A Model to Support OI Collaborative Risks Applying Social Network Analysis

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Abstract. Across the literature, is often claimed that the shortage of models to support projects in the collaborative dimension, creates distrust and pushes way organizations from those collaborative initiatives, such as the open innovation (OI). In the present work, a model based on three different scientific fields (Risk Management, Open Innovation, and Social Network Analysis), is introduces, aiming to support the management of OI projects. The model identifies project critical success factors (CSFs) by analysing three distinct collaborative dimensions (3-CD) that usually take place in OI projects - (1) Participation Degree, (2) Communication Degree, and (3) Response Agility Degree – of accomplished projects. Such CSFs can then be used to guide and estimate an outcome likelihood of upcoming or ongoing OI projects.

Keywords: Project management · Risk management · Sustainability · Social network analysis · Open innovation · Critical success factors · Collaborative networks

1 Introduction

The achievement of sustainable competitive advantages in the present complex and unforeseeable business landscape, compels organizations to develop strategies to boost their performance and innovation capacities [1]. Innovation and performance are dependent from factors, such as availability of resources, ability of top management to motivate a team [2], leadership style [3], ability of working in networks of collaboration [4], just to name a few. The last-mentioned factor is pointed as a major predictor of success regarding performance and innovation [5]. However, success is not proportional to the size of a given collaborative network, rather its quality measured in expertise diversity and reach [6]. Usually, most organizations alone do not hold the necessary resources and knowledge to efficiently innovate and perform, therefore they engage in networks of collaboration with business partners, customers, universities, in order to overcome those weaknesses [7]. OI [8], is one of the popular models in which organizations engage to overcome such weaknesses. However, despite the successful cases of the application of OI regarding innovation initiatives and organizational

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performance [7], organizations are not adopting it in a frequent way. This happens due the lack of existing models to support collaborative networks [8, 9]. Furthermore, OI does not properly work without the co-creation of value. This implies a trustworthy commitment between the different interacting entities, which not always is very easy to achieve. In the present work, a model developed based three different scientific fields (Fig. 1) (Risk Management, Open Innovation, and Social Network Analysis) provides support on the management of OI project´s collaborative challenges. The model identifies OI project critical success factors (CSFs) – by analysing three distinct collaborative dimensions (3-CD) that usually take place in OI projects: (1) Participation Degree, (2) Communication Degree, (3) Response Agility Degree – from delivered projects. Such CSFs can then be used to guide and estimate, the outcome likelihood of a given upcoming or ongoing OI projects.

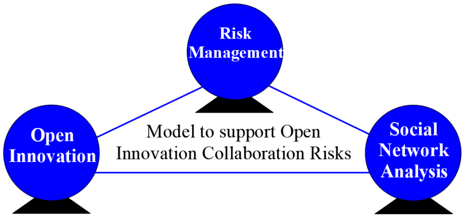

Fig. 1. The three different scientific fields that constitute the basis of the presented model

2 Literature Review

2.1 OI Benefits and Limitations

OI is an innovation model credited to Henry Chesbrough [8] and is considered a driver of organizational innovation [9]. OI can be defined as the use of inflows and outflows of knowledge and resources, to speed up internal organizational innovation [11]. OI states that organizations work together through networks of collaboration, sharing know-how, experiences, ideas, and technologies, to create value that they could not create if they worked in isolation [8]. OI has two different types knowledge and resources flows [8] – (1) outside-in (the most popular), and (2) inside-out. The first, when organizations use knowledge or/ and resources from the external environment. The second, takes place when organizations share their knowledge or/ and resources with the external environment. when both flow types simultaneously take place in an organization, can be called as a coupled flow type. This flow occurs through collaborative partnerships in forms of joint research, consortium, joint ventures, or others. Literature suggests, that OI positively contributes to the social, economic, and environmental sustainability [12]. Contrary to the closed innovation [7], OI enables organizations to increase the learning capacity, reduce costs of innovation, enlarge the diversity of R&D investments, facilitate new market´s entrance, share risks with OI partners, create new revenue streams, just to name a few [7, 12]. However, engaging in OI projects, may represent some downsides to organizations, such as higher dependence on external knowledge, less overall control over the innovation process, eminent risk of leak of confidential information and resources, less overall control over intellectual property, and so on [7, 12]. Research shows that, political, and culture issues, are the major constraints to OI [13]. Research identifies three major risk dimensions, that may emerge as organizations engage in OI projects [14]. They are: (1) pure risk or uncertainty (the probability of the occurrence of an event), (2) inherent risk of a innovation project (risks associated with resources, task duration, and costs estimations, political and regulation, risks), and (3) collaborative risks (comprises behavioral risks, task assignment risks to OI partners, and critical enterprises risks). Efficient collaboration is critical for OI projects, and it is critical be aware of the different dimensions that collaboration comprises. Before organizations engage into OI projects, research suggest that four critical dimensions of collaboration should be clearly understood. They are [10]: (1) Networking (comprises communication, information, and experiences exchange, usually without the existence of a common goal or structure to regulate timing and respective individual contribution), (2) Coordination (in addition to networking, comprises the alignment of the different activities, to efficiently achieve results, (3) Cooperation (in addition to networking and coordination, essentially comprises resource sharing, division of labor), and finally (4) Collaboration (in addition to the latest three, it requires trust, engagement, and the sharing of responsibilities and risks).

2.2 Risk Management and CFSs in Project Management

The PMI (Project management institute) defines project management as the application of skills, tools, knowledge, and techniques to project activities or tasks, so that project requirements across a project lifecycle are met [15]. As organizations deliver projects, risks (threats or/ and opportunities) emerge across a project's lifecycle. Such risks (usually threats), if not efficiently managed, will eventually lower the chances of a successful project outcome, which represents the non-alignment with at least one of the following project constraints - scope, cost, quality, schedule, or resources [15]. Project risk management expert [16] argues that here are four types of risks (Table 1) that may occur as projects are delivered, and for each, a proper management approach.

Other authors suggest that project risks, are in fact project critical success factors. Pinto & Slevin, 1988 [17] identified a set of project CSFs that alters their importance function of a given project phase. They are: (1) project mission poorly defined, (2) lack or inefficient top management support, (3) poorly project schedule definition, (4) poor or lack of client consultation, (5) lack of adequate expertise and technology, (6) insufficient team experience and skills, (7) ambiguous client acceptance, (8) inexistent proper project activities monitoring and feedback, (9) poor or inefficient communication, and (10) unable to deal with deviations from planned activities. To efficiently manage project risks, a wide-accepted risk management process is provided by the ISO 31000:2018 [18]. It consists of six well-structured steps, that identify, treat, and monitor risks. They are [18]: (1) establishing scope (clearly define risk management activities scope), defining context (define external and internal contexts) and criteria (define type and amount of risk that an organization is able to accept), (2) identifying risks (uncover and describe risks that may help or threaten organization´s objectives),

Table 1. Four types of project risks [16]

Risk types	Characterization	Suggested treatment approach
Event Risk	Also called “stochastic uncertainty”, or event risks, related to something that did not happened yet, but if it happens, will affect one or several project objectives	Well-established techniques supported in Risk Management Standards [49, 51]
Variability risk	Also called “aleatoric uncertainty”, are several possible known outcomes, but unknowing which one will really take place	Advanced analysis models: Monte Carlo simulation for example
Ambiguity risk	Also called “epistemic uncertainty” or know-how and know-what risks, emerge due the lack of knowledge or understanding. Include the use and application of new technology, competitor capabilities, market conditions, just to name a few	Learning from experience (lessons learned). Simulation and prototyping
Emergent risk	Also called “ontological uncertainty”, or “Black Swans”, can simply not be seen, because they are outside a human´s mindset or experience. Usually arise from game-changers result of disruptive innovations	Contingency planning

(3) analyzing risks (understand nature of uncertainties, risks and risks sources, consequences, events, scenarios, likelihoods, and risk controls), (4) evaluating risks (comparing results between risk analysis reports and defined risk criteria to identify where action is needed), (5) treating risks (define how and what treatment options will be implemented to treat risk, and measure its progress across time), (6) recording and reporting all previous steps (continuously monitor and review evolution of uncovered risks and the efficacy of implemented controlled measures).

2.3 The Application of SNA in Project Management

SNA can be defined as the process of studying and analysing social structures data using variety of metrics based on graph theory, which contributes to understand how social structures emerge and evolve across time, and their impact in the environment where they do exist [19]. SNA plays a critical role in understanding social capital issues and importance and has been adopted into organizational Risk Management Processes (RMPs) as a critical support tool in risk analysis and decision making [20, 21]. SNA studies and analysis talent shortages and retention, unethical behavior, network collaboration, innovation patterns, cultural fit, organizational and individual values, group and individual performance, fraud detection, just to name a few [22]. Although still at a very initial stage, SNA has been gaining huge popularity throughout the latest years, because provides unique insight in understanding the extent people´s behaviors and formal and informal relationships influences outcomes, such as performance, innovation, social cohesion, information diffusion, just to name a few [23, 24]. The application of SNA in project management essentially targets the identification of project CSFs regarding the dynamic of formal and informal project´s networks. Across literature, there are countless applications of SNA in project management. For example, Krackhardt, 1993 [6] argues that there are at least three critical project networks that are critical for the success of an organization. They are [6]: (1) advice network (uncovers actors to whom other actors go to get help to do their job), (2) trust network (uncovers actors where through sensitive information is exchanged), and (3) communication network (uncovers actors where through work-related information is exchanged). Rob Cross, 2004 [25] identified several unique organizational actors based on their location within a project social structure, which strongly impacts organizational performance and innovation. They are [25]: central connectors (central people where too many rely on for help or advice), boundary spanners (connect different organizational silos or departments), peripheral actors (isolated experts or non-integrated employees) and energizers (people that energize others). Most meaningful metrics used by SNA in organizations are centrality metrics [26]. Network centrality refers to the structural location of a given entity in a network, and measures a person's importance, influence, prestige, and control [25]. Network centrality, in a collaborative social network, is associated with informal power, which may influence decision-making and coordination [27]. Freeman, 1979 [28] defines centrality metrics, such as degree [26]- as an index of a network activity´s potential, betweenness [26] - as an index of communication control by connecting two different clusters of an network, and closeness [26] - as an index of independence network control potential. All mentioned metrics, but not only, will have impact in project outcome – successful or unsuccessful outcome [27].

3 Proposed Model Development

The presented model in this work provides support to the collaborative network risk´s management, in OI projects. First, the proposed model identifies OI project CSFs, by analysing the 3-CD that usually emerge in delivered OI projects. They are: (1) Participation Degree, (2) Communication Degree, and (3) Response Agility Degree. Second, after CSFs have been identified, these can be used to guide an upcoming or ongoing OI project, by estimating an outcome likelihood. In nutshell, the presented model aims to efficiently answer the following research question: to which extent does the dynamic collaboration of the different organizations that participate in a given OI project across all the distinct phases of a OI project lifecycle, conditions a project outcome? Answering the mentioned research question, is directly addressing the collaborative [14] and ambiguity [16] risk types, as organizations collaborate [10] in an outside-in, inside-out or coupled way [8] to deliver OI projects. The proposed model properly addresses both, collaborative and ambiguity risks types, in four different dimensions. First, the presented model is fully aligned with the suggested treatment approaches illustrated in Table 1 (lessons learned and simulation) for both risks suggested by [14] and [16], as it generates measurable information on how collaboration did occur from delivered OI projects, which in other words can be translated into lessons learned.

Second, estimating a project outcome likelihood, enabled by the comparison between identified CSFs and the actual evolution of an ongoing OI project, is doing a simulation of a possible future event, which as well represents a treatment approach suggested by [14, 16]. Third, the proposed model in this work analysis two (advice and communication networks) of the three organizational critical networks proposed by [6]. Fourth, the presented model applies SNA centrality metrics to identify behaviors associated with success or failure project outcomes, as suggested by [25–28] as being the most efficient and adequate tool to uncover dynamic relationships. The above-mentioned dimensions represent the contributes of both, SNA, and project management scientific fields, in the development of the presented model in this work. In Table 2, is illustrated the contribution of the risk management scientific field in the development of the presented model in this work.

Table 2. Contribution of the risk management process, to the presented model in this work.

Steps [18]	Proposed model corresponding process steps
"scope, context & criteria"	1-Select, collect, and prepare collaborative data (3-CD), from successful, and unsuccessful delivered projects
"risk identification"	2-Identification of unique collaborative behaviors (CBs) associated with successful, and unsuccessful delivered projects
"risk analysis"	3-Define and quantitatively measure project CSFs
"risk evaluation"	4-Quantitatively measure deviation between *actual status* of ongoing project and *desired status* regarding CSFs
"risk treatment"	5-Apply (quantitatively) actions to align ongoing project evolution with identified CSFs
"monitoring, and reviewing"	6-Continuously update the CSFs identification process (*continuous improvement cycle – self learning system*)

3.1 Proposed Model Functioning Principles

First, data from a set of successful (PSO) and failure (PFO) delivered OI project´s outcomes is collected according to Table 3. Collected information will be individually (project by project, phase by phase) quantitatively analyzed through the application of a set of SNA techniques & statistics, as illustrated in Table 3 (SNA Metric). Next, two project profiles will be generated. One project success profile (PSP) and one project failure profile (PFP). Both profiles, represent the average results of all individual results from all analyzed project data. In other words, it characterizes all the successful and unsuccessful delivered OI projects, respectively. Second, the proposed model initiates the identification collaborative behaviors (CBs) for both, PSP and PFP. Through a comparative process, each of the calculated metrics, will be analyzed (compared). At this point the model is looking for collaborative behaviors (CBs) that are unique to be observed in each project phase in both, PSP and PFP profiles. Third, if unique CBs are identified, means that OI critical success factors (CSFs) have been uncovered. In other words, the proposed model, has identified different dynamic collaborative behaviors - regarding the 3-CD dimensions - in projects that were successful delivered, from projects that were not delivered with success. It can also be concluded that project outcome (success or failure) is directly influenced by dynamic collaborative behaviors. If CSFs are not identified, then it can be concluded that project outcome is not directly influenced by organizational dynamic collaborative behaviors (CBs). Fourth, once having identified project CSFs, these can be used to guide and estimate the outcome likelihood of a given ongoing OI project. This implies, that for a given ongoing OI project, step 1 of the proposed model (according to Table 2) in this work process must be conducted for the respective time slot that characterizes the actual point (AP) (actual status of a project function of its project lifecycle status) of a given ongoing OI project, at the time of the assessment. In the assessment (according to Table 3) at the ongoing OI project, the same metrics that analyzed the set of delivered projects are to be applied (Table 3) for the respective time slot. For example, if an ongoing project is in the middle of phase 2 (according to the planed project lifecycle), then step 1 of the proposed model is to be conducted from the start of phase 2, until the middle of phase 2. At this point (AP) of the ongoing project, it will be generated an actual point project profile (APPP), which comprises the values of the metrics according to Table 3. Then, the values regarding the three collaborative dimensions (3-CD) of the ongoing project actual point profile (APPP) will be compared with the values of the collaborative dimensions (3-CD) of the PSP and PFP profiles, and the deviation between the actual status and a desired status will be calculated. Fifth, if the results show that the ongoing project results are not aligned with the results of the CSFs, then actions to bring the ongoing project back on track aligned with the values of the CSFs are needed. If the contrary, then the ongoing project - function of the 3-CD – is likely heading towards a successful outcome. The outcome likelihood will be estimated function of the highest percentage of metric-results pointing out towards success or failure outcome, unsuccessful or successful outcome, respectively. Finally, once the ongoing project is finished, undergoes all process previewed in this model for a delivered project, which will contribute to refine the identification of OI project CSFs. This step is representing the continuous improvement cycle, which can be considered an intelligent-learning system.

3.2 Proposed Model Application and Implementation

In Fig. 2, is illustrated the generic project lifecycle of phase pha of an OI project. In this phase participated six different organizations (O1, …, O6) where each contributed with a competence (a, …, f) respectively, illustrated at the competencies chart. In this phase, occurred five project meetings (E1, …, Et).

In each box above each meeting, are illustrated the organizations that participated in each meeting. The lines that link participating organizations, represent relationships degrees, which characterizes the number of times that any two organizations participated in project meetings. For example, O1 and O4, have a degree of 3 at the last project meeting, meaning they were together in three of five project meetings. The upper right box - ($\sum$ Emails) - represents the email communication channels between the organizations throughout all the phase *pha*. For example, applying (1) to O2, and O4, the participation evolution rates are for both negative (Fig. 3). Applying (2) to the email communication network, the density value is 53%, which represents a shared control (***Ds*** < 85%) network type (Table 3).

Table 3. 3-CD and respective SNA metrics of the proposed model in this work

3-CD	Proposed model description & metrics
Participation Degree (project meetings)	Objective: Analyze the participation of Key organizations (function of their competencies in the project) in face to face project meetings Required data: In each project meeting across a project phase, all the participating organizations should be record, as well as their competencies in the project SNA Metric: For this collaborative dimension, the centrality metric Total-degree [25] will be used to quantify the project meetings participating rate. For every key organization, a participating evolution rate will be traced with a simple linear regression $C_{DT}(n_i) = \sum_j x_{ji}$ (1) Where: C_{DT} = total degree of any given entity in a network (graph) n = total number of entities in a network, for i = 1, …, n xji = number of connections (links) from entity j to entity i, where $i \neq j$, and vice-versa The possible outputs are: 1- Negative slope (evolution): represents a decrease in the participation degree, as a given project phase heads towards the end 2- Positive slope (evolution): represents an increase in the participation degree as a given project phase heads towards the end 3- Neutral slope (evolution): represents a stable (continuously) participation degree as a given project phase heads towards the end
Communication Degree (project emails)	Objective: Analyze the density (reach) of the project email communication network and understand how a given organization holds control over that network. It is related with the importance of the communication network proposed by [6] Required data: All project exchanged emails within a given project phase, must be collected within a given time slot SNA Metric: For this collaborative dimension, the centrality metric Density [25] will be applied to quantify the spread or reach of the project email network in a project phase $Ds = \frac{N_{LREAL}}{N_{LMAX}}$ (2) Where: Number of maximum ties = $N_{LMAX} = \frac{n(n-1)}{2}$ (3) n = number of entities within a graph The possible outputs are: a. Total control: (Ds > 85%) one organization completely controls the email communication network throughout a given project phase

(*continued*)

Table 3. (*continued*)

3-CD	Proposed model description & metrics
	b. Shared control: (***Ds*** < 85%) one organization alone does not control, the email communication network throughout a given project phase
Response Agility Degree (project emails)	Objective: Analyze the feedback speed of an answer to an information- seeking sent email, regarding project activities. It is related with the importance of the advice network proposed by [6] Required data: All emails sent seeking/providing project data related with the chronologic timeline attached to each email SNA Metric: For this collaborative dimension, the centrality metric Reciprocity [25] will be applied to analyze which emails were replied (answered) with information project related, with the associated chronologic timeline to each pair sent/ received $\boldsymbol{R} = \frac{L}{\lvert L \rvert}$ (4) Where: L = Number of connections heading in both directions $\lvert L \rvert$ = total number of links within a network The output for the reciprocity metric is: A value in units of hours, that range from "1" (representing an instantaneous answer: < than 1 h period of time) up to "0" (represents the maximum duration of a given project phase in hours, for those cases where feedback is not found throughout the lifetime of a project in the respective email network)

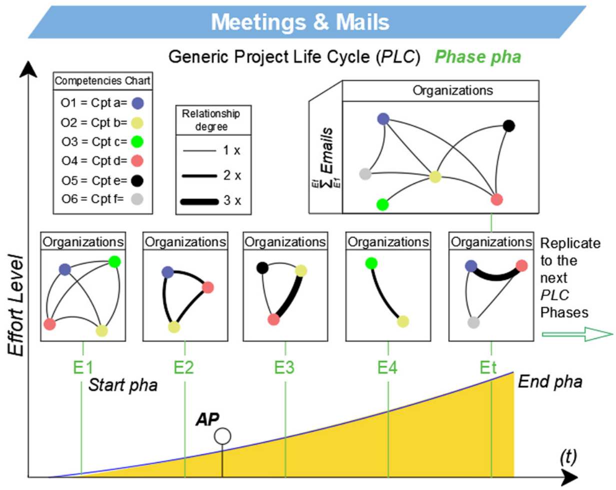

Fig. 2. Application framework of the presented model in this work

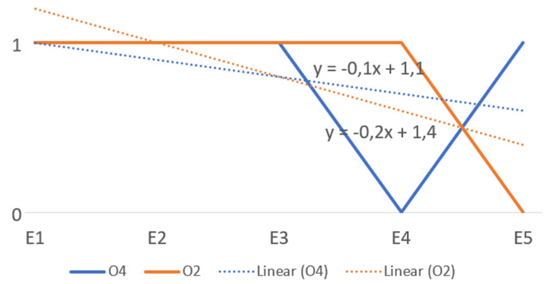

Fig. 3. Participation evolution rate for O2, and O4 according to Fig. 2.

If the project lifecycle of Fig. 2 represented a PSP, then the results regarding (1) and (2), would be CSFs. As conclusion, the participation degree evolution in project meetings of organizations that bring competencies b, and d, for future OI projects in phase *pha*, should follow the evolution (negative) illustrated at Fig. 3. Still, the email network communication, should be of *shared control* type, meaning that no organization holds completely control over it. Finally, for an ongoing project, data until the AP point (Fig. 2) should be collected and analysed. The results should then be compared with the results of the CSFs, and function of the deviation between actual status of ongoing project (AP) and desired status regarding CSFs, corrective measures should, or not be implemented.

4 Conclusions and Further Developments

As demonstrated in 3.2, the proposed model in this work, efficiently answers the research question presented in chapter 3. The proposed model generates valuable insight regarding to how past collaboration occurred (lessons-learned and working culture) between the different organizations that participated together in OI projects that had a successful and failure outcome. This enables organizations to eliminate or minimize behaviors associated with failure project outcome and replicate those associated with success. Quantifying collaborative behaviors, enables organizations to craft more data driven strategies, rather than traditional gute feeling approaches, and a more accurate management of intangible organizational assets. The presented model in this work, quantitatively measures two major risks - collaborative [14], and ambiguity [16] - that threatens the engagement of organizations in OI projects. The model proposed in this work, if efficiently implemented, is also a step forward in the organizational digital transformation strategy once it collects and analysis and interprets data in a fully automated way (self-learning system). Also, the collecting data process is non-invasive, and almost bias-free, by opposition to pulse surveys for example. Still, the proposed model, quantifies how much work is done through the mix of informal and formal networks of collaboration across an OI project. Finally, it contributes to the economic, social, and environmental sustainability by reducing risk associated with collaborative networks in projects, which in turn optimizes resources usage, and turns organization leaner oriented. However, the implementation of the model may be slow at an initial stage. This happens due a necessary change in the working culture of an organization, essentially regarding the data preparation, availability, and collection processes. Project related information that flows across phone calls and corridor chats, are not able to be collected by the model. In part this occurs due legal and ethical constraints, which ultimately can hinder the successful implementation of the proposed model in organizations. Finally, further research regarding the development of SNA metrics is recommended, to enable a deeper understanding to which extent organizational collaborative behaviors influence project outcomes.

References

1. Friar, J.: Competitive advantage through product performance innovation in a competitive market. J. Prod. Innov. Manag. **12**, 33–42 (2003)
2. Hansen, M.: Collaboration: How Leaders Avoid the Traps, Create Unity, and Reap Big Results; Harvard. Business School Press, Cambridge (2009)
3. Lutfihak, A., Evrim, G.: Disruption and ambidexterity: how innovation strategies evolve? Soc. Behav. Sci. **235**, 782–787 (2016)
4. Camarinha-Matos, L., Abreu, A.: Performance Indicators Based on Collaboration Benefits. Prod. Plan. Control **18**, 273–282 (2006)
5. Arena, M.: Adaptive Space: How GM and Other Companies are Positively Disrupting Themselves and Transforming into Agile Organizations. McGraw Hill Education, New York (2018)
6. Krackhardt, D., Hanson, J.: Informal Networks the Company behind the Charts. Harvard College Review, Massachusetts (1993). https://www.andrew.cmu.edu/user/krack/documents/pubs/1993/1993%20Informal%20Networks.pdf. Accessed 5 Mar 2018
7. Ullrich, A., Vladova, G.: Weighing the pros and cons of engaging in open innovation. Technol. Innov. Manag. Rev. **6**, 34–40 (2016)
8. Chesbrough, H.: The era of open innovation. MIT Sloan Manag. Rev. **44**, 35–41 (2003)
9. Santos, R., Abreu, A., Anes, V.: Developing a green product-based in an open innovation environment. case study: electrical vehicle. In: Camarinha-Matos, L.M., Afsarmanesh, H., Antonelli, D. (eds.) PRO-VE 2019. IAICT, vol. 568, pp. 115–127. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-28464-0_11
10. Camarinha-Matos, L.M., Afsarmanesh, H.: Collaborative networks. In: Wang, K., Kovacs, G.L., Wozny, M., Fang, M. (eds.) PROLAMAT 2006. IIFIP, vol. 207, pp. 26–40. Springer, Boston, MA (2006). https://doi.org/10.1007/0-387-34403-9_4
11. Huizingh, E.: Open innovation: state of the art and future perspectives. Technovation **31**, 2–9 (2011)
12. Rauter, R., Globocnik, D., Perl-Vorbach, E., Baumgartner, R.: Open innovation and its effects on economic and sustainability innovation performance. J. Innov. Knowl. 4 (2018)
13. Narsalay, R., Kavathekar, J., Light, D.: A hands-off approach to open innovation doesn't work (2016). https://hbr.org/2016/05/a-hands-off-approach-to-open-innovation-doesnt-work. Accessed 06 Sept 2018
14. Abreu, A., Martins Moleiro, J.D., Calado, J.M.F.: Fuzzy logic model to support risk assessment in innovation ecosystems. In: 2018 13th APCA International Conference on Automatic Control and Soft Computing (CONTROLO), Ponta Delgada, pp. 104–109 (2018)
15. PMI (Project Management Institute) Project Management Body of Knowledge (PMBOK® Guide), 6th edn. Project Management Institute, Inc., Newtown Square (2017)

16. Hillson. D. How to manage the risks you didn't know you were taking. http://riskdoctor.com/docs/NA14MTL02%20Hillson%20paper%20%20How%20to%20manage%20all%20your%20risks.pdf. Accessed 4 Jan 2020
17. Pinto, J.K., Slevin, D.P.: Critical success factors across the project life cycle: definitions and measurement techniques. Proj. Manag. J. **19**, 67–75 (1988)
18. ISO – The International Organization for Standardization. https://www.iso.org/home.html. Accessed 01 Jan 2019
19. Durland, M., Fredericks, K.: An introduction to social network analysis. New Dir. Eval. **2005**, 5–13 (2006). https://doi.org/10.1002/ev.157
20. Krivkovich, A., Levy, C.: Managing the people side of risk. McKinsey Global Institute (2015). https://www.mckinsey.com/business-functions/risk/our-insights/managing-the-people-side-of-risk. Accessed 15 Feb 2019
21. Nunes, M., Abreu, A.: Applying social network analysis to identify project critical success factors. Sustainability **12**, 1503 (2020). https://doi.org/10.3390/su12041503
22. Blacker, K., McConnell, P.: People Risk Management: A Practical Approach to Managing the Human Factors That Could Harm Your Business. Kogan Page Publishers, CPI Group (UK) Ltd, Croydon (2015)
23. Borgatti, S.: Introduction to social network analysis stephen, University of Kentucky (2016). https://statisticalhorizons.com/wp-content/uploads/SNA-Sample-Materials.pdf. Accessed 15 Jan 2019
24. Ruan, X., Ochieng, A.: The evaluation of social network analysis application's in the UK construction industry. ARCOM 2011 (2012)
25. Cross, R., Parker, A.: The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organizations. Harvard Business School Press, Boston (2004)
26. Wasserman, S., Faust, K.: Social network analysis in the social and behavioral sciences. In: Social Network Analysis: Methods and Applications, pp. 1–27. Cambridge University Press; Cambridge (1994). ISBN 9780521387071
27. Liaquat, H., Wu, A., Choi, B.: Measuring coordination through social networks. In: Proceedings of the ICIS 2006 Proceedings, Milwaukee, Wisconsin, USA, 10–13 December 2006
28. Freeman, L.: Centrality in social networks conceptual clarification. Soc. Netw. **1**, 215–239 (1979)