Applying Social Network Analysis to Support the Management of Cooperative Project´s Behavioral Risks

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According to several literature sources and bodies of practices, effective cooperation between organizations in the deliver of projects is a critical success factor for project successful outcome. Nevertheless, it seems that organizations are still reluctant to engage in cooperative networks more than it would be expected. The major reason for this - according to several literature sources – is due to a lack of efficient models to support organizational cooperative networks. This work introduces a model that contributes to the management of organizational cooperative networks, by adressing behavioral risks that usually emerge as organizations engage in cooperative networks to deliver projects. The proposed model was developed based on four key pillars ((1) project management, (2) risk management, (3) cooperative networks, and (4) social network analysis centrality metrics), and will analyze how four critical organizational cooperative informal networks ((1) trust, (2) problem-solving, (3) advice, and (4) communication), emerge and evolve throughout the different phases of a generic project lifecycle. The development and implementation of the proposed model is supported by a case study.

Keywords *Project Management, Project success, Risk Management, Social Network Analysis, Informal Networks, Cooperative Networks, Social Network Analaysis Centrality Metrics*

1. INTRODUCTION

It is no longer new to argue that if organizations want to achieve success, they have craft sustainable stra–tegies - that very often -, comprise a given form of par–tnership with other organizations, institutes, universi–ties, or even direct and indirect competitors [1-7].

The reason behind this trend is that, more often than not, organizations alone do not hold the critical resources (people, technologies, competencies, and so on) to efficiently respond to the increasing market needs [1, 6]. In fact, several research in the organi–za–tional field argues that in today's business landscape, more important than individual competencies, is how efficient and effective individual competencies flow across an organizational social network, which in other words means - how good can an organization work in cooperative networks in the internal and external envi–ronments [7,8].

Research also shows that the ability to work in cooperative networks, boosts innovation and perfor–mance, which are two of the critical factors to achieve sustainable competitive advantages [3,4].

Furthermore, research also shows that an efficient ability to work in cooperative networks enables the implementation of an ambidextrous leadership style, which is characterized the exploitation of present conditions by optimizing existing business model´s while exploring emerging opportunities which will help to redefine existing business models, essentially by taking pioneering risks [9-12].

However, it seems to be easier said than done. According to several research sources in the orga–nizational field, organizations are still very reluctant to work under cooperative networks, essentially due to the lack of efficient models to support the management of organizational cooperative behavioural risks that emerge, evolve, and eventually disappear or remain, as projects are being delivered [2,13].

Several research sources also show that not all ways of working in cooperative networks are healthy for an organization. In fact, research in the field of sociology and organizational theory show that there are a number of critical informal networks, such as communication, problem-solving, trust, advice, access, information exchange - just to name a few -, that play a central role in organizational performance and innovation, which should be properly identified and managed [1, 8, 14-20].

Such critical informal networks are those that more often than not lead to the emergence of cooperative behavioural risks that can compromise the successful outcome of a given project [1, 13].

This work introduces a heuristic model that contributes to an efficient way to the management of cooperative network´s behavioural risks, as orga–ni–zations deliver projects across all the phases of a given project lifecycle. The proposed model in this work was developed based on four key pillars. They are: Pillar 1 - project management, Pillar 2 - risk management, Pillar 3- cooperative networks, and Pillar 4 - social

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network analysis (SNA) centrality metrics. The model will analyse how four critical organizational coop–erative informal networks emerge and evolve throug–hout the different phases of a generic project lifecycle. They are: (1) trust network, (2) problem-solving net–work, (3) advice network, and (4) communication net–work. The proposed model four key pillars and the four critical organizational cooperative informal networks are illustrated in Figure 1.

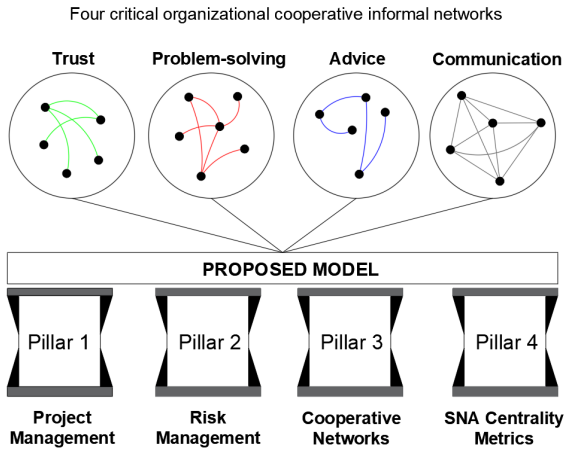

Figure 1. Proposed model´s four key Pillars and the four critical organizational cooperative informal networks.

Table 1. Individual contributions of each of the four Key Pillars that form the base to the development of the proposed model in this work.

Key Pillars	Description and individual contribute to the proposed model
Project Management	Provides the proposed model the definitions and structure of a typical project lifecycle according to the PMI (Project Management Institute) [21] which include subjects, but not only, such as the definition of project management and projects, and project lifecycle.
Risk Management	Provides the proposed model the definitions and world-wide standard approach to manage project risks, which include, but not only, definition of risk and risk management, and generic risk assessment process.
Cooperative Networks	Provides the proposed model the definitions of project cooperative networks, which include, but not only, the importance of cooperation for organizations achieve success in a sustainable matter.
SNA Centrality Metrics	Provides the proposed model the definitions of social network analysis in organizations and its importance, which includes subjects , such as, but not only, organizational social network, organizational informal networks, and social network analysis centrality metrics.

The informal networks in Figure 1 are illustrated by the lines green, red, blue, and grey within each circle located above the proposed model area, that connect the several black dots. Informal networks are by opposition to formal networks (also known as the organizational hierarchical chart) not characterized by a specific ordinated arranged order, rather by multiple configurations function of the specificity to be mapped [18]. The detailed individual contributions of each of the four Key pillars that were used to develop the proposed model in this work, are illustrate in Table 1.

As it can be seen in Table 1 the four key Pillars are used to develop the proposed model in this work which will analyse how the four critical organizational cooperative informal networks ((1) trust network – which essentially points out who trusts whom within a given cooperative project social network regarding project related matters, (2) problem-solving network – which essentially points out who turns to whom to get solutions to cooperative project related issues and challenges, (3) advice network - which essentially poi–nts out who turns to whom to get advice or guidance related to cooperative project uncertainties, and finally (4) communication network - which essentially maps how the communication network of a cooperative project is structured and how it evolves across time) where the results of the analysis can be used to correlate project success or failure with certain observed unique behaviours, which can be classified as cooperative projects behavioural risks [1, 2, 13]. The efficient identification of such critical cooperative project's informal networks in a timely manner, is one of critical success factors that need to be taken into consideration if organizations want to strongly increase the changes of successful project outcome [7]. Moreover, the efficient management of cooperative projects behavioural risks will strongly help organizations in their transformational steps (which implies the intelligent networking of processes and procedures with the help of information and communication technology across the overall organizational structure -also known as Industry 4.0 [22]) towards a more efficient, responsiveness, capable, dynamic, and flexible organization, which in turn enables a more data driven decision-making process. In this line of thought, the proposed model in this work is aligned with the latest organizational trends regarding how to improve organizational performance, boost innovation and become sustainability-oriented and customer-centric, through the implementation of digital transformation and industry 4.0 strategies [22]. Finally, the proposed model combines four of the most critical key pillars in project management as it will be described in the literature review, which provides the research that conducted to the development of the proposed model a unique and novel approach to manage cooperative project risks.

2. LITERATURE REVIEW

2.1 Risk Management in Project Management

The Project Management Institute (PMI) defined project management as the application of specific techniques and knowledge throughout the several phases of a given project lifecycle to enhance the chances of successful deliver a project [21]. The PMI defines a project as temporary endeavour that has a well-defined start and end, aiming the delivery of a unique product, result, or service [21]. Risk management, according to the International Organization for Standardization (ISO), is defined as a set of coordinated activities to control and direct an organization concerning risk [23]. The ISO defines that

risk can be seen in two different dimensions – (1) risk as a threat to project activities or tasks, and (2) risk as positive opportunity to project activities or tasks [23]. Risk management can still be defined as a combined and continuous decision-making process and proactive management which should be an integrative part of an organization's governance, design & structure, that should be continuously supported and incentivized by all members of an organization [24].

Risk management in project management can then be the result of the combination of the individual con–tributions of project management and risk management in project´s environment. Some authors and project risk management experts argue that project management is in fact nothing else than risk management [25]. This view of project management, directly implies that by doing risk management (set of coordinated activities to control and direct an organization concerning risk – threats and opportunities) one is ultimately and uni–quely concerned with the factors that may hinder or support the achievement of organization´s goals thro–ugh the delivery of projects, assuming however, that all the respective specific project management work, such as project planning, resources planning, stakeholder management, just to name a few, is previously done.

More concretely, risk management in project ma–nagement can be defined as the merge between risk management and project management, being thus characterized by the incorporation of best practices and world accepted standards regarding risk and project management [25]. In this line of thought, it becomes crucial to identify project risks that can be managed with risk management standard approaches as argued by Hillson 2014. Such risks, according to Hillson, 2014, which be divided into four different categories ((1) event risks – also known as stochastic uncer–tainties, are risks that concern something that hasn't yet occurred, but if it will, then will impact project´s objectives, (2) variability risks – also known as alea–toric uncertainties, are risks characterized by a set of different possible known outcomes, however nobody knows exactly which outcome will occur, (3) ambiguity risks – also called as epistemic uncertainties, are risks that are characterized by a general lack of previous knowledge or understanding, and finally (4) emergent risks - also called as ontological uncer–tainties, are risks that are simply unable to be predicted or seen, because no one has ever thought about them, because they are simply outside a one´s mindset or past experience) cover all the spectrum of possible high level risks that may occur in cooperative projects.

In a more detailed approach, Abreu et al., 2018, particularizes behavioural risks (which can comprise the mentioned critical informal networks, but not only) as being one of the risk types that may occur in cooperative projects, characterized by the repre–sentation of relationships that are established between the different cooperative project´s partners during the delivering of a project. Other cooperative risks types include the risk of assigning tasks to cooperative project partners, risk of critical enterprises, resources allocation risks, and managerial risks [26].

The present model in this work, directly addresses cooperative behavioural risks as proposed by Abreu et al., 2018. However, the proposed model in this work can also be used to address the ambiguity risks types as proposed by Hillson, 2014. This happens because the proposed model in this work will provide knowledge to a previous unknown *status*, which can be translated into the mapping (identification) and understanding of cooperative project´s informal networks emerge and evolve across the several phases of a project lifecycle.

2.2 Social Network Analysis in Organizations

Social Network Analysis, also known as SNA, or still as organizational networks analysis (ONA) can be defined as the studying and analysis of social structures by the application of diverse metrics developed based on graph theory [27]. The application of such metrics ultimately will contribute to explain how the different social structures evolve across a finite period, and the impact they exert in the environment they exist [27]. The application of SNA in organizations plays a fun–damental role in the understanding of the importance of organizational social capital and has been introduced in organization´s risk and project management depart–ments, as a decision-making tool [1, 2, 28].

SNA in organizations can be used to identify key informal roles within an organization such as central connectors (represent central people where too many other people rely on for help advice or other, boundary spanners (represent people that links different orga–nizational departments or silos, peripheral people (may represent isolated (usually misfitted people) or subject matter experts, and energizers (represent people that positively energize a group or entire network), just to name a few [17].

The identification of such key informal people within a cooperative project social network is of ext–reme importance because such people have what is known as informal power and may use it to influence others and drive outcomes [1, 2].

2.3 Social Network Analysis in Project Management

According to some research sources the application of SNA in project management is still in a very initial stage [1, 2]. However, it has significantly been gaining popularity among project practitioners essentially due the benefits that represent for organizations that deliver projects [1, 2, 18]. In fact, according to research in the project management field the application of SNA provides project stakeholders a unique insight regar–ding the understating the extent to how project people dynamic interactions (behaviours) may impact project outcomes [2, 18]. Furthermore, the application of SNA in projects enables to map project people behaviours that may explain factors, such as information diffusion, individual and collective performance, unethical behaviours, fraud, resources shortages and retention, just to name a few [2, 7, 18]. Still according to several research sources, the application of SNA in project management is of crucial importance, because the insights generated simply cannot be generated with the

application of traditional management tools and techniques [1,2,18, 29].

In the model presented in this work, the application of SNA will enable the mapping and the quantitative measurement of project people dynamic interaction across the several phases of a typical project lifecycle.

2.4 The importance of Social Network Analysis Centrality Metrics

SNA metrics refer to the mathematical approach by which quantitative results can be outputted [1,2,7]. SNA centrality metrics are those which more meaningful insight provide to organizations in a straightforward way [1,2,7, 17]. Such SNA centrality metrics include metrics, such as in-degree (which characterizes how many links a given person or entity receives from others), out-degree (which characterizes how many links a given person or entity gives to others), betweenness degree (which characterizes how between a person or entity is from all other persons or entities within a certain social network), closeness degree (which characterizes how close a person or entity is from all other persons or entities within a certain social network) which quantitatively explain the informal importance of a given person or entity within a given social network [1, 2, 7, 16, 17, 18]. Such links may represent several different preferences, such as like, dislike, need, just no name a few [16]. In a cooperative project social network centrality refers to the structural location of a particular person or entity and can be used as a measure of an entities' importance, prestige, influence, and control [16, 18].

For example, in and out - degree can be used as an index of potential of a network´s activity, while betweenness can be an index of the communication control bridging two different clusters of a network [14]. Closeness is an index of the potential of independence of one´s person or entity from the network´s control, where it is contained [14]. Centrality is directly linked to informal power in a cooperative social network which will ultimately impact on project coordination and decision-making [19].

In the proposed model of this work, the SNA centrality metric in-degree and weighted in-degree will be used to quantitatively measure cooperative project risks, which characterize a certain behaviour pattern across the different phases of a project lifecycle regarding the four critical organizational cooperative informal networks - (1) trust network, (2) problem-solving network, (3) advice network, and finally (4) communication network.

3. THE IMPORTANCE OF COOPERATIVE NETWORKS IN ORGANIZATIONS

Cooperative networks can be defined as a variety of entities, such as people, organizations or other, that exchange information, share resources, plan, and orient activities to the achievement of compatible goals [30]. Still, cooperation among the organizational landscape, requires a given division of work among participants, where the aggregated final value, comes from the sum of individual value-generated contributions, in an almost independent manner [30]. Furthermore, cooperation between and within organizations, in most cases, does not requires the existence of a common goal [30]. However, very often, in cooperation between and within organizations, there is a common plan, which may or may not be designed by one single entity [30]. Cooperative networks are not something new. In fact, research shows that cooperative networks exist for many years, and these tend to become more virtual enterprises which represent a particular business form in the society [6, 22]. Nevertheless, such form of ma–king business, has never been unchangeable throuhout the years, and strongly varying from country to country and form different economic sectors [6].

According to several research sources, effective and efficient organizational cooperative networks, heavily depend on factors, such as the reliance of the coope–rative on reciprocity (information or / and advice exc–hange in both directions between any two orga–nizations), trust and interlocking directorates (where a member of one organization's board of directors also serves on another organization's board or within anot–her organization's management position) [5, 6, 22]. Efficient cooperative networks may enable organi–zations to profit from resources that one organization does not has or even does not has the capacity to have, which are crucial to an organization´s survivance for example and contribute increase the success chances of a project or an operation, while minimizes and enhan–ces risk (threats and opportunities respectively) [1, 20].

In this work, joint work (which characterizes work done between different entities which may charac–terized by different people, groups, or organizations) will be assumed as the cooperation principles above mentioned.

4. DEVELOPMENT AND IMPLEMENTATION OF THE PROPOSED MODEL IN THIS WORK

4.1 Introduction to the proposed model in this work

The proposed model in this work was developed based on four key pillars (Pillar 1 - project management, Pillar 2 - risk management, Pillar 3- cooperative net–works, and Pillar 4 - social network analysis centrality metrics) and aim an efficiently way to the management of cooperative network´s behavioural risks by analy–sing four critical organizational cooperative informal networks emerge and evolve throughout the different phases of a generic project lifecycle ((1) trust network, (2) problem-solving network, (3) advice network, and (4) communication network), as organizations deliver projects across all the phases of a project lifecycle. In Figure 2, is illustrated the proposed model in this work development and implementation´s framework.

In Figure 2 is illustrated the proposed model´s development and implementation framework built on a generic organizational cooperative project's lifecycle.

The generic project lifecycle illustrated in Figure 2 comprises all the possible project phases that comprise a given project, from phase I, II, III, up to phase f. In other words, it means that the proposed model in this work is not constrained to a specific number of project phases.

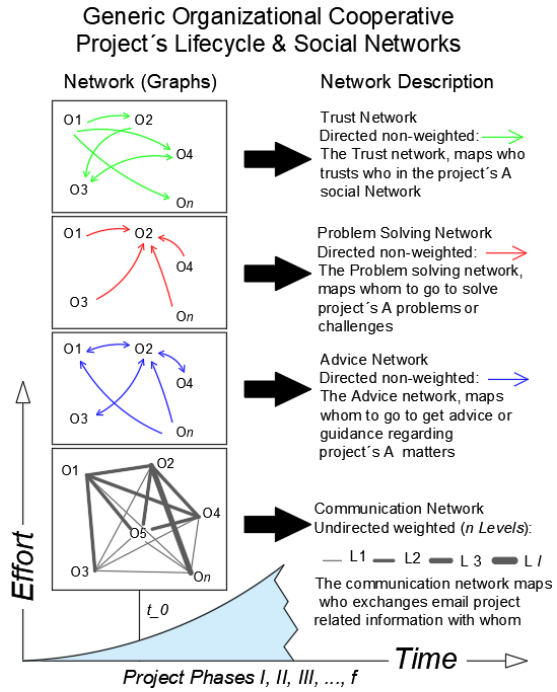

Figure 2. Proposed model development and implementation framework.

In each project phase f of a given project lifecycle, the network analyst (which can be represented by the project manager or any other project stakeholder with power to intervene in the management of the cooperative project social network) must define a set of points in time (across the duration of a given project phase f), that represent the points in time where the assessment to the cooperative project social network will be made.

Such points in time t, are represented by t_0, t_1 up to t_t in Figure 2, under each of the lowest boxes displayed over the generic project lifecycle curve. In each point in time t, the network analyst will assess and collect information that comprises a period between t and t-1.

This period between t and t-1, shall contain all the necessary information regarding dynamic interaction between project people, that is required by the proposed model in this work to perform the cooperative project´s behavioural risk analysis. To the data collection process occurs in an effective and efficient way, it is necessary that all required information for the proposed model in this work to be available and readable.

Regarding the necessary data to be collected, more on this topic will be ahead described. In each point in time t, the network analysist will collect data regarding the dynamic interaction of all project participants between the period of time between t and t-1, which will enable the mapping of four distinct cooperative project social networks (also called as cooperative projects dynamic graphs). With the collected data, the proposed model in this work will map the trust network (illustrated in Figure 2 on the upper row with the green lines in it), the problem-solving network ((illustrated in Figure 2 in the middle row with the red lines in it), the advice network (illustrated in Figure 2 in the third row with the blue lines in it), and finally the communication network (illustrated in Figure 2 in the lowest row with the grey lines in it).

The first network to be mapped according to Figure 2, is the trust network, however, when the proposed model is in operation the order is totally customizable by the network analyst.

As for an illustrative example, in the upper left box illustrated in Figure 2, is illustrated the trust network for the time in point t_0. In this box are represented a set of organizations (O1, O2, O3, O4, …, On) connected with directed green lines between them. As mentioned before, the green colour of the lines represents the trust network, however the choice of the colour to be used is also totally customizable by the network analyst. The green lines are directed lines, which are represented by the arrow at one or both ends of the lines.

This latter information is also displayed in Figure 2 in the right side inside each box with the tithe – Network Description. In the case of the first trust network, for example, the line that points from O1 to O2, represents that there is a trust relationship that goes from O1 to O2. In other words, it means that organization O1, trusts in Organization O2, when it comes to project related matters. These lines between different organizations may be or not reciprocal. In a reciprocal connection (line) the preference is feedbacked from a given organization to another giver organization. For example, between O2 and O2 in the first trust network, there is no reciprocity to be observed. This means that while O1 trusts O2, O2 does not seem to trust O1.

In the same network, there is a reciprocal connection between O3 and O4. In this case, O3 trusts O4, and O4 trusts O3. The same analogy is to be made to the problem-solving and advice networks illustrated in Figure 2.

To map the mentioned networks (trust, problem-solving, and advice), data that is collected in surveys launched to the project social network will be used. For example, to map the trust network, a possible question to be launched to the project social network (to the elements that comprise each organization) that participated in the project phase between t and t-1 could be: whom do you trust to discuss project problems and opportunities without fearing retaliation or other undesired and intimidation actions?

The answers provided by each respondent would enable to map the trust network as it is illustrated in the upper left corner in Figure 2.

To map the problem-solving network, a possible question to be launched to the project social network (to the elements that comprise each organization) that participated in the project phase between t and t-1 could be: whom do you turn to when you need to get a project related problem or issued solved?

The answers provided by each respondent would enable to map the problem-solving network as it is illustrated in the second row of boxes in Figure 2.

To map the advice network, a possible question to be launched to the project social network (to the elements that comprise each organization) that participated in the project phase between t and t-1

could be: *whom do you turn to when you need advice or guidance related to a project matter?* The answers provided by each respondent would enable to map the advice network as it is illustrated in the third row of boxes in Figure 2. The last network to be mapped is the communication network. This network is illustrated in Figure 2 in the last row with the grey lines in each of the boxes.

To map this network, email exchanged project related information is used. In other words, the information that regards project related matters is to be collected in a specific virtual platform, filtered, and used to map the respective communication network.

In this network (communication network) are comprised all the project related subjects that were discussed across a period between t and t-1.

The communication network is built by collecting all exchange email information between project participants. After that, the lines between any two given organizations represent the number of exchanged emails between them.

In other words, the grey lines that are represented in the lowest row of Figure two, represent the number of emails exchanged between any two organizations that took part in the project activities within in a period between t and t-1. The lines in this of the communication network are non-directional. This means that there is no direction to be mapped (in other words – preferences), rather the number of channels in a given cooperative project social network, and the respective number of emails exchanged.

For example, in the lower left corner of Figure 2, is illustrated the first communication network. In this network, there is a line, for example, between O1 and O3. This line represents an email communiciaotn channel between O1 and O3. The thickness of the line represents a certain number of emails exchanged, which can be classified in several levels that range from L1 up to Ll, as it is illustrated in the lower right corner box, with the description of Network Description. Such levels respect to a given number of exchanged emails and are totally customizable by the network analyst. As it is illustrated in Figure 2, the network´s arrangements may strongly vary between any two different ts, and for a given t, between the different networks (trust, problem-solving, advice, and communication).

The information to be collected to enable the mapping of the different networks, must be legally agreed by all intervenient parts, and in conformity with the global GDPR standards and locally policies.

4.2 Proposed model SNA centrality metrics

As previously mentioned, the proposed model in this work uses social network analysis centrality metrics to quantitatively characterize the different behavioural aspects regarding the dynamic interaction between dif–ferent project people (where the sum of the individual contribution respects the organization as a whole). In Table 2, are illustrated the SNA centrality metrics and objectives. To the proposed model in this work.

Table 3. Social Network Analysis centrality metrics and objectives for the proposed model

CN	Data origin	Objectives and SNA mathematical description
(1) Trust Network	***Project Survey***: Addressed to all Or–ganizations (to all organization´s mem–bers) that participa–ted in a given time period between t and t-1, within a given project lifecycle. The assessment is to be conducted in every desired point in time *t*.	Objective: Identify who trusts whom, regarding the discussion or sharing of information project related. SNA Metric name: In-degree $C_{ID}(n_i) = \sum_j x_{ji}$ (1) where: C_{ID} = total in-degree of a pro–ject participant in a network n = total number of project participants within a network for i= 1…, n x_{ji} = number of connections from an entity j to an entity I, where i≠j, and vice-versa.
(2) Problem-solving Network	***Project Survey***: Addressed to all Or–ganizations (to all organization´s mem–bers) that participa–ted in a given time period between t and t-1, within a given project lifecycle. The assessment is to be conducted in every desired point in time *t*.	Objective: Identify who has knowledge or connections to solve project or related matters or issues. SNA Metric: same as in (1)
(3) Advice Network	***Project Survey***: Addressed to all Or–ganizations (to all organization´s mem–bers) that participat–ed in a given time period between t and t-1, within a given project lifecycle. The assessment is to be conducted in every desired point in time *t*.	Objective: Identify who pro–vides advice to whom regarding project related matters SNA Metric: SNA Metric: same as in (1)
(4) Communication Network	***Project Emails***: Addressed to all Organizations (to all organization´s members) that participated in a given time period between t and t-1, within a given project lifecycle. The data collection is to be conducted in every desired point in time *t*.	Objective: Identify how many email communication channels exist and the number of emails exchanged. Identifies who is who is central and who is peripherical in the Project Email exchange Network. SNA Metric: Weighted In-degree $C_{WID}(n_i) = \sum_j x_{ji}$ (2) where: C_{WID} = total weighted degree of project participant in a network n = total number of project participants within network for i = 1…,n xji = number of links and their weight from project participant j to entity i, where i≠j, and vice-versa.

As it can be seen in Table 2, for the trust, problem-solving and advice networks, the In-degree centrality metric will be applied to quantitatively identify preferences regarding project related matters.

Regarding the communication network, the In-degree weighted centrality metric will be applied to quantitatively identify the number of email commu–nication channels and the respective number of exc–hanged emails between any two given project participants.

5. APPLICATION OF THE PROPOSED MODEL – A CASE STUDY

5.1 Introduction to the case study

The following application of the propose model in this work, took place in an organization that delivers Food and Beverage projects in Europe.

The Food and Beverage organization (named as Organization T in this work) planned the delivery of a project (named in this case as project A), and for that matter outsourced project tasks and activities to other organizations namely O1, O2, O3, O4, O5, and O6. Each of the organizations bring different competencies that are needed for the accomplishment of project A.

For the matter of the illustration regarding the application of the proposed model in this work, and due data protection legal aspect, no further details are need or may be illustrated over the participating organizations.

The objective of the application of the propose model in this work to the project A, is to effective and efficiently manage the different dynamic interactions that emerge across the different phases of the project´s A lifecycle.

The application of the proposed model will enable organization T, to understand how the different dynamic interactions emerge, and how they may influence the project A´s outcome (successful or unsuccessful).

For this matter, data has been collected in project surveys to map the trust, problem-solving, and advice networks by launching the three following questions to all organization's participants, respectively:

- whom do you trust to discuss project problems and opportunities without fearing retaliation or other undesired and intimidation actions? - To whom do you turn to when you need to get a project related problem or issued solved? and - To whom do you turn to when you need advice or guidance related to a project matter?

To map the communication network, all email project related exchanged information regarding participating organizations O1, O2, O3, O4, O5, and O6 was collected for the analysis period between t0 and t4.

Figure 3 illustrates the four different critical organizational cooperative informal networks. The interpretation of the generality of Figure 3, is to be made based on Figure 2 and the respective explanation that follows Figure 2.

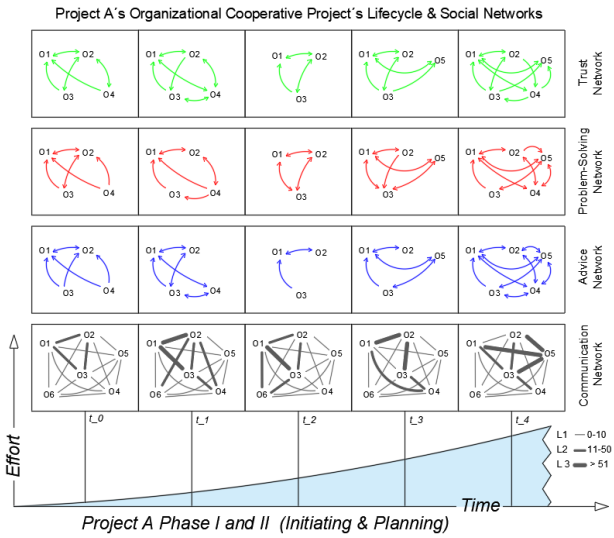

Figure 3. Results of the application of the proposed model to project´s A initiating and planning phases.

Figure 3 illustrates the results of the application of the proposed model in this work to project A managed by organization T in the project A initiating and planning phases. Both phases were compressed in to one phase – decided by organization T, and five assessment were made, which are in Figure 3 represented by t_0, t_1, t_2, and t_3. The time between each period comprised of t and t-1 is about 6 weeks. The analysis to be performed by organization T, comprises the longitudinal analysis type, which represents the evaluation of the evolution of the four different critical organizational cooperative informal networks across the mentioned period of time.

Regarding the communication network, three different levels have been defined. The first (L1) comprises the number of exchanged emails that ranges from 1 up to 10, the second (L2) comprises the number of exchanged emails that ranges from 11 up to 50, and the last and third (L3) comprises the number of exchanged emails that ranges from higher than 51.

From now own the longitudinal analysis will be illustrated, regarding the evolution of the different four critical cooperative informal networks that emerged across the initiation and planning phases of project A, as the different organizations (O1, O2, O3, O4, O5, and O6) cooperated to deliver project A.

In Figures 4 and 5, are illustrated the trust and problem-solving degree longitudinal evolution within the period t_0 and t_4 of project A.

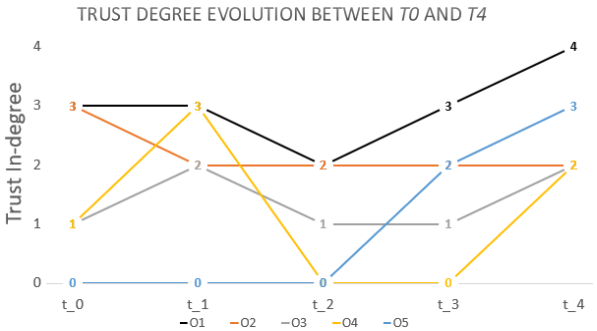

Figure 4. Trust degree evolution between t0 and t4 for project A

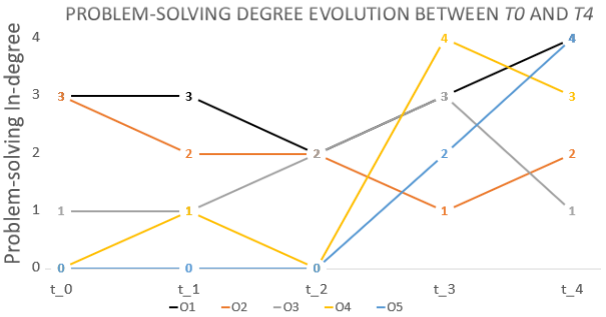

Figure 5. Problem-solving degree evolution between t0 and t4 for project A

In Figures 4 and 5, are illustrated the five different organizations characterized with different colours, and their dynamic evolution across period between t_0 and t_4 of project A´s initiation and planning phases.

As it can be seen in Figure 4, the evolution of the trust network is far from being constant across all participating organizations in the period between t_0 and t_4 of project A´s initiation and planning phases.

In an immediate form, the same note is to be applied to the network of Figure 5, which represents the problem-solving network in the period between t_0 and t_4 of project A´s initiation and planning phases.

For example, in Figure 4, organization O4 and O5 have the highest unstable behaviours regarding the trust network, when comparing them with the other organizations (O1, O2, O3). This high variability observed in O4 and O5 may represent that as the project evolves between t_0 and t_4, the trust degree fluctuates from 0 to a maximum of 3 and 4 respectively, introducing a certain working instability regarding how project tasks and activities are executed. For example, O5, only after t_2 onwards seems to have gained the trust from the other organizations regarding it contribute to project A.

The behaviour of O4 observed in the trust network may represent even a higher instability status in the cooperative network. In this case, O4 started to be a credited organization, but as the project moves across the timeline, it drops to a zero-trust level. This behaviour may represent a cooperative behaviour project risk, in the sense that introduces high instability in the project´s A social network, which in turn may lead to operational problems such as, delays, non-conformities, task and activities execution redundancy.

Furthermore, it may overload other organizations that by the fact that they lost trust in O4, they now must undertake some tasks that were previously assigned to O4. The instability observed in Figure 4, seems to have affected the problem-solving network illustrated in Figure 5.

Although, for example, there is very little variation in the behaviours of organizations O1, O2 and even to a certain extent O3 when comparing the trust network with the problem-solving network, for organization O4 and there is however a different evolution. O4 in the problem-solving network, seams to try to get influence within the project´s A social network, by taking a more dynamic approach. From t_2 onwards, O4 has strongly increased the dependency from the other organizations regarding the problem-solving network.

The behaviour should be very carefully analysed because it ay represents that something within the project´s A social network happened, and O4 has took a 180° shift regarding the problem-solving network. In other words, O4 become the central organization for problem solving. There may have been may different reason for the change in behaviour, and it would be strongly recommendable a follow up investigation to uncover the reasons behind it. The fact that O4 hast made a drastic shift special from t_2 onwards in the problem-solving network, may introduce cooperative behaviour risks. For example, it may lead to overload some of the O4 employees, or even lead to the emergence of knowledge silos within the project´s A social network.

In Figures 6 and 7, are illustrated the advice and communication degree longitudinal evolution within the period t_0 and t_4 of project A.

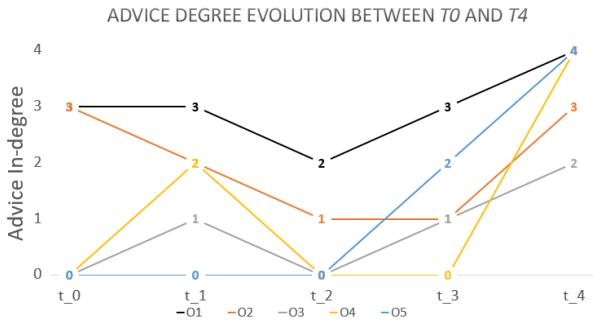

Figure 6. Advice degree evolution between t0 and t4 for project A

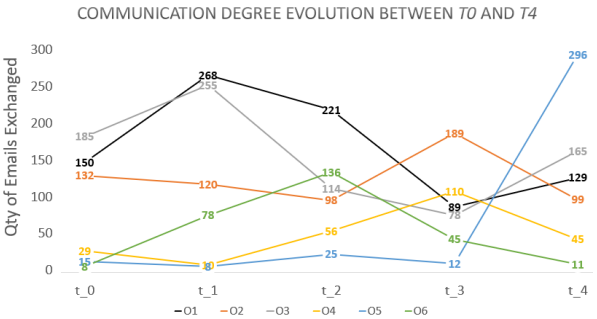

Figure 7. Communication degree evolution between t0 and t4 for project A

As it can be seen in Figures 6 and 7, the evolution of the advice and communication networks is far from being constant across all participating organizations in the period between t_0 and t_4 of project A´s initiation and planning phases.

In the advice network, the general fluctuation is more accentuated than in the previous two analysed networks (trust and problem-solving). This behaviour is to a certain extant normal, because before people head to someone to get help, usually people check with more than one person before. However, O1 presents an unchangeable behaviour in the advice network when compare with the other two already analysed in Figures 4 and 5. Again, O4, together with O5, have the highest fluctuation in the advice network which is in line with what was previously observed. This fact can be considered as quite normal, once advice, trust and problem solving are to a certain extent interrelated [1, 2, 7].

In the advice network, O2 presents a slight decrease between t_0 and t_3, which it may represent a loss of informal power in the mentioned period, while it remained pretty much constant in the trust network for the same period. The negative variation observed in the advice network, my explain the negative variation observed in the problem-solving network. The fact might have been that, although O2 has been decreasing in the number of times that was asked to solve a problem or provide advice, it kept his trust intact because it might have forwarded such requests to a trustable source (other organization's members).

In the communication network illustrated in Figure 7, it can be seen the variation of project related emails exchanged across the period between t_0 and t_4. It is clear to be observed that as the project evolves across the time lime, the number of exchanged emails strongly decreases. This trend should be later correlated with the outcome of the project in order to understand if there is a relationship between negative fluctuation of exc–hanged emails and project outcome. In the communi–cation network, O1 and O3, clearly dominate the exc–hanged emails network almost across the entire period.

All the other organizations remain quite stable. However, there is a new organization to be observed. This new organization – O6, has not participated in the surveys of the previously three analysed networks (trust, problem-solving, and advice).

O6 is an outsourced expertise organization that had very little direct impact in the project´s A social network. However, from t_3 onwards, this organization rockets its email communication exchange from almost a zero level up to the highest level ever observed in the period between t_0 and t_4 with an amount of 296 exchanged emails. This exponential growth may be due several different reasons, and it would be worth to follow up in detail why it evolved this way. For example, this abrupt increase of exchanged email, may be a sign of a late entrance of O6 in the project´s A, which may have introduced some instability in the project´s A social network. If that is the case, then we are facing a cooperative behaviour project risk. This behaviour may lead to dramatic consequences, if O6 is not able to cope with so much information at once, which in tur, among others, may lead to information delays and bottlenecking.

The description elaborated in this section regarding the four critical organizational cooperative informal networks, were just the high-level aspects that are quite visible to be observed at the naked eye when analysing the networks of Figures 4,5,6, and 7.

Much more insights can be taken if an exhaustive analysis is undertaken on the networks of

Figures 4, 5, 6, and 7, and thus get even a clearer picture on how the four critical organizational coope–rative informal networks evolved across the analysed period (t_0 up to t_4), and how such behaviours can ultimately impact on project´s A objectives and out–come.

6. CONCLUSIONS AND FURTHER DEVELOPMENTS

This paper contributes to create knowledge and foster a continuous development of the four scientific pillars that were used to develop the model in this work in a holistic and interrelated way. The propose model was developed under a multidisciplinary approach and can be applied to identify cooperative project behavioural risks by analysing how project stakeholders dynamically interact across the different phases of a project lifecycle applying SNA centrality metrics. The proposed model provides a novel approach regarding the management of project human resources across the typical different phases of a project Lifecyle (where its specificities and unique characteristics are provided by the project management scientific field) while simultaneously correlating such human resources dynamic interactions with project´s outcome. This in turn provides organizations a tool to improve their project risk management approaches and procedures by being able to - in a holistic and heuristic way -, effectively identifying, correlating, and monitoring in a timely manner project stakeholder behaviour that may put at risk project success. By applying SNA centrality analysis to quantitatively identify cooperative project behavioural risks, directly implies to point the importance of the research conducted in this work towards the organizational cooperative networks field. This fact, according to several specialized research already mentioned in this work ([1,2,7,8, 17,18, 20]), is fully aligned with the work is fully aligned with finest state of the art recommendations (approaches, tools and techniques), used to manage cooperative project risks, and the challenges of the industry 4.0 in the organizational context.

6.1 Managerial implications

The presented model in this work aims to support the management of project cooperative networks by analysing four critical organizational cooperative informal networks ((1) trust, (2) problem-solving, (3) advice, and (4) communication), that emerge, and organizations work in cooperative networks across the different phases of a project lifecycle.

From a managerial prespective, the presented model in this work, is designed to efficiently identify in a quantitatively way changes in project social behaviours, that may affect project activities or tasks. It directly addresses two cooperative project risks (behavioural and ambiguity risks) as proposed by [25, 24], respectively.

This will enable organizations to in a very simple and a timely manner access the variability of the dynamic interactions between different organizations that participate in the delivery of a project, enabling them to perform a more data informed decision making, to correct or support observed behaviours within the project social network.

As illustrated in the presented case study, the proposed model efficiently uncovers unbalanced cooperative behaviours that may emerge across the different phases of a project lifecycle, that ultimate may become unsustainable and unmanageable.

The proposed model in this work provides still a unique and valuable insight regarding the historic of the evolution of cooperative initiatives across the different phases of a given project lifecycle if therefore orga–

nizations have a recording system where cooperative project data can be recalled for further analysis. In this line of thought, the propose model in this work, provides organizations a measurable historic evolution regarding how cooperation between the different project stakeholders that did participate in collaborative projects, which enables to generate in a quantitative way the so-called lessons learned, that can be latter correlated to given project outputs and outcomes. This point may strongly contribute to the achievement of sustainable competitive advantages, in the short and long-term, concerning future cooperative partnerships.

The adoption of the proposed model in this work provides organizations a new way of working in the sense that triggers a new way of planning, thinking, and executing cooperative work, taking into consideration actual acknowledged cooperative aspects by organizations. This will contribute to a more efficient working culture, which according to research leads to a better business performance [31].

Finally, it is recommended that organizations integ–rate the proposed model in this work into a typical organizational business intelligence architecture to improve the general analysis process (data collection, data transformation, data calculations, speed, and dash–boarding), and thus minimize errors and spent time.

6.2 Academic implications

From an academic prespective, the presented model in this work uniquely contributes to each of the four key pillars that were used as base to development of the model.

As for example, in the SNA centrality metrics pillar, the quantitatively measuring capacity of the proposed model in this work, may trigger the development of new insights concerning the importance of the different roles in a particular social network in project outcomes.

Regarding the cooperative networks pillar, the propose model in this work enable to get a deeper insight on the importance of the different join work (partnerships) intensities across the different phases of a generic project lifecycle.

In the project management pillar and risk manage–ment pillar, the proposed model in this work provides a new view on how project human resources (stake–holders) should be managed, which may lead to the creation of new standards and approaches to project leadership and management.

Finally, it is recommendable that more SNA cent–rality metrics are applied to the information collected in surveys and in the email communication exchange, so that a 360° view on cooperative dynamic behaviours is able to be fully pictured.

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ПРИМЕНА АНАЛИЗЕ ДРУШТВЕНИХ МРЕЖА ЗА ПОДРШКУ УПРАВЉАЊУ РИЗИЦИМА У ПОНАШАЊУ КООПЕРАТИВНИХ ПРОЈЕКАТА

М. Нунеш, А. Абреу

Према неколико извора литературе и збирки пракси, ефикасна сарадња (кооперација) међу орга–низацијама у извођењу пројеката је критичан фак–тор успеха пројекта. Ипак, чини се да организације и даље оклевају да се укључе у кооперативне мреже више него што би се очекивало. Главни разлог за то - према неколико извора литературе - је недостатак ефикасних модела за подршку организационим кооперативним мрежама. У овом раду представљен је модел који доприноси управљању органи–зационим кооперативним мрежама, моделирањем ризика у понашању који се обично јављају када се организације укључују у кооперативне мреже ради извођења пројеката. Предложени модел развијен је на основу четири кључна стуба ((1) управљање пројектима, (2) управљање ризицима, (3) коопера–тивне мреже и (4) метрике централности за анализу друштвених мрежа), и анализира како се четири критичне организационе кооперативне неформалне мреже ((1) поверење, (2) решавање проблема, (3) савети и (4) комуникација), појављују и развијају у различитим фазама генеричког животног циклуса пројеката. Развој и имплементација предложеног модела је подржана студијом случаја.