrete methods from fluid mechanics and multiphysics, and connection of medical data with mechanics solvers. He was a PI of scientific program for bioengineering, a PI and Co-PI of many national and international scientific project, a Managing Editor of the *Journal of the Serbian Society for Computational Mechanics*, a Coordinating Member of the European Society of Biomechanics for Serbia, a member of the European Society for Artificial Organs, and a member of Board of the Serbian Society for Mechanics.

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