MDPI

Article

Project Manager Competencies for Dealing with Socio-Technical Complexity: A Grounded Theory Construction

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Abstract: An ongoing question is what constitutes the characteristics of a project manager. This is the subject of many studies. The characteristics, skills, abilities and knowledge of project managers—essential factors in a project's success—describe their level of competency. This study aims to assess the relationship between project manager competencies and project complexity in the information technology (IT) sector. In total, 21 semi-structured interviews were conducted with senior practitioners associated with complex IT projects in the private and public sectors. All transcripts were analysed through grounded theory and content analysis, with experts approving the results. Our study identified 41 competencies within project complexity, with these grouped under the following 10 dimensions: project management (PM) knowledge; management skills; interpersonal skills and attributes; professionalism; expertise; emotional skills; contextual skills; influencing skills; team working; and cognitive skills. According to this research, leadership is the core competency of a project manager, while project management knowledge is the most essential of these competency dimensions. This study's findings can assist both academics and practitioners in simplifying the complexity of projects and helping to achieve a project's objectives.

1. Introduction

A key factor in the success of projects is the appointment of a manager who fits the project. Hiring an inappropriate project manager lacking the required knowledge and experience can threaten the success of a project [1]. The roles of the people involved in any project are vital, and the importance of developing their maturity level is widely accepted [2]. Many studies have emphasised that competency is a vital factor in project success [3–5]. However, appointing an appropriate project manager is a critical challenge, as many dimensions must be considered [6].

The term 'competency' was first introduced in the management literature in 1973 by McClelland [7] and later entered the business environment. In 1982, Boyatzis presented the first competency model in the book *The competent manager: A model for effective performance*. Following this, managerial competence models gained impressive attention among scholars. To improve the model, organisations designed customised competency models suited to their contributions [8] to developing project manager competencies, with works by [4,9–13] outstanding.

To date, project manager competencies have been established by active organisations in the information technology (IT) sector. The first project management competency standards were introduced in the 1990s. The Project Management Institute (PMI), the International Project Management Association (IPMA) and the Australian Institute of

Project Management (AIPM) are the leading institutions providing standards of competency. Other countries, such as the United Kingdom (UK), South Africa, Canada, Japan and New Zealand, have established their own standards. The PMI produced the Project Manager Competency Development (PMCD) framework for general application in organisations, regardless of their nature, type, size or level of complexity [14–16]. Although these standards and frameworks have provided a foundation for further understanding, little has been written about the linkage between project manager competencies and the associated potential challenges and complexities, thereby providing a worthwhile area of research. Hence, the objective of this study was to identify project manager competencies related to project complexity in the IT sector. This article answers the following research question: what are the key project manager competencies concerning the complexity of large IT projects?

To answer this question, 21 semi-structured interviews were conducted among project managers in two organisations that constitute the main source of large-scale enterprise resource planning (ERP) system implementation projects in Iran. Open and axial coding was applied to analyse and interpret the data and to develop a framework for identifying and ranking competencies in IT projects.

This article is organised as follows. The literature is reviewed in Section 2; the methodology is introduced in Section 3; the results and discussion are presented in Section 4, and the article is concluded in Section 5.

2. Literature Review

2.1. IT Project Competencies

The current study determined competencies in the IT project context. In the prior literature, Skulmoski and Hartman interviewed 22 IT project managers and revealed that initiation, planning, implementation and closeout competencies related to different phases of a project. These comprised the following seven competencies: interpersonal attributes, communication, leadership, negotiations, professionalism, social skills and project management [17]. Dillon and Taylor ran a qualitative study that applied the grounded theory approach to assess the behavioural competencies required from IT project managers. Their interviews were conducted by applying the behavioural event interview method. These authors, in exploring the IT project context, found that project managers face technically complex situations, often with a high level of uncertainty. They found 25 behavioural competencies for IT project managers, which were then categorised into nine [2].

Erasmus et al. collected data from 220 IT project managers and ran a quantitative survey to determine the performance and personal competencies of IT project managers in South Africa [18]. Afzal et al. assessed the impact of project manager competencies on IT project success using four variables. They assessed communication, teamwork, attentiveness and conflict management as the four dimensions of IT project manager competencies [19]. Silva and Pejic-Bach determined the competencies of information systems (IS) project managers, with 107 project managers asked about the importance of 47 competencies extracted from the International Competence Baseline v.3.0 (ICB3) standard, with these ranked based on the survey results [20].

2.2. Competencies and Complexity

Researchers have emphasised the importance of identifying and reviewing the competencies of project managers in terms of project complexity. The complexity of projects has become a serious issue and an obstacle to their successful completion. To master these complexities, it is essential to identify the relevant management competencies of project managers [21]. Identifying managers' competencies in complex projects and finding the correlations with some complexity factors are addressed in the prior literature. Müller and Turner, in assessing the correlation between different leadership styles and varying levels of complexity in projects, found that: (1) emotional competency and communication have a positive correlation with the success of projects with medium and high levels of complexity,

and (2) an individual's competency in sensitivity contributes to the success of projects with a high level of complexity [22].

In 2007, the Global Alliance for the Project Professions (GAPPS) introduced a competency framework of 18 dimensions for low complexity projects and 21 dimensions for projects of high complexity. Rekveldt et al. assessed the competencies related to the technical, organisational and environmental dimensions of complexity and concluded that leadership competency is effective in these dimensions. Procurement and contracting competencies are advantageous for organisational complexity, while project engineering competency will be beneficial for addressing technical complexities [23]. In terms of the project environment, Thomas and Mengel found that the project manager should be endowed with competencies in shared leadership, social competence and emotional intelligence, communication and skills in organisational politics, and should value the importance of perspectives, values and beliefs [24]. Ochieng and Price used a framework to introduce the following eight dimensions: leadership styles, team selection process, cross-cultural management, team development process, intercultural communication, cross-cultural collectivism, cross-cultural trust and intercultural uncertainty as a project manager's critical dimensions for managing the complexity of multicultural teams in a construction project [25].

According to Müller and Turner, to manage projects of medium complexity, managers must be equipped with the following competencies: critical thinking, resource management, empowerment, self-awareness, sensitivity, influence and conscientiousness. In their evaluation of managers in very successful projects with a very high level of complexity, all of these competencies scored high in all aspects [1]. Vonk-Noordegraaf found that competencies such as social and communication skills and process management are essential in relation to complexities associated with the diversity of stakeholder views and stakeholder interdependence [26]. In 2012, the International Centre for Complex Project Management (ICCPM), at the request of the Australian Ministry of Defence, published the Competency Standards for Complex Project Managers, in which the competencies of managers of complex projects were discussed from nine different perspectives of concern [27]. Zhang and Fan assessed the following six dimensions of emotional intelligence: self-awareness, emotional self-control, empathy, organisational awareness, cultural understanding and communication as being essential for the success of large and complex construction projects [28].

Khattak and Mustafa interviewed experts and determined complexity factors and their correlation with the competencies of project managers of infrastructure projects in Pakistan [21]. By applying competencies in the International Competence Baseline (ICB) 2006, the Project Manager Competency Development (PMCD) 2007 framework and the technical, organisational and environmental (TOE) complexity factors' framework, these authors allocated project complexities into three categories (i.e., technical, organisational and environmental), thus adding new competency dimensions. Their study determined each competency's importance in the complexities dimension based on complexities scored by experts. These authors determined the scoring average of leadership competency through the number of goals, misalignment of goals and uncertain complexities of goals, obtaining this through responses from 22 interviewees. Based on this score average, they found the most important of the three expressed complexities to be leadership. The three new dimensions were then applied to confirm the 20 dimensions of the ICB and PMCD framework's behavioural and individual competencies.

In their qualitative study, de Rezende et al. assessed the competencies required for managers of complex projects in the Brazilian defence industry. They obtained 27 core competencies by conducting 22 interviews with senior industry managers. These competencies were grouped into 10 categories: influencing, communication, team working, cognitive skills, management skills, contextual skills, professionalism, project management knowledge, personal skills and personal attributes [29].

Studies in which the competencies of project managers have been assessed in relation to a project's complexities, complex projects or IT projects are tabulated in Table 1.

Table 1. Project manager competencies related to project complexity and IT projects.

Ref.	Country/ Context	Methodology	Top Competencies	Complex Project	IT Industry	Relationship between Competencies and Complexity Factors
[17]	Canada/Information system	33 Qualitative interviews	Personal attributes/ Communication/Leadership/Negotiations/ Professionalism/Social skills/Project management	✗	✓	✗
[3]	New Zealand/Information technology	Grounded theory method (GTM)/Behaviour event interviews	Internal and external communication/Project control/Project oversight/Higher authority involvement/Personal (project manager [PM]) characteristics/Project team selection and development/Use of technology/Adaptability/ Awareness of external issues	✗	✓	✗
[18]	South Africa/Information technology	Quantitative/220 Questionnaires	Ranking the existing competencies	✗	✓	✗
[19]	General/Information technology	Quantitative/250 Questionnaires	Ranking the existing competencies	✗	✓	✗
[20]	General/Information systems	Quantitative/107 Questionnaires	Communication/Engagement/ Motivation/Leadership/Reliability/ Results orientation/Conflict and crisis/Project orientation/Teamwork/Interested parties resilience/Ethics	✗	✓	✗
[2]	General/Engineering/ Construction/Information and telecommunication technology/Organisational change	Quantitative/400 Questionnaires	Intellectual/Managerial/Emotional	✓	✗	✓
[23]	General/Book chapter	-	Leadership/Procurement/Contracting/ Project engineering	✓	✗	✓
[24]	General	Review	Shared leadership/Social competence/Emotional intelligence/Communication/Organisational politics/Values/Beliefs	✓	✗	✓
[25]	Kenya and UK/Construction	Qualitative (20 Interviews)/Quantitative	Leadership styles/Team selection process/Cross-cultural management/Team development process/Intercultural communication/Cross-cultural collectivism/Cross-cultural trust/Intercultural uncertainty	✓	✗	✗
[28]	International companies/construction	Survey (112 Questionnaires)	Emotional self-awareness/Emotional self-control/Empathy/Organisational awareness/Cultural understanding/Communication	✓	✗	✓
[21]	Pakistan/Engineering infrastructure	Qualitative (32 Interviews)/Quantitative (85 Questionnaires)	Project characteristic-related/Contractor-related/Market criteria-related/Contract criteria-related/Client criteria-related	✓	✗	✓
[29]	Brazil/Defence	22 Interviews/Content analysis	Influencing/Communication/Team working/Cognitive skills/Management skills/Contextual skills/Professionalism/Project management knowledge/Personal skills/Personal attributes	✓	✗	✗

Despite the availability of many IT project studies that intended to identify the competencies of project managers, these studies were run on complex IT projects. Therefore, the development within these studies of competencies related to complexities is rare. More studies need to be run, as complex projects have unique characteristics, each of which should be addressed separately. These infrequent studies are in other industries, such as [1], which considered engineering, information and communications technology (ICT), and organisational change projects. The work of [24] generally reviewed and discussed complexity-related competencies. Moreover, [21] investigated project competencies dealing with complexity in the context of engineering infrastructure projects. These studies shaped a valuable foundation regarding the importance of studying project managers' competencies in relation to the complexity of projects. On the other hand, IT projects have a high degree of complexity. They are highly capital intensive, involve diverse experts and stakeholders, are conducted over relatively long periods, absorb an enormous level of components and resources, and run in a competitive and inter-connected environment. As technology advances, IT projects grow in scale and scope and become more challenging to implement. Therefore, recognising and managing IT projects' complexity are essential and challenging in the industry [30].

Generally speaking, two leading approaches are used to define and assess competency [31]. In the first attribute-based approach, interpersonal attributes, such as knowledge, skills, values, attitudes and other characteristics, are identified and assessed. Competency is inferred based on the presence of the necessary attributes. In the second performance-based approach, work outcomes and performance levels are identified and assessed. Competency is inferred based on the demonstrated ability to satisfy the performance criteria.

The approach of the current research was attribute-based [31], and the questionnaire in this study was based on the findings of Eftekhari et al. [32] with the following [33,34]. In their study, they developed a mid-range theory to assess complexity factors in IT management projects in Iran and identified the following eight categories of factors: diversity, context, transparency, knowledge and skill, interdependency, trust, regulations and sanctions [32].

The 19 subcategories, identified by these authors are as follows: variety in product components; technological newness of the project; multiple and diverse stakeholders; multiple offshore teams; cultural and regional types in project teams; conflicts between stakeholder goals; constant changes in project scope; the project context's traditional environment; barriers to the transparent transfer of employers' requirements; non-tangibility of project progress for the employer; non-certainty of project objectives; the employer's lack of knowledge and project literacy; unofficial team members; lack of appropriate management method to fit the project; interdependencies between departments and the organisation; interface count in the project organisation; lack of trust; non-compliance with state regulations with the rapid change in IT; and sanctions.

3. Research Methodology

In the current study, the competencies necessary to better manage complexity factors in IT projects were assessed by adopting the qualitative approach. Understanding the role of competencies in managing project complexities was the focus. With competency one of the essential aspects of complex projects and an aspect that should be considered a high priority [35], many IT projects fail partly due to the inability and inefficiency of project managers when encountering challenging conditions related to their competencies [2]. The grounded theory method (GTM) was adopted in the study to obtain more reliable results, with the authors having to collect data from multiple sources to ensure the internal validity of the results, which could then be triangulated [36]. Data were collected from three sources. As confirmatory evidence, the authors used archival materials and direct observation of projects, in addition to semi-structured interviews with interviewees. The interview process involved seven stages, as described by Kvale and Brinkmann in [37] and Kvale in [38], and are shown in Figure 1.
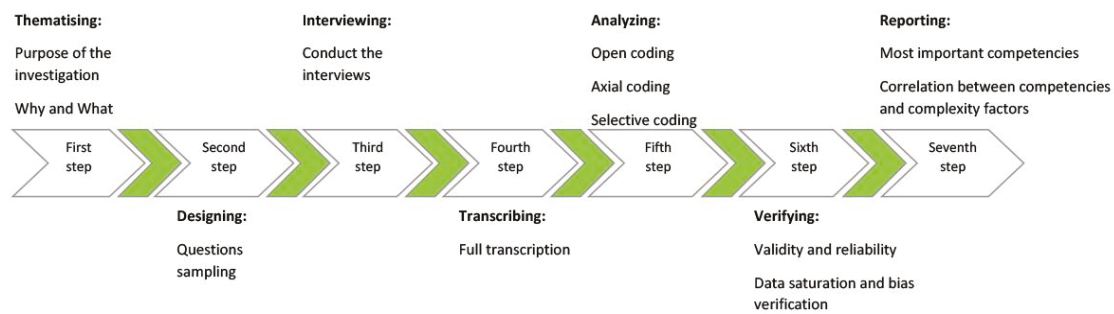
Figure 1. Research methodology.

Step 1—Thematising: the purpose of the study was explained before the interview begins, and the 'why' and 'what' were described before specifying the research method. The 'why' was to identify and understand the competencies of managers for complex projects in the IT industry which, according to Afzal et al., are a critical factor in the successful delivery of these projects [19]. The question to answer is: what is the essential component that contributes to the competencies needed when managing complex factors?

Step 2—Designing: this involved determining question content and explaining the sampling. Special steps were followed to ensure the validity of the questions in order to achieve practical results. The interview questions were devised by resorting to the related literature and complexity factors in IT project management [32]. A pilot interview was conducted with two experts experienced in complex IT projects to provide appropriate feedback and improve the interview questions beforehand. The focus was on complex IT projects, examples of which have more complexities compared to many other sectors and industries [29]. As IT projects often require high-level and innovative technologies, this leads to a high level of uncertainty. Ever-changing requirements, software and hardware issues, security issues and lack of necessary skills at different levels are other features of concern in projects in this industry. The IT industry provides the best context in which to understand the role of competencies in managing project complexity. In selecting the sampling method, the characteristics of the IT industry were of concern. Due to security reasons, access to some IT project data was limited. Due to non-disclosure agreements with their employers, staff in some organisations did not want to cooperate with a research team. In this research, a purposive sampling technique was applied.

Step 3—Interviewing and data collection: firstly, a list of regional companies active in the IT field was collated to enable selection of the most appropriate and experienced experts. Next, a list of project managers, specialists and university professors with experience in large IT projects was compiled, with 40 candidates from this list then notified by email about the interview. Based on their willingness to participate and their authority and access to project documents, only 21 were selected for interviews (see Table 2).

Due to the COVID-19 pandemic, the data collection took about 7 months (February–August 2020). Each interview lasted between 60 and 100 min (a total of about 26 h) and, with the interviewee's consent, was recorded for subsequent analysis.

Step 4—Transcribing: after being recorded, each interview was fully transcribed to obtain the most information and data for analysis. The interviews ceased when the research reached theoretical saturation, with no new information obtained.

Step 5—Analysing: this took place by adopting the GTM from the literature and applying this method to the information collected for coding [39]. The GTM is a qualitative and systematic method that introduces a theory [40]. The coding process is applied to analyse the data, according to [41], and textual data are interpreted by identifying the themes/patterns, according to [42]. Open coding was applied as the basis of the analysis, in which the interviews were carefully reviewed, and similar data with the same concept were assigned to standard codes. Appropriate concepts were assigned to the interviewees who expressed what they had described. This was followed by axial coding; that is, views and concepts with the same characteristics specific to their expressions (quotations) and

common ideas were grouped together. Selective coding was applied to select the core, through which the similarities and dissimilarities of the concepts obtained from axial coding were identified, and concepts with similar characteristics were categorised. The competencies were determined based on their impact on the complexity of IT project management and were categorised according to their commonalities.

Table 2. Demographic descriptive statistics of interviewees.

Demography	Dispersion	N	n (%)
Age range	30–35	11	54
	35–40	5	23
	40–45	3	14
	45–50	2	9
Education level	BS/BA	0	0
	MSc	15	68
	PhD	6	32
Years of experience	<5	1	5
	5–10	10	48
	>10	10	47
Field of experience	Project manager	6	33
	Project control and planning manager	2	9
	PMO manager	4	18
	Marketing department manager	1	4
	Portfolio manager	2	9
	IT manager	3	14
	Expert Project Manager Office	2	9
	University faculty member	1	4
Sector type	Public	1	5
	Private	18	86
	PPP	2	9
Overall		21	100

Note: PPP = public–private partnership.

Step 6—Verifying: the data obtained were evaluated for validity, reliability, theoretical saturation and bias. To assess validity and increase reliability, coding and transcribing of the interviews took place simultaneously, with interviewees assessing the open coding. After reaching theoretical saturation and completion of the coding, six experts (from the 21 interviewees) were selected to confirm the results and categories and remove misunderstandings. The selection criteria consisted of the experts' willingness to participate and the level of their accessibility to project information. This step required face-to-face meetings with the interviewees. The theoretical data saturation was obtained after 18 interviews (Figure 2). No bias was found in the interviewees' responses.

Step 7—Reporting: the competencies expressed by at least half the interviewees are emphasised in the Results and Discussion section below, with these grouped into two categories to identify the importance of these competencies for project managers. As the presented competencies were obtained by focusing on complexity factors [32], the correlation between both concepts was also reported.
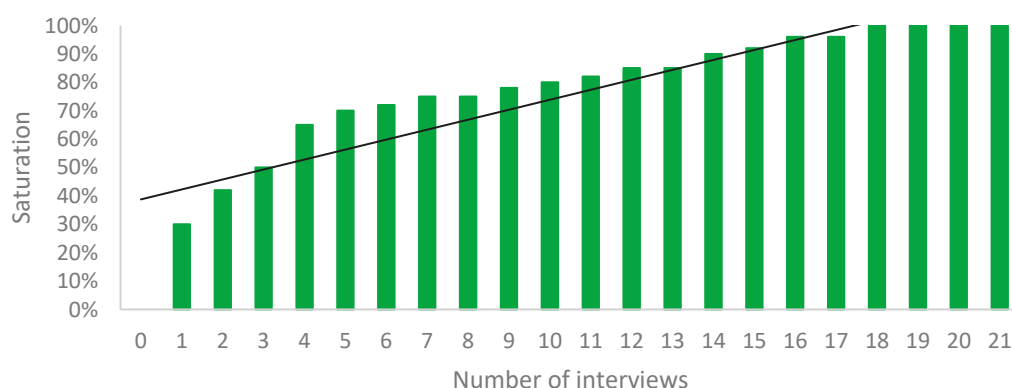
Figure 2. Data saturation.

4. Results and Discussion

Analysing and coding the interviews, as conducted in the open coding stage, led to the discovery of 41 competencies (see Table 3). The table reports the results of an in-depth scan of the interviews with IT project experts when they were asked to describe their experiences and how to confront the complexities they encountered in projects.

Table 3. Open coding concepts, ranked by the count of the quotation per concept.

Concept Code	Concepts	Interviewees	Quotes
X	Leadership: leading the team in difficult situations and performing the right task	20	41
I	Planning skills: precise planning and updating enables successful management	20	37
A′	Results orientation: seeing the big picture and focusing on the results	18	34
B	Experience: reflecting and learning from experience	20	34
V	Motivating the project team: motivating the project team with an awareness of the cultural differences at the operational level	19	32
W	Problem solving: finding the best possible solution based on the existing conditions	20	30
A	Technical expertise: the necessary knowledge for managing technical tasks, technologies and systems	19	29
C	Integration management: assisting teams to work together in a more integrated manner	17	29
D	Change in management: changes in the project plan must be managed in an integrated manner	17	27
G	Management uncertainties: risks are manageable when uncertainties are viewed as matters of concern	12	27
J	Agile methodologies: agility in the management approach	18	27
P	Commitment: accepting the highest level of responsibility and being committed to the project	20	26
E	Coordination and organisation skills: meeting deadlines, decision-making, delegation, organising and coordinating different groups, etc. in a team	19	25
F	Monitoring and controlling skills: constant monitoring of the cost, time, quality, safety, dimensions, etc., and periodically re-evaluating project objectives	18	25
H	Stakeholder management: managing internal and external stakeholders and their contribution to project implementation	16	23
G′	Systems thinking: considering the project and its elements as a system and realising the impact of a decision	12	20
N	Business expertise: data analysis, understanding the economics, negotiation, etc.	18	19
O	Strategic thinking: trying to answer questions on which long-term success depends	9	19
T	Political awareness: being sensitive to public policies and state performance	9	19
U	Accountability: being responsive to the effects of an action	15	19
S	Team building: choosing the right experts	15	19
F′	Contract law: drafting contracts that correspond to the level of complexities and uncertainties of the project	14	17

Table 3. *Cont.*

Concept Code	Concepts	Interviewees	Quotes
Z	Supporting those involved: providing encouragement and assistance to those involved	10	17
H′	Empowering others: providing permission, authority and legal rights to those involved	16	17
J′	Adaptability: responding to unforeseen circumstances, adjusting after the occurrence of an event or problem. showing flexibility in different situations	14	16
L	Managing stakeholders' expectations of the project	8	15
K	Configuration management: knowing how to respond when encountering issues and how to solve them in a short period while stopping their multiplicity	9	14
D′	Prioritisation skills: determining which tasks, works, expenditures and objectives should be addressed first	10	14
E′	Simplifying complexities: proportioning complexities into single concepts/ability to convert a complicated module into several simple modules	7	13
I′	Persuasiveness: having the power to induce action or embrace a point of view in critical situations/ability to convince senior managers, stakeholders and the project team in critical situations	11	12
Q	Ethics: observing ethical principles in the workplace/being aware of ethical principles in customer relations	8	12
T′	Networking skills: networking for project goals/strong networking in business environment	5	12
L′	Courage: being courageous in decision making/courage in innovation/courage in actions	7	10
M	Stress management: controlling stress within its context	6	9
N′	Empathy: showing empathy with the project team/showing empathy with critical stakeholders in critical situations	4	9
B′	Creativity: using new methods/taking the right action in stressful situations	5	6
C′	Self-control: having self-control	5	6
R	Recognition of the project's cultural dimensions	2	3
K′	Effect on organisation strategy	1	2
P′	Sustainable thinking	1	2
M′	Effect on the team's value	1	2

The competencies obtained from the axial coding process were grouped, with this process making possible the discovery of correlations and commonalities among the competencies. The 41 competencies extracted from the coding stage were placed in the following 10 groups: project management (PM) knowledge; management skills; cognitive skills; expertise; influencing skills; professionalism; contextual skills; interpersonal skills and attributes; emotional skills; and team working. To classify this stage, the study reviewed the related literature (see Appendix A).

4.1. Correlations between Competencies and Complexity Factors

The correlations between competencies and complexity factors were carefully assessed to determine the competencies required to manage complexity in IT projects (see Figure 3, Appendix B).

As observed in Figure 3, the 41 competencies comprised 22 competencies in Cluster 1 (in red) and 19 competencies in Cluster 2 (in blue). Cluster 1 referred to those competencies in which more than 50% of interviewees expressed their interest for managing complexity in IT projects. Due to the high content of complexities and competencies, Cluster 2 collated the complexities referred to by less than 50% of interviewees. In Figure 3, each circle (group) contains the quotations associated with each of the competencies obtained in the open coding process. The line thickness connecting the circles reveals the correlation rate between each competency and complexity category.
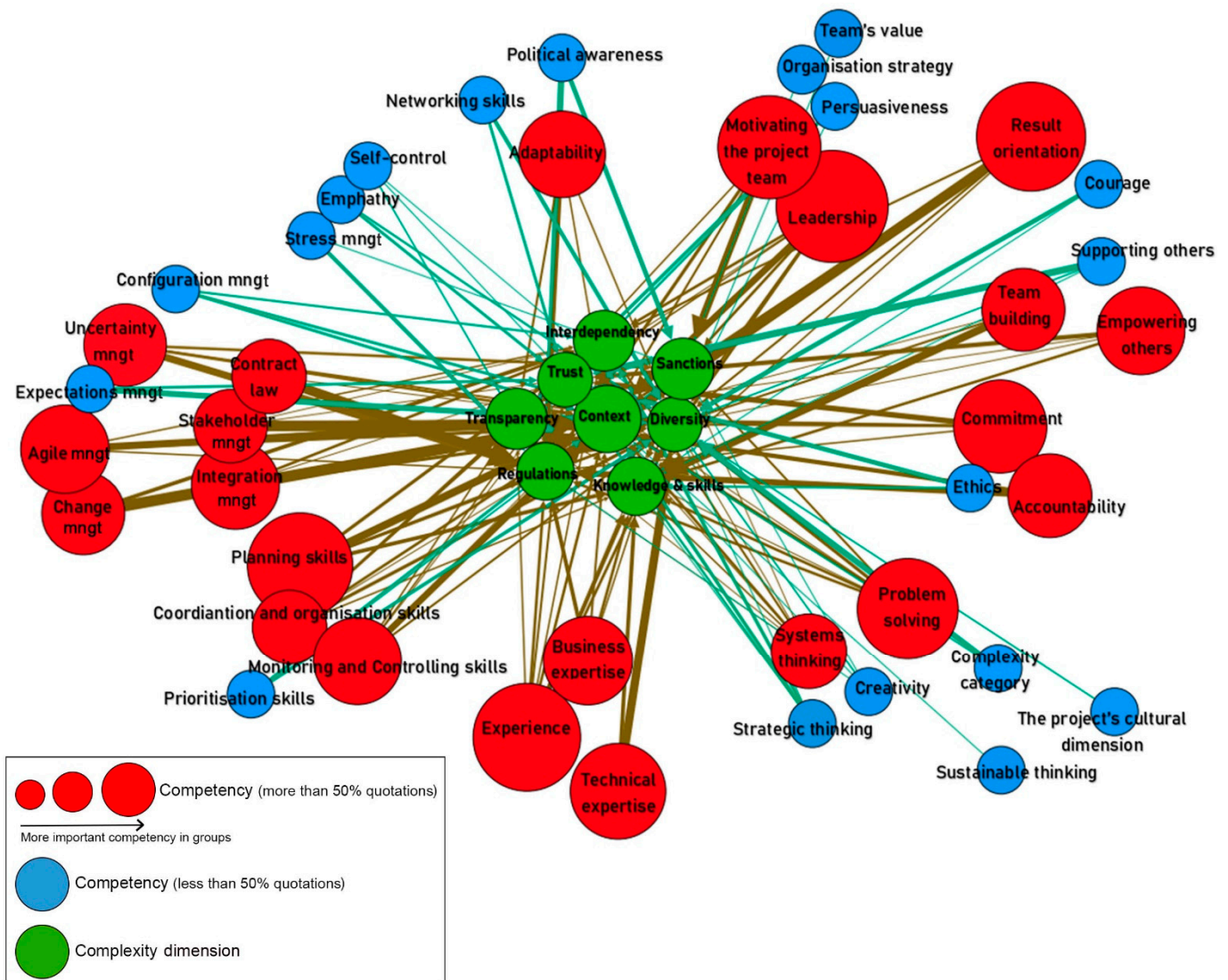
Figure 3. Network of correlations among the competency and complexity categories.

As observed in Figure 3, leadership, planning skills, results orientation, experience and motivating the project team were the five conceptual components referred to by most interviewees. Most referred to context complexity as change management; most referred to diversity complexity as stakeholder management, and most referred to knowledge and skills complexity as team-building skills and accountability. The interviews revealed a total of 25 competencies that related to context complexity, among which most expressions referred to the competencies of management skills, PM knowledge and leadership. The correlations of the competencies with each of the complexity categories are shown in Appendix B, and Figure 4 depicts required competencies to manage IT project complexities (CITC).

The 16 competencies in the PM knowledge, interpersonal skills and attributes, professionalism and expertise groups constituted the individual competencies (IC) set of dimensions, accounting for about 43.9% of the total competencies required to manage the complexity of IT projects. The other 25 competencies in the management skills, emotional skills, contextual skills, influencing skills, team working and cognitive skills groups constituted the social competencies (SC) set of dimensions, comprising about 56.1% of the competencies. About 47.07% of expressions referred to IC, while SC were referred to by about 52.92% of expressions. In this article, the focus is on IC, which form Cluster 1.
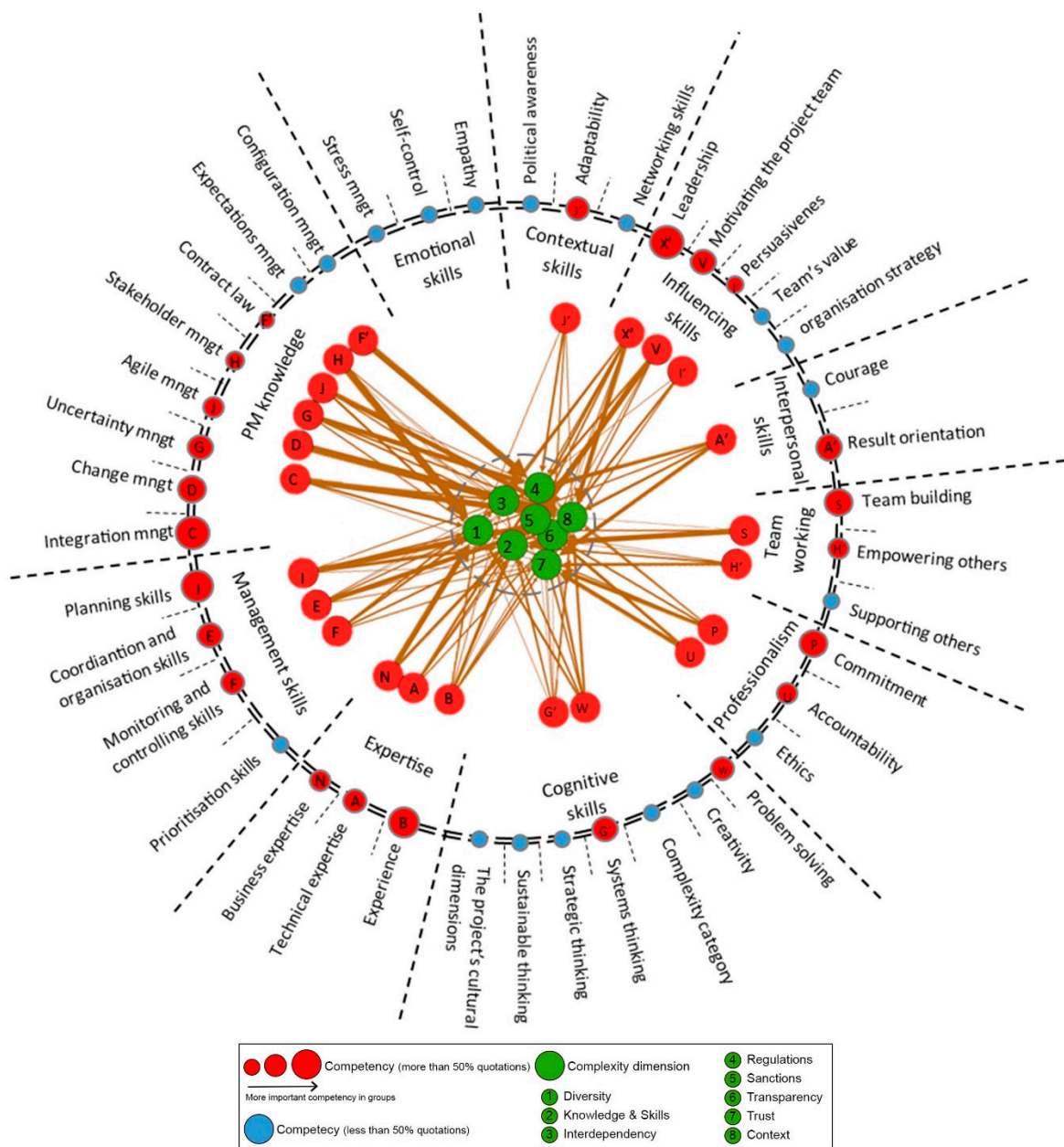
Figure 4. Competencies to manage IT project complexities (CITC). Note: mngt = management.

4.2. Individual Competencies (IC)

This set consisted of four groups of competencies, comprising PM knowledge, interpersonal skills and attributes, professionalism and experience. These groups describe the characteristics, abilities, skills and individual capabilities of project managers.

4.2.1. Project Management (PM) Knowledge

With 179 expressions (quotations), the PM knowledge group ranked the highest of all groups, with eight competencies comprising: agile methodologies (18 interviewees [85.71%]); integration management (17 interviewees [80.95%]); change management (17 interviewees [80.95%]); stakeholder management (16 interviewees [76.19%]); contract law (14 interviewees [66.66%]); uncertainty management (12 interviewees [57.14%]); configuration management (9 interviewees [42.85%]); and expectations management (8 interviewees [38.09%]).

Although two competencies in this group were placed in Cluster 2 competencies, including configuration management, they were considered essential. According to [43,44],

expectations management is a crucial factor in the success of IT projects [36,45]. The Cluster 1 competencies in the PM knowledge group were related to the complexity group and comprised diversity, regulations, interdependency, sanctions, transparency, trust and context.

The agile methodologies, having expanded from IT industry projects to other industries and performing effectively in situations of uncertainty [46], were highly regarded by the expert interviewees owing to their abilities to deal with volatile requirements. Due to the continuous changes and uncertainties during IT projects, the lifespan of their methods and approaches should be prolonged to promptly react to situations, thus being effective when facing complex conditions and complexity. Based on interviewees' descriptions, the agile methodologies address complexities such as regulations, interdependency, transparency, context and diversity.

According to the PMI, integration management knowledge consists of "processes and activities to identify, define, combine, unify, and coordinate the different processes and project management activities" [16]. According to de Rezende et al., integration management knowledge is one of the core competencies in complex defence project management [29]. As reported by the interviewees, some of the complexities related to IT project management are affected by the integration management implementation process. In contrast, some projects, owing to a high count of stakeholders and users and the project lifespan motivators, through proper implementation may face less complexity. Integration is one of the competencies required to design and integrate the physical components of the product as a project. Integration management is related to complexities in trust, interdependency, context and diversity.

Project plan changes, due to their effects on different dimensions, are essential; consequently, some experts name this change leadership [47]. The management knowledge competency is related to factors that fall into the complexity categories of context and interdependency. According to [9], project managers are named as the change agents, and more than 80% refer to this as being essential change.

Another competency in the PM knowledge group essential in managing IT projects' complexity is stakeholder management knowledge. Often, IT projects have many users who are the project's key stakeholders [32], and as their count and diversity increase, their management becomes difficult. According to the PMI, the use of stakeholder management knowledge, applied as one of the nine areas of project management knowledge, is effective in managing complexities in the categories of diversity, interdependence, trust and transparency [16].

In IT projects, to better manage the complexities of context and regulations that often have a significant impact on contract clauses, it is important for the contractual parties to have a broad knowledge of contract laws and the rights therein. The lack of this knowledge is the primary cause of most disputes.

Uncertainties in a project, next to the known (known unknowns), contain unknowns (unknown unknowns) [48]. According to [49–51], uncertainties in any project are inevitable, and regardless of their rate, they directly affect project execution. This factor in contract and project management was one of the competencies referred to by more than 50% of the interviewees. Uncertainty management knowledge is related to complexities, such as diversity, regulations, sanctions and context.

4.2.2. Interpersonal Skills and Attributes

Results orientation (18 interviewees [85.72%]) and courage (7 interviewees [33.33%]) were grouped under the interpersonal skills and attributes group and addressed in 44 expressions. According to this study's results, a correlation was found between the results orientation competency and better complexity management. This competency is effective in managing the complexities of diversity, regulations, interdependence, knowledge and skills, trust and context. In any industry, the project manager's focus should be on the project outcomes, not the process, with this described through the results orientation competency [21].

4.2.3. Professionalism

With a total of 57 expressions, the professionalism group, with the following three competencies: commitment (20 interviewees [95.23%]); accountability (15 interviewees [71.42%]) and ethics (8 interviewees [38.09%]), ranked sixth among the 'competencies to manage IT project complexities' (CITC) groups. Although less than half of the expert interviewees (38%) focused on ethics, this competency in Cluster 2 was considered one of the most critical aspects of project management and affects complexity management. Commitment and accountability, focused on by more than 70% of the interviewees, were in Cluster 2. According to the interviewees, commitment is related to the complexities of diversity, regulations, transparency, trust and context, while accountability is related to transparency and trust.

Managers of complex IT projects, as in many other industries, must make many decisions throughout the project lifespan and must be committed. In complex situations, this competency builds trust between the project team and key stakeholders and can be effective in managing complexities.

4.2.4. Expertise

The expertise group consisted of three competencies, with these expressed by more than 50% of interviewees. A total of 82 expressions extracted from 20 interviewees (all of whom were practitioners) indicated the consensus regarding this group. The competencies of the expertise group comprised technical expertise (19 interviewees [90%]); experience (20 interviewees [95.23%]); and business expertise (18 interviewees [85.71%]).

According to descriptions provided by the expert interviewees, this group of competencies is common in all categories of complexities. Technical expertise is related to knowledge and skills, sanctions and diversity, while business expertise is related to regulations, sanctions and knowledge and skills. As expressed by all interviewees, expertise is effective in managing all groups of complexity, complementing knowledge and providing better knowledge capability, and is an essential aspect of managing complexity in IT projects.

The necessary knowledge and skills for managing technical tasks, technologies, products and systems are described through technical expertise [29]. In a complex project with many interfaces and interacting components, sufficient expertise with related technology is the appropriate way to address complexity. When an organisation's strategic goals are influenced by its business environment or the project's goals rather than being aligned with the organisation's business goals, business expertise performance contributes highly to managing complexities.

4.3. Social Competencies (SC)

The social competencies (SC) set consists of the category groups of management skills, cognitive skills, influencing skills, contextual skills, emotional skills and team working.

4.3.1. Management Skills

Management skills, with 100 expressions by the interviewees, constituted the second of the category groups with the following competencies: planning skills (20 interviewees [95.2%]); coordination and organisation skills (19 interviewees [90.47%]); monitoring and controlling skills (18 interviewees [85.7%]); and prioritisation skills (10 interviewees [47.6%]). Due to their high level of competency requirements, high stakeholder count, diversity of interests and many changes throughout their lifespan, IT projects require planning, control, monitoring and organising skills. Although prioritisation skills constitute the only competency in this group (Cluster 2), 10 interviewees referred to its importance in managing the complexities of IT projects.

Analysis of the management skills group revealed that this group is related to all complexity factors except sanctions. Among the competencies of this group, the interviewees focused on the correlation of monitoring and controlling skills with the transparency category and coordination and organisation skills with the knowledge and skills category.

According to the expert interviewees, management skills are essential in all projects but should be strongly emphasised in complexity management. Project managers in complex IT projects are required to manage complexity in coordinating their tasks. Appropriate planning methods (e.g., rolling wave planning) allow the initial high-level planning in the work breakdown structure (WBS) to develop into more detailed iterative planning or enable the drafting of an appropriate integration plan to implement the project.

4.3.2. Cognitive Skills

Cognitive skills are referred to by de Rezende et al. as abilities relevant in mental processes that consist of perception, judgment and reasoning, but not abilities in emotional and discretion processes [29]. Based on the count of interviewees' expressions, cognitive skills with more competencies had the same status as the knowledge and expertise group. These competencies comprised: problem solving (20 interviewees [95.23%]); systems thinking (12 interviewees [60%]); strategic thinking (9 interviewees [42.85%]); simplifying complexities (7 interviewees [33.33%]); creativity (5 interviewees [23.8%]); recognition of the cultural dimensions of the project (9 interviewees [9.5%]); and sustainable thinking (1 interviewee [4.76%]). Even though this group contained the competencies of strategic thinking, simplifying complexities, creativity, recognition of the project's cultural dimensions and sustainable thinking, it was placed in Cluster 2.

According to the interviewees' descriptions, problem solving and systems thinking were the most frequently expressed competencies in the cognitive skills group and were related to all complexity factor categories. A strong correlation existed between the problem-solving and sanctions categories. As sanctions affect all aspects of a project and a project manager's most important task is decision making, this skill is expected to be required in managing complexity. Hahn and Kuhn assessed the importance of decision-making skills in the success of projects [52].

4.3.3. Influencing Skills

The project manager's ability to influence actions, behaviours, opinions, values and strategies is described through influencing skills. This group included the following competencies: leadership (20 interviewees [95.2%]); motivating the project team (19 interviewees [90.47%]); persuasiveness (11 interviewees [52.38%]); effect on organisational strategy (1 interviewee [4.7%]) and effect on team's values (1 interviewee [4.7%]).

The higher the level of project complexity, the greater the requirements of the leadership task, with leaders needing to be capable of leading the team, promoting team members and improving the working atmosphere, rather than simply reacting to the inevitable changes and challenges [24]. The leadership competencies in addressing complexity are detailed in the GAPPS competency framework [31]. As projects expand, leadership becomes more important; consequently, leaders must be equipped with more practical skills to face complexities. Perhaps that is why interviewees provided 41 expressions addressing the importance of leadership in managing IT complexity, with this ranked the highest among all competencies, both in terms of expressions and the number of interviewees. This competency is related to all categories of complexity.

In complex situations, along with time, quality and cost constraints, the project team faces additional internal and external pressures, making the need for other aspects of influencing abilities, such as motivating the project team, more apparent. According to more than 90% of the interviewees, motivating the project team in critical situations is one of the essential actions that project managers need to take.

4.3.4. Team Working

The team working group comprised the following competencies: empowering others (16 interviewees [76.19%]); team building (15 interviewees [71.42%]); and supporting others (10 interviewees [47.61%]), with the first two of these competencies placed in Cluster 2. The competency of empowering others relates to the four complexities of diversity, knowledge

and skills, trust, and transparency, while the team-building competency relates to the three complexities of diversity, knowledge and skills, and context. According to [53,54], the importance of being technically and socially competent in changing environments is essential for team building in IT project management. This competency enables project managers to build teams that work dynamically and creatively in complex situations.

In a crisis in which the team's efficiency is affected by multiple pressures, the project manager's role in supporting the team is one of the most powerful tools for project sustainability. According to [55], a project manager's capability of supporting others is essential to achieving success; however, this capability was expressed by less than 50% of interviewees.

4.3.5. Contextual Skills

Contextual skills focus on understanding and managing circumstances or facts that prevail over an event, situation or environment [29]. These skills comprise three competencies, with interviewees (by number) ranking adaptability first, with this competency related to diversity, regulations and context complexities. The other two competencies were political awareness and networking skills. Both [56,57] highlighted the importance of these skills in the success of IT projects.

In Iran, IT projects are highly influenced by changes in new regulations and laws that, at times, lead to their disruption, if not destruction. In recent years, the parliament's enactment of laws and regulations and the imposition of restrictions by Ministries have greatly influenced projects in the IT sector. Accordingly, the adaptability competency is very effective in managing the complexities of IT projects in unstable and uncertain conditions; consequently, being aware of the state's view on IT projects contributes to making better decisions. This competency relates to regulations, sanctions, knowledge and skills, transparency, and context.

4.3.6. Emotional Skills

Emotional skills describe abilities related to emotions in management. Interviewees believed that the following three competencies fall into the emotional skills group: stress management (6 interviewees [28.57%]); self-control (5 interviewees [23.8%]); and empathy (4 interviewees [19.04%]). Although the importance of emotional skills has been highlighted in many studies, such as those of [22,58], in the current study, only a few interviewees referred to the correlation between emotional skills and IT project management in relation to complexity.

Stress management, self-control and empathy with team members and critical stakeholders constitute essential emotional skills in critical situations. A project's complexity could aggregate pressures to the point where the project may fail. Having a project manager with strong emotional skills assists in absorbing the impact, thus, providing some relief. Due to the nature and high environmental uncertainty of complex IT projects, having a project manager with these competencies will lead to more effective complexity management.

5. Conclusions

The extensive discussion on project managers' competencies, regardless of project complexity, is evident in the available literature. This study focused on competencies related to project complexity to identify and assess the competencies of IT project managers that are necessary for improving complexity management. In the three stages of coding, and applying the GTM and content analysis method, 41 competencies of project managers were identified, assessed and categorised. These competencies were classified into 10 groups through axial coding, and then into two sets, one of individual competencies (IC) and one of social competencies (SC), in the selective coding step.

The results of this study provided a 'competencies to manage IT project complexities' (CITC) model, in which the correlation between project complexity and project managers' competencies is evident. This model categorises the competencies of project managers in terms of project complexity. The model's 10 competency groups consist of: project management (PM) knowledge; management skills; interpersonal skills and attributes;

professionalism; expertise; emotional skills; contextual skills; influencing skills; team working; and cognitive skills. The top 10 competencies are: leadership; planning skills; results orientation; experience; motivating the project team; problem solving; technical expertise; integration management; change management; and uncertainties management. Although the importance of each group and the competencies therein varied in each complexity category, 43.9% of the competencies were in the IC set, and 56.1% in the SC set. The interviewees most frequently expressed PM knowledge and management skills in the IC and SC sets, respectively.

The fundamental knowledge and skills that project managers need to manage the complexity of IT projects were assessed in this study. These results provide managerial insights for individuals and companies dealing with complex projects in developing their competencies. The constraints in this study could provide suitable topics for future studies. Despite the study's contributions, the findings must be interpreted with caution due to two limitations, namely, the project context and sample size. The findings were from 21 interviews conducted in Iran, namely, a single geographic zone with specific cultural and working standards. Due to this limitation, the study's findings should be treated with caution, as they may have limited generalisability in other countries with a dramatically different socioeconomic context. Thus, further research is warranted to test the findings across various geographic zones on cases with identical varied sociotechnical technology systems. Furthermore, this study was based on interviews with 21 IT project managers (a limited sample size). It is thought that a larger sample size could yield more advanced results, although this is not absolute.

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Appendix A

Table A1. Meaning of acronyms.

| Sets	Axial Code	Groups	C. Code	No. of Quotations
Individual competencies (IC)	C2	PM knowledge	K, D, F′, H, J, L, G, C	179
	C10	Expertise	A, B, N	82
	C5	Professionalism	Q, P, U	57
	C8	Interpersonal skills and attributes	A′, L′	44
Social competencies (SC)	C3	Management skills	I, D′, E, F	101
	C4	Cognitive skills	R, G′, O, P′, E′, B′, W	93
	C1	Influencing skills	I′, M′, V, K′, X	89
	C6	Team working	H′, Z, S	53
	C7	Contextual skills	T, J′, T′	47
	C9	Emotional skills	M, C′, N′	24

Appendix B
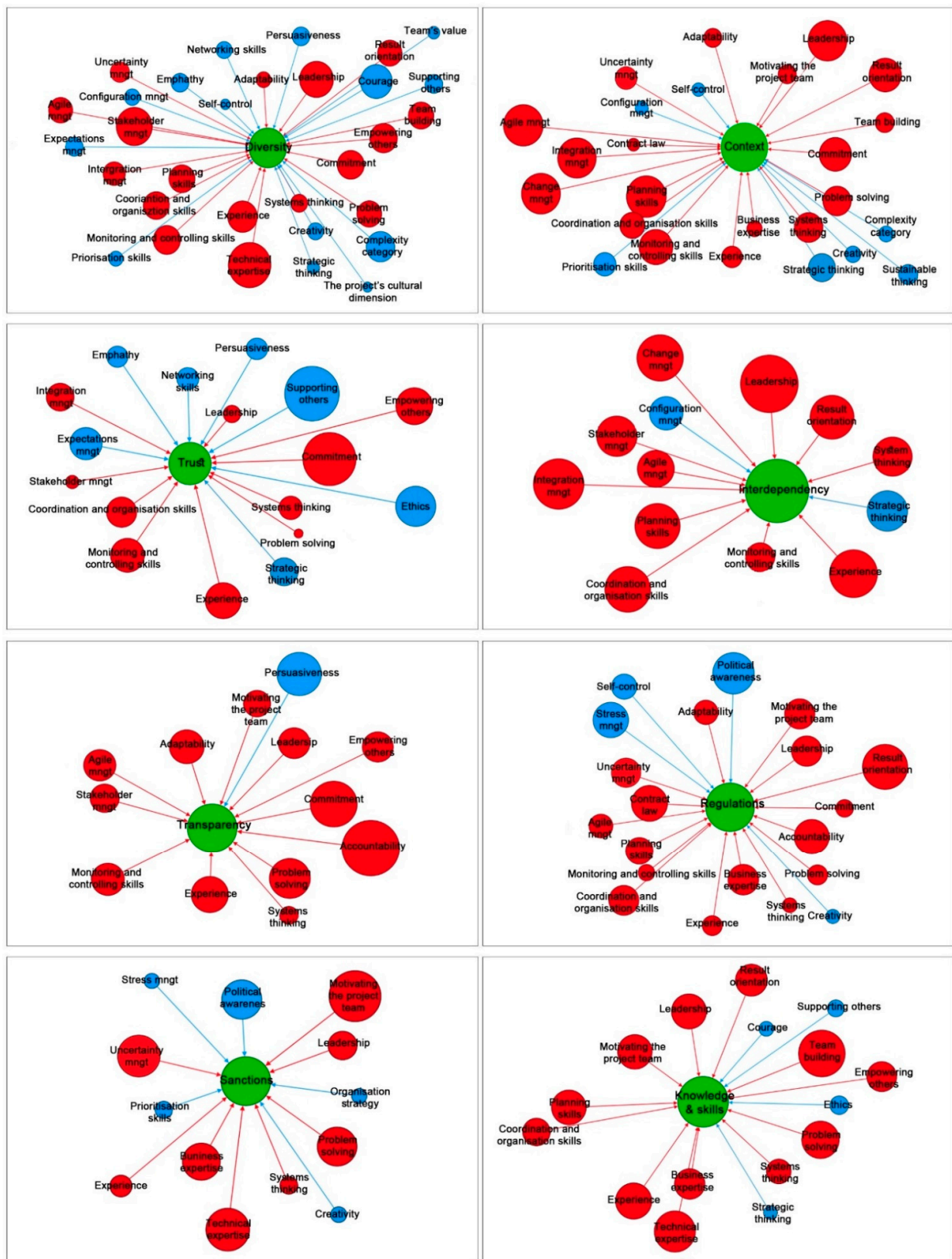
Figure A1. Correlation of project manager's competencies and complexity dimension.

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