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Editorial

It is our great pleasure to bring you the second number of the third volume of IJISPM - International Journal of Information Systems and Project Management. The mission of the IJISPM is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

In this issue readers will find important contributions on enterprise resource planning systems post-implementation stage, team management and conflicts management.

The first article, "The ERP post-implementation stage: a knowledge transfer challenge", examines the knowledge transfer process in Enterprise Resource Planning systems (ERP) post-implementation projects, and specifically between the ERP project teams and the IT support team. The authors, Sylvain Goyette, Luc Cassivi, Mathieu Courchesne and Elie Elia, have conducted case studies in three large organizations and data was collected via semi-structured interviews. Descriptive and graphical representations were used to analyze knowledge transfer processes for each case and a cross-case analysis was performed. Results from this exploratory study shed light on the relation between the ERP evolution structure and the use of knowledge transfer mechanisms based on different types of knowledge (functional and technical). This article highlights the need of relying on both formal and informal knowledge transfer mechanisms to cover recurring and ad hoc exchanges between the different stakeholders responsible for the evolution of an ERP. The article also highlights the impact of the ERP integrator and its different inclusion strategies that are critical for the knowledge being shared by the ERP project stakeholders.

The second article, "Distributed team cohesion – not an oxymoron. The impact of information and communications technologies on teamness in globally distributed IT projects", is authored by Olga Stawnicza. Globally distributed Information Technologies (IT) projects are common practice in today's globalized world. Typically, project team's members work on interdependent tasks, with a common goal to be achieved as one team. However, being split between multiple locations impedes communication among team members and hampers the development of trust. Information and communications media enable communication between geographically distributed project team members and help to create and maintain trust within project units. Communication and trust are particularly significant for fostering a feeling of oneness among project team members. Oneness, also referred to as "teamness", is repeatedly mentioned as one of the challenges facing global project teams. However, prior literature on teamness is very scarce and its importance is underrepresented. This article contributes to the field in two ways. First, the theoretical study based on a systematic literature review examines available evidence of teamness in globally distributed projects. Secondly, an empirical study based on interviews conducted with global project managers fills the current gap in literature on the link between use of IT and establishing a sense of team unity. This article also draws practitioners' attention to the importance of striving for teamness in spite of the geographical distance that exists between project team members.

José Ramón San Cristóbal is the author of the third article "The use of Game Theory to solve conflicts in the project management and construction industry". A typical project involves a wide range of disparate professionals, in many cases geographically distributed, working together for a relatively short period of time on the design and construction of a facility. Since organizations are becoming flatter, culturally rich, geographically diverse and intensely competitive, the possibilities for conflict in such environments are greater. Negotiation is an important aspect of a project and plays an important role in resolving claims, preventing disputes, and keeping a harmonious relationship between project participants. Part of any project manager's role as a leader is to recognize conflict, understand the sources of conflict and manage it, and to do this a project manager must be able to understand the basics of negotiation theory and have sufficient competencies to lead in such situations. To address the complex technical and human issues in negotiation, different negotiation theories and models are available which mainly include game theory, economic theory, and

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behavior theory. Since Game Theory provides, by its very nature, the appropriate tools for the analysis and eventual solution of conflicts of any kind, this article uses a model based on Game theory in order to identify the activities that are responsible for the delays in a project and divide the costs among them.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work, for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

João Varajão

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João Varajão is currently professor of information systems and project management at the *University of Minho*. He is also a researcher of the *Centro Algoritmi* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997) and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are in Information Systems Management and Information Systems Project Management. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 50 Masters and Doctoral dissertations in the Information Systems field. He has published over 250 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served in numerous committees of international conferences and workshops. He is co-founder of CENTERIS – Conference on ENTERprise Information Systems and of ProjMAN – International Conference on Project MANagement.

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The ERP post-implementation stage: a knowledge transfer challenge

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The ERP post-implementation stage: a knowledge transfer challenge

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Abstract:
This paper examines the knowledge transfer process in ERP post-implementation projects, and specifically between the ERP project teams and the IT support team. Case studies were conducted in three large organizations and data was collected via semi-structured interviews. Descriptive and graphical representations were used to analyze knowledge transfer processes for each case and a cross-case analysis was performed. Results from this exploratory study shed light on the relation between the ERP evolution structure and the use of knowledge transfer mechanisms based on different types of knowledge (functional and technical). This paper highlights the necessity of relying on both formal and informal knowledge transfer mechanisms to cover recurring and ad hoc exchanges between the different stakeholders responsible for the evolution of an ERP. The paper also highlights the impact of the ERP integrator and its different inclusion strategies that are critical for the knowledge being shared by the ERP project stakeholders.

Keywords:
ERP; project management; knowledge transfer; post-implementation.

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1. Introduction

Enterprise Resource Planning (ERP) systems are now a widely used commodity, present in more than 75% of North American manufacturing firms and 60% of service firms [1]. Projects to implement these integrated systems have their share of challenges as they require major investments, and success is far from being assured. Recent statistics show that over 50% of projects experience cost overruns and over 60% have schedule overruns [2]; these numbers have hardly changed since 15 years ago, when 70% of ERP implementations were considered to be failures or negative experiences [3].

These bad experiences can be explained by several factors, but one that stands out is the time and effort required to fine-tune the ERP system. Most organizations consider the initial implementation of the ERP to be the final activity rather than just one stage in the life cycle of the system. In order to reap the benefits of an ERP implementation, several concerns linked to the evolution of the systems must be taken into account [4]. The process of evolution, which consists of multiple iterations of revisions, reimplementations or upgrades [5], ultimately focuses on making sure the ERP is aligned with the organization's current and future business needs [4]. Corrective actions may be seen as continuing the initial implementation of the ERP [6], and many organizations implement their ERP progressively [7]. Different levels of effort are needed to keep the ERP running and upgrade it according to the implementation plan.

Wenrich and Ahmad [8] state that several activities included in ERP evolution must be managed as separate development projects in order to be successful, but they also emphasize that a permanent support structure must be maintained to cover the ERP users' operational needs. In this context, projects are used to manage major changes of the ERP system, while support activities maintain the implemented functionalities. Thus, the knowledge produced by the different project teams is essential for the support team to maintain the new ERP functionalities and also serves as a base of knowledge for subsequent projects. The challenge for organizations is rooted in the temporary nature of projects, which means that structures and mechanisms to transfer knowledge are needed in order to maximize the use of an ERP system [9].

The objective of this paper is to understand how organizations transfer knowledge between the ERP project teams and the ERP support team to steer the evolution of an ERP in an organization. More specifically, it investigates the following questions:

- How is the ERP evolution structure configured?
- What knowledge transfer mechanisms are used?
- What other aspects may influence knowledge transfer in this context?

The next section reviews the literature on the main themes of this study. It is followed in section 3 by the methodology used to conduct the research project; the findings are presented in section 4. In conclusion, section 5 discusses the study's limits and highlights the paper's main contributions.

2. Literature review

2.1 Enterprise Resource Planning (ERP) systems

Several definitions of an ERP are available in the literature [1,5]. In a nutshell, an ERP is a software system designed to support organizations in managing the processes or components of their businesses. The ERP automates business processes and collects transactional business information, giving real-time information visibility to the multiple users dispersed throughout the organization. The literature on ERP systems has increased significantly in the last few years [10,11]. Although the majority of publications focus on the implementation stage, interest has now shifted to the post-implementation stage [10] to some extent.

This study focuses on one of the under-investigated topics associated with the post-implementation stage – ERP system optimization – which begins when the ERP becomes available to the final users, and ends when the system is no longer used [12]. Researchers who have investigated the post-implementation stage agree that the literature on the subject is sparse [5,8,13,14]. The themes studied by these researchers include ERP maintenance activities [4,15,16], which are defined by the maintenance strategies applied [5]; knowledge transfer between the development team and the final users [17]; and knowledge management planning and continuous improvement in ERP implementations [9,14,18,19].

The ERP literature does not make a clear distinction between support, maintenance and evolution activities, which enhances the interest of this particular study. Several authors [8,20] consider that all activities executed in the post-implementation phase are maintenance activities, regardless of the type of initiative (project or support). Hence, certain activities are defined as support by some authors, but are assigned to evolution by others [10]. Empirical research has identified several activities considered to fall under evolution, such as deploying new functionalities, optimizing existing tools, upgrading to a new version and implementing in other sites (subsidiaries) of the organization. Such activities may be perceived as projects according to the definition provided below (see section 2.2). In fact, as we saw, Wenrich and Ahmad [8] mentioned that certain ERP maintenance activities need to be managed as projects in order to be successfully completed. For the purpose of this paper, evolution consists of support activities (a permanent structure) and projects (temporary structures).

The literature also notes that different types of knowledge are critical in implementing ERP systems, notably technical and functional knowledge. Expertise and experience linked to the system's functionalities and configuration and technical knowledge are normally obtained from external resources, while functional knowledge and business process knowledge are found within the organization [4].

These two types of knowledge must be combined during ERP projects if the system is to be correctly adjusted to the organization's business processes [21]. The IT experts own the technical knowledge while the expert users hold the functional knowledge. Furthermore, these two types of knowledge are divergent but must be made to converge [21]. In other words, an ERP application requires functional knowledge to ensure a good alignment with the business needs defined, and it also needs technical knowledge to respect the limitations of the software.

Gable et al. [5] list several types of ERP knowledge such as business processes, ERP configuration, organizational design, organizational culture, IT architecture and infrastructure, project management and its resources. For the purposes of this research, ERP configuration, IT architecture and infrastructure are considered technical knowledge, while the other kinds are all considered functional knowledge.

2.2 Project *management*

Research on project management is constantly changing; this field, which was mainly controlled by professionals in the 1970s and 1980s, has produced rigorous, high-quality research over the last 20 years [22]. Smyth and Morris [23] mention the lack of theory in the field of project management, which is explained by its multidisciplinary nature. A project is defined as "a temporary group activity designed to produce a unique product, service or result" [24]. Managing a project is therefore "the application of knowledge, skills and techniques to execute projects effectively and efficiently" [24]. The focus is, however, slowly changing; the execution of a project (notably with Atkinson's [25] "iron triangle" of time, cost and quality) is giving way to the knowledge transfer (learning) perspective often put forth in recent project management publications [26]. This perspective stipulates that "during the project, knowledge must be transferred, integrated, created, and exploited to create new organizational value" [26, p. S4].

A project consists of different stages, which are often represented by different steps of a project life cycle including a closing phase. The Project Management Institute (PMI) body of knowledge (PMBoK) typically proposes four distinct stages: project initiation, planning and design, execution, and closing [27]. Other authors suggest different terminologies for the life cycle stages of a project [28,29,30].

Lundin and Söderholm [31] present an interesting terminology for the different stages of a project life cycle: action-based entrepreneurialism; fragmentation for commitment-building; planned isolation; and institutionalized termination. This study focuses on the institutionalized termination stage, in which the temporary organization (project) is coupled with the permanent organization (maintenance).

This coupling involves a transfer (or bridge) between the members of the project teams and the organization in order to create a link between the different projects and the organization's operations [31]. In this particular study of ERP evolution, the bridge to be analyzed involves the transfer between ERP project and ERP support team.

2.3 Knowledge transfer and knowledge management

Knowledge is a "dynamic human process of justifying personal belief toward the truth" [32]. Knowledge is dynamic as it develops interactions between individuals [32] and is context-specific (time and place). Several authors have categorized knowledge into two types: explicit and tacit [32,33]. Explicit knowledge may be articulated in formal language and is easy to codify, transfer or store, while tacit knowledge is personal and difficult to codify as it is sculpted in the actions, procedures, routines, values and emotions of the individuals involved.

Knowledge management (KM) is defined as the "process of capturing the collective expertise of the organization from different sources (i.e. databases, paper, people) and utilizing that knowledge base to leverage the organization" [34, p. 298]. Several authors present their perspective of knowledge management and its processes, especially through life cycle stages [34,35]. In this study, we chose to adopt Sedera and Gable's [34] four phases. The first phase – knowledge creation – embodies everything that is linked to the knowledge creation process, either developed through internal resources or obtained externally via specialists. The second phase – knowledge retention – consists in maintaining knowledge in a referential form in order to allow this knowledge to last over time. The third phase – knowledge transfer – implies the use of informal and formal transfer channels to enable the distribution of knowledge within an organization. Finally, the last phase – knowledge application – is the use of the knowledge by one or more individuals who received the knowledge during the transfer.

Knowledge transfer is therefore a subcomponent of knowledge management [34]. Knowledge transfer is only possible with formal and informal mechanisms that integrate, interpret and share knowledge anchored in individuals or groups of individuals [36].

The literature review allowed us to identify four categories of formal transfer mechanisms: (i) personnel movement; (ii) use of tools; (iii) role assignment; and (iv) training. Personnel movement simply consists in transferring an employee to another department or division [37]. It improves the employee's communication abilities and enables a stronger network to be developed within the organization [37]. The use of tools, the second category of mechanisms, involves information technologies, rules, procedures, reports and manuals used by employees in the organization [38]. In the third category, certain mechanisms call on individuals to take on particular roles, such as *knowledge broker* or *power user* [17]. Finally, training allows for the transfer of designated knowledge to one or more specific resources [39].

Ajmal and Koskinen [40] point out that the vast majority of knowledge is not stored in computers or other electronic devices but exists only in individuals' brains. Personal interaction is therefore very important in organizations. Although organizations try to formalize these interactions, many of them are conducted informally. Such interactions between two individuals (one-on-one) or within a group [41], along with social networks [42], are the most common informal mechanisms for transferring knowledge.

Some authors have explored the factors that affect the selection of knowledge transfer mechanisms. For instance, Chai et al. [38] indicate that the choice of the mechanism depends on the nature (tacit or explicit) of the knowledge being transferred, and of the dependence of the knowledge on its context. Jasimuddin [41] asserts that the selection of the transfer mechanism depends on three elements: the status of the actors involved in the transfer; relational aspects; and

the actors' social ties and proximity. Many studies on knowledge transfer exist in the literature, but there are very few on the mechanisms used to transfer knowledge [41,43].

2.4 Summary of the literature review and analysis framework

The literature and practices related to ERPs recognize that a permanent structure is required to address the continuous user needs in an organization. Hence, firms must integrate temporary evolution initiatives while supporting the overall ERP solution. McGinnis and Huang [9] indicate that the success of project teams is based on the knowledge of the current ERP environment, along with the evolution and support activities related to the system. They also mention that to efficiently support users, the ERP support group needs to understand the nature of the decisions related to the ERP evolution initiative, and the reasons explaining these decisions. The adoption of a project management mode to conduct certain evolution initiatives makes knowledge management more difficult, as the project team is usually dissolved when the project ends [44].

The existing literature on knowledge transfer in ERP projects mainly focuses on the implementation and posits very specific implementation stages [45] that are not transferable to the post-implementation stage. As such, for ERP project teams, a more general approach, which includes conceptualization, development, testing and deployment (as illustrated in Fig. 1) is more appropriate.

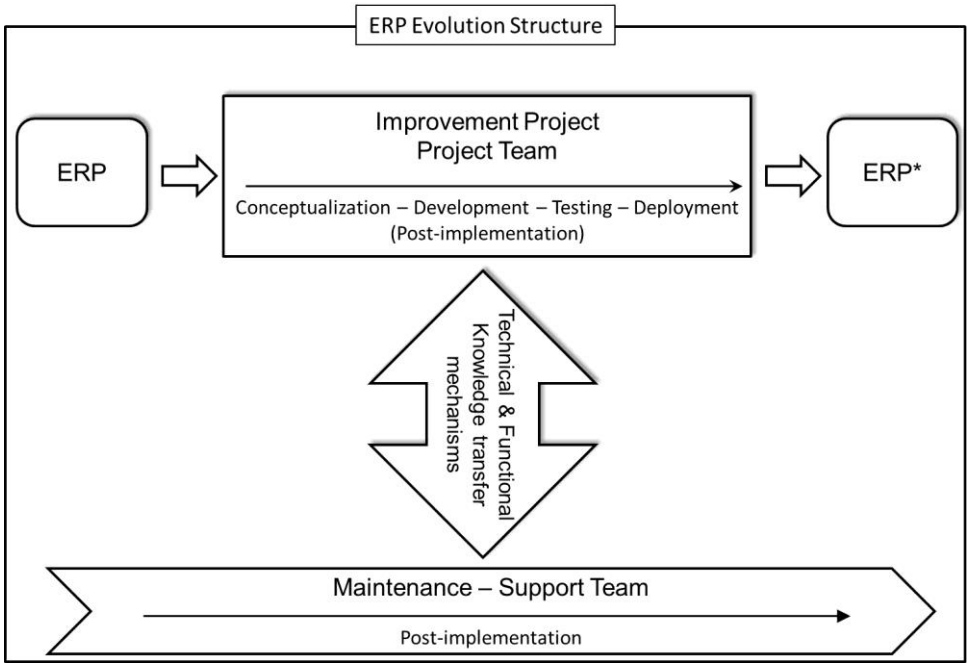


Fig. 1. Analysis framework

The analysis framework (Fig. 1) presents both the support team and the project teams that are involved in developing the ERP. The study looks into the mechanisms for transfer between these two groups. The challenge of integrating management activities related to ERP systems exists primarily at the knowledge management level. On one hand, there is a need for current knowledge to be transferred to projects. In return, knowledge must be transferred by project managers and their teams to the support group so they can continuously support the users.

With both functional and technical knowledge being crucial in an ERP context [19], and with knowledge management being a critical process for the life expectancy of the ERP, mechanisms are required to transfer the necessary knowledge [9]; these mechanisms are the focus of this study.

3. Methodological approach

A case study approach was chosen for this study as it enables researchers to retain the holistic, meaningful characteristics of real-life events [46]. As mentioned above, there is relatively little literature on knowledge transfer mechanisms between project teams and support teams in IT, which justifies the methodological approach chosen [47]. Furthermore, the distinction between the phenomenon and the context is not clearly delimited [47], which also calls for a case study approach. Since the unit of analysis is the organization, the case study approach is appropriate to collect the data for this level of analysis.

A five-step methodology was followed. First, organizations and respondents were selected. Sampling was done at the organizational level and also at the respondent level. Selection criteria were used to ensure the quality of the information provided and validate the subsequent research results [48].

Second, data collection was conducted via semi-structured interviews [49] and document analysis to ensure triangulation of the data [46]. Semi-structured interviews allow respondents to talk, in their own language, about a subject defined at the start [49]. The interviewer orients respondents with reformulated questions to ensure that all the topics of the interview are covered. The interviewer also observes and actively listens when conducting the interview as he or she must not only take into account what the respondents say but also how they say it and what they feel when saying it [50]. The number of interviews was established according to semantic saturation and theoretical data saturation [49]. Semantic saturation is obtained when the additional interviews conducted do not add any new descriptors to prior interviews [49]. Theoretical data saturation is achieved when each descriptor in an interview is placed within a theory or a model, obtained either by the author or by the literature [49]. All interviews were recorded and transcribed.

In the data analysis step, a narrative and graphical representations of the process were created, and a mixed interpretation strategy was used to analyze each case individually [51]. Following the individual analysis, cross-case data analysis was conducted to identify similarities and differences in the process and to develop a process model that will help understand the knowledge transfer process applied by the organizations in question [52].

Finally, a panel was conducted with key representatives of each company involved to validate and understand the results of the research [52].

3.1 Profile of the organizations and respondents

Three organizations from the public/para-public sector were chosen to participate to this study. With over 30,000 employees, Organization A, a large municipal agency, implemented its ERP in 2006. Since 2010, three initiatives have been developed to add advanced procurement functionalities, a human resource module and a payroll component (all from the same enterprise application). Organization B, which employs 9,000 people, is active in the field of transportation and has gradually implemented several ERP modules (all from the same enterprise application) over the last 13 years. Finally, Organization C, with 22,000 employees, is a utility. It began implementing an ERP in 1999 and has since continued gradually to include new modules in several of its operational divisions. Its evolution strategy involved software from different enterprise applications, as some specialized functionalities were not available from the original one.

At each of these organizations, interviews were conducted with three different employee profiles (IT support managers, IT project managers and ERP internal customers). The interviews lasted approximately 75 minutes. A total of 12 interviews were conducted in the three organizations (four in each).

4. Findings

Following the research design, comparison analyses were conducted between the selected organizations. The findings are presented in three blocks, related to the main research questions (see section 1): ERP evolution structure (section 4.1); knowledge transfer mechanisms (section 4.2); and other aspects that influence knowledge transfer (section 4.3).

4.1 ERP evolution structure

The ERP evolution structures of the three organizations were compared and analyzed with respect to two specific organizational aspects: centralization and localization of resources.

Centralization

With regard to centralization, the strategies of organizations A and B have involved pooling resources in a single team to cover both ERP projects and ERP support (see Fig. 2). Both organizations identified the same advantages, as this structure has improved their activities, particularly in terms of knowledge transfer. As the IT manager at Organization A said, "One, it's a proven concept in our organization, and two, splitting resources into two groups would raise costs with additional resources required, and less efficiency, I am convinced." The IT manager in Organization B mentioned the importance of continuity: "This hybrid zone where two teams back up the knowledge is an advantage, as if one leaves for retirement or for another reason, a team is able to compensate, and this has happened in both ways in the past." In Organization C, a different strategy was applied: the ERP project teams are separate from the ERP support team (see Fig. 2). People at Organization C consider that this structure improves the specialization of the resources and increases the employee retention level. The impact of this structure involves information duplication and the creation of more knowledge transfer processes to compensate for the resources' lack of proximity. The analysis of the structural integration of the project and the support resources in these three organizations reveals this element to be an important factor in the ERP knowledge transfer as it facilitates the exchange of information among the members of the group.

Localization of resources

Although organizations A and B have both implemented centralized support groups, the localization of their employees is quite different (see Fig. 2). The results also show the criticality of distinguishing technical resources from functional resources, and therefore technical knowledge from functional knowledge. The integration of these two types of knowledge is critical to the success of an ERP implementation, as noted by Baskerville et al. [21]. For Organization A, the technical and functional resources are located in an ERP expertise center (part of the IT department). The pooling of all resources in one place allows knowledge sharing among multiple functional experts, which is not completely the case for Organization B. The technical resources in Organization B are grouped in an ERP expertise center (part of the IT department), while functional experts are located in each of the business units. In fact, for certain business units functional areas of Organization B, both project and support knowledge are covered by only one person, who covers IT and operational responsibilities. In this case, the availability of the employee for knowledge transfer activities to the other functional and technical resources is very limited, and the organization faces risky knowledge management issues, which will be discussed in section 4.2.

The data gathered during the interviews showed that Organization B has chosen this set up to ensure better interactions and collaboration between IT support and internal customers, while Organization A aims for better integration between the different ERP modules. The head of the support team from Organization A explains: "It is meant to be integrated (ERP). It is like living in a condominium: although you live in separate apartments, you have to run it as one… Decisions from a particular domain have an impact on others…"

Our findings, summarized in Table 1, are coherent with the centralization and structural integration dimensions presented by Chen and Huang [53]. Gallagher et al. [19] also described this dilemma of having to choose between a centralized, a decentralized or a hybrid structure for functional resources after an ERP implementation. Another

implication of localizing the functional resources in the business units is related to the distribution of ERP knowledge among the functional experts. In sum, it demonstrates that certain structural configurations may complicate the transfer of knowledge. For instance, according to our findings, the number of interactions between groups and their physical proximity has an impact on the knowledge transfer process.

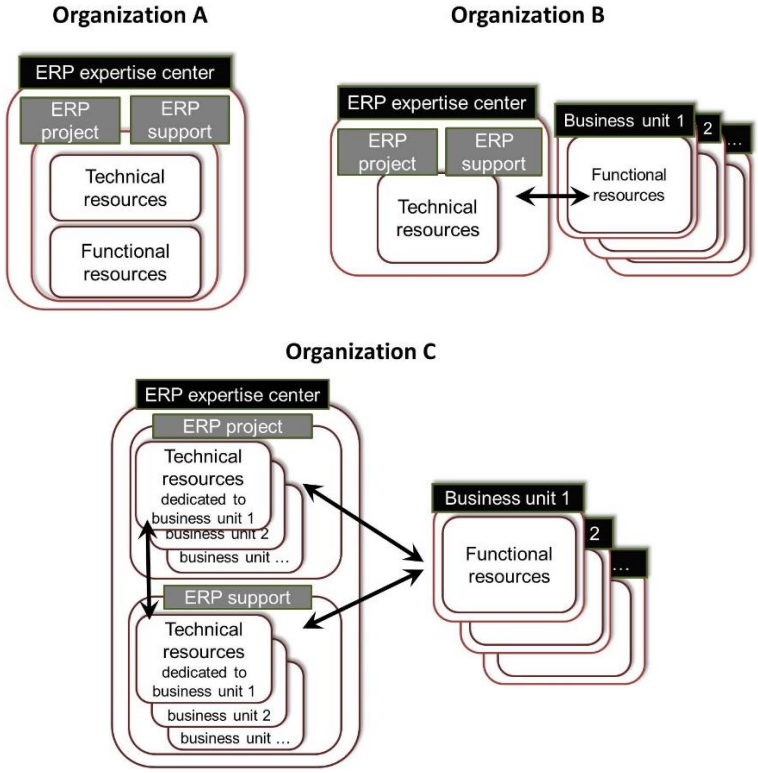
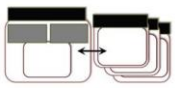
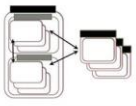


Fig. 2. ERP evolution structures identified in the three organizations (A, B and C)

Table 1. Comparison of the evolution structures

	Organization A	Organization B	Organization C
			
ERP Evolution Structure	Centralized	Hybrid	Hybrid
Resource Integration	Technical and functional resources integrated	Technical and functional resources physically separated	Technical and functional resources physically separated
IT Resource Assignment	Shared between project & support	Shared between project & support	Split between project & support

4.2 Knowledge transfer mechanisms

Following our analysis framework, the use of knowledge transfer mechanisms was compared by type of knowledge (technical and functional) and orientation (from project to support and vice versa). The results are discussed and summarized in Table 2.

Formal transfer mechanisms used for functional knowledge

As shown in Table 2, our findings show a similar pattern in the use of transfer mechanisms for functional knowledge. All organizations exploit the movement of employees as their primary mechanism of functional knowledge transfer (see Table 2). The richness and complexity of the contextual information is the main reason for the use of this strategy, which takes three different forms:

- Complete assignment, where the support resources are assigned full-time to the project;
- Shared assignment, where resources work part-time for both the support teams and the project teams; and
- Hand-offs, where the knowledge transfer is fully conducted when the project goes live.

The IT manager of Organization A gives an example of this complexity: "It's easy for a programmer or a configurator to read the programming lines to understand what the program does. But what is more difficult is to get the background information on why the program is what it is. When change requests arrive, they are very rarely related to a change in the program. It is a user need that is requested. Therefore, you have to understand what is in place, the link with the business need, and how you can make it happen... And it is all of that knowledge, and your understanding of the business needs and business solutions that must be disclosed to the support resources."

Training is another mechanism used by organizations B and C. As explained in section 4.3, the ERP integrator's responsibilities are very important in ERP projects. Therefore, the knowledge transfer in the implementation phase is reduced, and a training mechanism at the end of a project compensates for that deficiency.

Table 2. Main formal mechanisms according to knowledge and transfer types

Type of Knowledge	Transfer Type	Organization A	Organization B	Organization C
Technical	*Project* ***to*** *Support*	• Documentation	• Documentation	• Documentation
	Support ***to*** *Project*	• Not applicable	• Not applicable	• Not applicable
Functional	*Project* ***to*** *Support*	• Staff movement • One -on-one Interaction	• Staff movement • Training provided by the consultant	• Staff movement • Training provided by the consultant
	Support ***to*** *Project*	• Staff movement	• Staff movement	• Staff movement

Formal transfer mechanisms used for technical knowledge

All three organizations use tools, more specifically documents, as their prime mechanism for capturing and transferring technical knowledge. The centralization of the IT resources in organizations A and B also allow the movement of employees to complement the knowledge transfer. Organization C's current evolution structure seems to be an obstacle

for the personnel movement mechanism. Some of the stakeholders interviewed complained about this gap in their knowledge transfer process; for example, a system analyst at Organization C commented: "The support resources lack some of the knowledge acquired by the project team and remain dependent on the project team long after the project is completed." The relationship between the two groups seemed tense. On the one hand, the support team had the impression that the project teams were delivering prematurely, without a proper knowledge transfer, in order to get rid of their responsibility for fixing the remaining anomalies. On the other hand, the project teams complain of being bombarded by requests from the support team for tasks they were not responsible for. Furthermore, this context has a negative impact on the relations between the IT department and its internal clients, who have to deal with two separate entities depending on whether the functionality in question is still the project team's responsibility or has been transferred to the support team. As an IT manager from Organization C reported: "Having two sources of support duplicates information and increases the risk of knowledge loss." In addition, our results show that role assignment mechanisms are not used to transfer technical knowledge; this mechanism is mainly used for knowledge transfer between the IT organization and the internal customer.

Informal transfer mechanisms

In the three organizations analyzed, the two informal mechanisms used, one-on-one interactions and social networks, are complementary, since interactions are mostly conducted within the individuals' social network, as can be seen by the following quotation from a team leader in Organization A: "When we are in production mode and our friend or colleague is in project mode, as soon as there is a major change, hey, we raise our hand and we tell him."

Other mechanisms are also used to complement the movement of employees. For instance, organizations A and B use one-on-one interactions, but in different ways. In Organization A, the functional resources distributed between projects and support activities organize regular meetings to discuss the different activities for which they are responsible. In Organization B, the project methodology includes multiple quality assurance activities in which the support team members are invited to participate.

To complement formal mechanisms put in place by the organization, organizations A and B use informal mechanisms to share more information and to make knowledge transfer more efficient. It is another story at Organization C, which uses informal mechanisms to compensate for the inefficiencies of its formal mechanisms. As one of its business managers put it: "it's ad hoc, really… you've got a problem, well, come and see me. It's always you've got a problem, come and see me…so you really learn from trial and error… yes, trial and error." Comments gathered from the respondents in Organization C emphasized the importance of the social networks of the employees in vital positions for the evolution of the ERP. For example, the head of the accounting system worked for six years in the IT department and three years as a business analyst before obtaining his current position. His network serves him well as he is now the intermediary between the IT department and his business unit. As such, inter-department communications are more efficient when employees communicate with people in their former departments [37]. In Organization C, the efficiency of knowledge transfers clearly depends on the social networks in place. The loss of one or more employees could have terrible consequences for knowledge transfer

Relational aspects may not be as critical for organizations A and B, but they are important for the knowledge transfer process in these organizations too. The relationship between the source (who shares the knowledge) and the recipient (who receives the knowledge) has a great influence on knowledge transfers in an organization [54]. According to our findings, this relationship has a greater influence on knowledge transfer when informal mechanisms are used, as compared to formal mechanisms. A resource will certainly be more inclined to share knowledge with a recipient with whom he or she has a good relationship. However, a formal mechanism can offset the lack of motivation to share knowledge if a weaker relationship exists.

In sum, the analysis of organizations A and B basically shows that they are in line with the transfer mechanisms presented in the literature. They mainly use formal transfer mechanisms and use informal individual mechanisms (e.g., personal contacts and networks, ad hoc meetings, etc.) only in exceptional non-recurring situations. This finding is coherent with Boh's [36] conclusions that individual informal mechanisms should be used only for unique situations,

while formal mechanisms should be used for recurring information. However, the formal transfer mechanisms are not sufficient in Organization C, as there is little personnel movement to spread technical knowledge and no other formal mechanism to compensate for that lack. However, given that informal mechanisms are widely used, Organization C is still able to run the system and execute change requests on the ERP.

4.3 The role of ERP integrator in the knowledge transfer process

The last objective of this research was to identify other aspects that may influence knowledge transfer in a post-implementation ERP context. Only one aspect was identified in this research: the ERP integrator's role. In most ERP projects, an integrator (external consultant) may participate in the project in different ways. Specific specialized knowledge of an ERP system may be developed by an internal team, but often comes first from the external consultant. Knowledge transfer is therefore critical to the long-term viability of the system.

In Organization A, the integrators' role was moderate, mostly during ERP support activities where they acted as trainers and transferred their knowledge. In Organization B, the inclusion of integrators was low; their services were mainly provided during the project with a mixed team of internal and external resources. Knowledge transfer to the support team was conducted at the end of the project. Finally, in Organization C, the integrator was highly involved in the ERP activities and was even responsible for some projects within the organization. The impact of the different integrator inclusion strategies is important for the knowledge being shared by the project stakeholders. In Organization C, significant efforts must be deployed to retain knowledge about the project, but the transfer mechanisms are not always used appropriately to capture all of the critical information. In Organization B, minimal efforts are made to retain the information from the integrators, but substantial work is done to transfer the knowledge from the project team to the support staff.

5. Contribution and future research

The results of this study should be interpreted in light of certain limitations. First, although a qualitative approach proved to be efficient to address the study's research questions, it limited the number of organizations included in the study and prevents us from making any broad generalizations. Second, although the organizations are from different areas of activity, they are all large public-sector organizations located in the same geographical region. This limitation prevented the study of cultural aspects related to sectorial and regional factors. Third, although the number of respondents was adequate, 12 for the three organizations, a larger number would probably have permitted further analysis and provided additional insights.

However, these limitations are offset to some extent by the research design and by the detailed qualitative analysis, which enabled the study to achieve the research objectives and provided a preliminary understanding of the knowledge transfer process between ERP projects and IT support. It generated new insights into the context of ERP evolution and shed some light on the role of the ERP evolution structure and the use of knowledge transfer mechanisms based on different types of knowledge (functional and technical). As mentioned earlier, our research focuses only on public-sector organizations, leaving room for further exploration in the private sector. An interesting potential future research initiative would be to use a quantitative approach with a larger number of respondents in order to generalize the results obtained in this study.

For business managers, our paper confirms the importance of establishing a proper ERP evolution structure to facilitate knowledge transfer within the organization. It also shows the necessity of relying on both formal and informal knowledge transfer mechanisms to cover recurring and ad hoc exchanges between the different stakeholders responsible for the evolution of an ERP.

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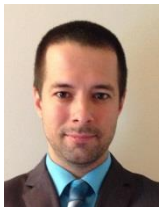

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Distributed team cohesion – not an oxymoron. The impact of information and communications technologies on teamness in globally distributed IT projects

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Distributed team cohesion – not an oxymoron. The impact of information and communications technologies on teamness in globally distributed IT projects

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Abstract:
Globally distributed IT projects are common practice in today's globalized world. Typically, project team members work on interdependent tasks, with a common goal to be achieved as one team. However, being split between multiple locations impedes communication among team members and hampers the development of trust. Information and communications media enable communication between geographically distributed project team members and help to create and maintain trust within project units. Communication and trust are particularly significant for fostering a feeling of oneness among project team members. Oneness, also referred to as "teamness", is repeatedly mentioned as one of the challenges facing global project teams. However, prior literature on teamness is very scarce and its importance is underrepresented. This research contributes to the field in two ways. First, the theoretical study based on a systematic literature review examines available evidence of teamness in globally distributed projects. Secondly, an empirical study based on interviews conducted with global project managers fills the current gap in literature on the link between use of ICT and establishing a sense of team unity. This paper draws practitioners' attention to the importance of striving for teamness in spite of the geographical distance that exists between project team members.

Keywords:
information and communications technologies; teamness; oneness; team cohesion; global project management; distributed IT project team.

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1. Introduction

Globally distributed information technology (IT) projects have emerged primarily due to outsourcing, globalization, and the ever increasing internationalization of companies. Furthermore, the rapid development of information and communications technologies (ICT) has facilitated communication between different project sites, which has additionally impacted the increasing use of dispersed project teams. Ever since then, globally distributed IT projects have expanded and become commonplace in today's business world.

Information and communications technologies enable project team members to better cope with various challenges. In practice, the features of this type of international collaborative work, which are frequently regarded as challenges, may have a positive impact on project performance. Different time zones enable organizations to work round the clock. Cultural diversity enriches project results as different points of view are reflected. Even different understandings of assignments do not necessarily lead to conflicts, but may instead result in better and more innovative task solutions [1]. Geographical dispersion enables the employment of highly skilled project members where they are available without the need for costly personnel transfers. Thus, even though globally distributed IT projects are more challenging than co-located projects, they offer organizations great opportunities and benefits.

However, in order to benefit from successful global projects, team members must trust each other to communicate and collaborate regardless of geographical, temporal, and cultural distance. Communication and trust are essential to every type of business setting but they certainly play a dominant role in virtual organizations, and for this reason also in globally distributed IT projects [2]. Regular face-to-face (F2F) communication among team members of co-located projects supports the building of trust and the sense of "teamness" [3]. As face-to-face communication is not always possible in globally distributed projects, information and communications technologies play a crucial role in communicating and developing trust within global project teams. Though companies extensively use ICT to enable and support communication in distributed project teams, communication is still recognized as one of the biggest challenges encountered in globally distributed IT projects [4]. Another challenge, strictly related to communication, is fostering a bond among geographically dispersed project team members. Project team members located at different sites are less likely to perceive themselves as part of the same team than members of a co-located project team [5]. As globally distributed projects rely heavily on communication media [1], it is important to ensure that project team members are able to use the available means effectively.

While effective communication and trust are among five of the most frequently identified challenges in the project management of distributed software development, fostering team spirit was identified in only five of 54 analyzed studies [6]. Though the frequency measured by da Silva et al. [6] only indicates the number of times a particular challenge was identified in different papers and not how significant this challenge could be, the author of this research believes that the issue of the sense of team unity is underrepresented in prior literature and requires further in-depth analysis.

The goal of this research is twofold. First, the author attempts to identify new trends toward ICT use in globally distributed IT projects. Secondly, the author aims to fill the gap in prior literature by analyzing how ICT can be used for developing this sense of teamness within globally dispersed project teams. In light of the increasing importance of globally distributed project teams, this study draws practitioners' attention to the importance of striving for teamness in globally distributed IT project teams.

The paper contains the results of two research methods: theoretical and empirical. After presenting a theoretical background related to the study, the theoretical part is continued with a structured literature review on the topic. Subsequently, the research method implemented in the empirical part of the study is justified, followed by the preliminary results of the semi-structured interviews with global project managers in India. The author concludes by evaluating the limitations of the current study, as well as suggesting possible directions for future research.

2. Theoretical background

According to Binder (2007), global projects involve people distributed across various countries and organizations [7]. Likewise, DeSanctis and Monge (1999) define a virtual organization as "a collection of geographically distributed, functionally and/or culturally diverse entities that are linked by electronic forms of communication and rely on lateral, dynamic relationships for coordination" [2]. Available evidence indicates that while an IT project can be global – albeit conducted within a single organization – it cannot function without sufficient ICT involvement (e.g. a software development project at Motorola which involved engineers from Motorola's software development centers in six different countries [8]). ICT is used in many industry global projects, but this research focuses solely on globally distributed IT projects. IT projects (including software development projects) are perceived as being more challenging than other industry projects (e.g. construction projects) due to the following characteristics [9]:

- A higher level of uncertainty resulting from higher technological novelty;
- Low product visibility;
- High-speed pressures requiring more flexible project management;
- Changeability;
- Higher risk involvement.

The communication problems that global projects often face tend to arise from missing informal communication, which is a constant struggle for internationally distributed teams [10]. Past evidence indicates that communication in global software development (GSD) is less frequent [5] and less effective [11] than in traditional, co-located project teams. Thus, the ICT must strive to strengthen the effectiveness and efficiency of communication practices between geographically distributed team members. Furthermore, communication media should enable rapid information exchange and promote regular communication. Previous research results indicate that ICT reduces the negative effects of intercultural communication and supports the positive aspects of decision making in global virtual teams (GVT) [12].

On the one hand, ICT enables communication in distributed teams. On the other hand however, heavy use of ICT and a strong dependence of project team members on technology represent another reason for communication problems in globally dispersed projects [1]. An unforeseen technical problem, such as a sudden power outage at one location, can lead to temporary communication breakdown. This in turn can result in increased anxiety felt by team members at the other site. Furthermore, a high information load due to excessive volume of e-mails can lead to delays as well as increasing the risk of overlooking important information [13], [14]. In addition, slow or delayed feedback due to communication media has a negative impact on global project team performance. When using asynchronous communication tools, such as e-mail, discussion boards, shared documents, web logs, etc., for solving urgent issues, the lack of immediate response can delay the decision making process. Delayed response is perceived as an obstacle to the development of 'familiarity' and a sense of unity among dispersed project team members [15]. Thus, choosing the right communication media in particular situations is crucial.

Communication media differs according to the level of information richness [16]. The Media Richness Theory (MRT), proposed by Daft and Lengel (1986), is used to define the ability of different communication media to transfer information [17]. The communications medium with the highest level of richness is face-to-face communication, followed by video conferencing, phone, and online chat respectively. The lowest richness level is represented by e-mail, text messaging, and written documents [16]. A loss of communication richness is considered to be one of the major communication problems and one of the main collaboration challenges facing typical global software development projects [18], [19]. The ongoing research attempts to study the link between different communication tools and creating oneness in globally distributed IT projects.

The basic infrastructure that any organization conducting global projects must be equipped with consists of computer-mediated communication systems (CMCS) [20]. Rice (1987) described computer-mediated communication systems as those that "use computers to structure and process information and use telecommunications networks to facilitate its

exchange" [21]. These systems include, among others, e-mail, voice messaging, and computer conferencing. The rapid development of technologies that support communication and facilitate the exchange of data and information, including the Internet, telephony, broadcast media, and all kinds of audio and video transmission technologies, improves teamwork undertaken by geographically distributed project team members.

Current trends demonstrate an increased use of social media by many organizations [22], [23]. Social media and related applications are used extensively in globally distributed projects, as they enable quick communication between project teams and stakeholders dispersed across the globe. Perpetual communication and the possibility of direct response plays an important role in global settings, particularly in conflict management [24] but also in relation to building up trust between project team members [14] and nurturing a sense of unity.

Cooperation between project team members is crucial for successful project team performance [14]. However, establishing a sense of unity, also referred to as "oneness" or "teamness", is recognized as one of the challenges facing global teams [25]. Teamness is characterized as an intangible feature of a team's performance [26]. It is the ability of individuals to collaborate and work effectively as a team [27]. Teamness can be identified by close relationships among team members, their strong commitment to the team's success, and a perceptible unity of team members. Teamness is a synonym of oneness which places more emphasis on the aspect of striving for a common team achievement.

Creating a sense of unity in globally distributed projects poses a challenge, in particular due to the distances that exist between project team members and a lack of regular face-to-face communication that would strengthen trust among team members. Distant project team members often feel less teamness and perceive their other colleagues to be less cooperative and helpful in the event of increased workloads [5]. While prior literature recognizes the need to reduce distance separating parts of globally distributed projects [11], [28], [29], to the author's knowledge there is no research indicating that a higher level of teamness can decrease a perceived distance between team members. The author found that previous research on the significance of teamness in global projects, as well as the literature on the impact of ICT on creating a sense of unity in geographically dispersed project teams, is scarce.

3. Review of teamness in prior research

One of the motivations for conducting a literature review on teamness is that different researchers employ different terminology to describe the same aspects. This poses a problem, as different terminology and definitions lead to discrepancies in the results [1]. This literature review aims at structuring the knowledge of teamness in globally distributed IT projects. Moreover, the author expects to identify a link between the use of ICT and developing teamness in distributed projects. To perform this systematic literature review (SLR), the author followed the SLR guidelines proposed by Kitchenham [30]. The review process involved several steps.

3.1 Methodological approach

In the first step, the need for a review was identified by recognizing the lack of structured knowledge about teamness in globally distributed IT projects. Moreover, the link between the use of ICT and teamness was not clear. To the author's knowledge, there is no research reviewing how ICT supports or interfere with developing the feeling of oneness in distributed project teams. Teamness is an important aspect for team performance and it becomes even more critical as team dispersion increases. However, teamwork quality is more difficult to achieve in distributed projects [31]. Thus, its meaning should be more stressed in the literature.

In the second step, the research questions were defined:

SLR Q1: What terminology is most commonly used when referring to teamness?

SLR Q2: What is the relationship between the use of ICT and unifying distributed project teams?

Subsequently, the search process was conducted. The process involved five steps as presented in Fig. 1. First, several trial searches were conducted to determine the most appropriate keywords, resulting in the following Boolean search string:

Project AND
(global or distribut* or dispers* or virtual*) AND*
(IT project OR software project) AND
(teamness OR oneness OR team cohesion OR teamwork OR performance OR commitment) AND
ICT.

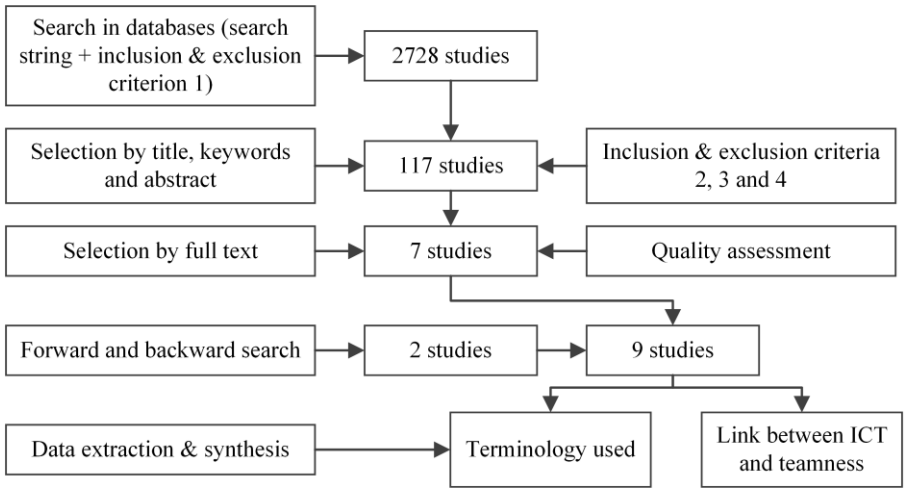

Fig. 1. Literature search process

The selected search string was adopted in three major scientific databases: EBSCO database; ScienceDirect; and AIS Electronic Library (AISeL). The database search included the full text of the papers, ensuring that no relevant study would be omitted. In order to limit the very broad scope, it was limited to the most recent articles and conferences or conference proceedings published between 2006 and 2014. The initial search resulted in 2728 studies. Subsequently, while studying the title and abstract, a few inclusion and exclusion criteria were considered ensuring that the primarily selected items:

1) Were studies published since 2006;
2) Were full research papers published in a scientific journal or conference proceedings;
3) Were theoretical (applying systematic literature review methods) or empirical studies;
4) Were related to globally distributed project teams.

117 unduplicated studies fulfilled the criteria and were examined in more detail. By analyzing the full text of the preselected articles, the following quality assessment criteria were taken into consideration:

- Is the study based on practitioners' experience or classroom research? (Studies derived from classroom analysis were excluded from the selection list);
- Is the study related to the IT industry? (Studies involving other industries, e.g. construction projects, were excluded from the selection list);
- Is the study related exclusively to project teams and not working teams? (Only temporary teams are relevant as it is more challenging to develop the feeling of oneness in project teams than in ongoing work teams, thus, researches on ongoing working teams were excluded from the selection list);

- Is the study relevant for examining the link between ICT and the development of teamness in distributed teams? (Studies that focused solely on other issues, such as using ICT for knowledge sharing or conflict management, were excluded from the selection list).

The rigorous quality assessment resulted in seven articles. However, there are of course relevant articles that were published prior to 2006 or were included in other scientific databases. In order to ensure a high quality and completeness of the literature review, the limited research sources were expanded by backward and forward search as suggested by Webster and Watson [32]. Backward search is conducted by reviewing the references of the primarily selected studies, while forward search leads to other articles that cited the selected papers [32]. After conducting the search, two relevant articles (fulfilling the inclusion/exclusion as well as the quality assessment criteria) were additionally included in the selection list. In total, nine high quality studies were extensively reviewed and analyzed from the point of view of using ICT and developing teamness in globally distributed IT projects.

The quality of the selected papers was assured by including only full research studies published in scientific journals and conference proceedings, i.e. all papers have been peer-reviewed. The relevance of the selected papers was assured by including only those articles that fulfilled the quality assessment criteria of this research. Studies from the initial selection list that were not included in the final review were rejected frequently due to lack of focus on IT project teams. However, as expected by the author, the main reason for rejection was the missing input concerning teamness.

3.2 Relationship between ICT and teamness in globally distributed IT projects

Table 1 represents the complete list of reviewed articles along with the terminology related to teamness used in each paper. The last column of the table presents evidence of teamness in prior literature. It includes also evidence of the use of ICT that could impact the level of teamness in globally distributed IT project teams.

Table 1. Articles on the use of ICT and its impact on developing teamness in distributed projects

Authors	Year	Terminology	Evidence of teamness and ICT
J. Ahuja [33]	2010	Team participation; Teaming; Relationships; Ties; Sense of belonging; Group cohesiveness.	Ties connecting virtual team members are lateral but weak due to lack of face-to-face (F2F) interaction, the span across cultural and organizational boundaries, and lack of emotional support; Virtual teaming is a new way of managing and organizing work that allows people to work together even though they are geographically separated; Daily communication between members and team leader is a kind of glue that holds the team together; Teams that had relational link training show higher group cohesiveness.
L. Dube and D. Robey [34]	2009	Teamwork; Group cohesion; Belonging; Relationships; Team identification; Relational ties; Social ties.	Reliance on ICT can hinder the development of group cohesion; Occasional F2F contact is insufficient to establish team identification that is stronger than subgroup identification; Use ICT to break the isolation and get everyone's input; Use newsgroups to make team members "feel like [they] are part of the team, even if [they] don't see or talk to each other every day"; F2F exchanges include more social information and help to develop relational ties through nonverbal cues; Once established, social relationships could be maintained through ICT; Because ICT reduce the amount and richness of the information, establishing social relationships requires more effort; Increased frequency of communication helps to establish social relationships; Better relationships come from learning to use communication media differently: don't use e-mails only for task-related conversations, have a smile in your voice; Shared calendars help team members to maintain their virtual presence.

R. Giuffrida and Y. Dittrich [35]	2013	Team spirit; Relationships; Team awareness; Group interrelations.	Social software supports social relations and team spirit; Instant messaging may encourage informal communication and relationship building; Facebook is used to build rapport and stronger working relationships; Organizational social networking sites are used for creating team awareness, and for fostering community building and group interactions.
H. Holmstrom, E. O. Conchur, P. J. Agerfalk and B. Fitzgerald [36]	2006	Teamness; Team cohesion; Feeling of belonging.	A major challenge is how to create a feeling of teamness among distributed project members; A mediator between sites may be helpful in developing the feeling of teamness; Keep photos on the website and a profile of everybody to realize that there is actually 'a human-being at the other side'; Have some co-located team building activities; Use team websites to foster the feeling of teamness.
B. Koehne, P. C. Shih and J. S. Olson [37]	2012	Team cohesion; Team awareness.	Awareness tools should be provided to increase a sense of presence across distributed teams; Remote team members should give the impression that they are available and easy to reach; Team managers can strive for higher team cohesion by promoting an open communication culture in the team; Implementing specific ICT that broadcasts activities and group interaction, such as instant messaging, document management systems and newsletters can increase team awareness.
J. Nabila and D. Mohamed [38]	2008	Collective awareness; Team cohesion.	In team having short life span and whose members work together for the first time, it is difficult to build collective awareness; The establishment of a mutual trust within the team and team cohesion supports and facilitates information exchanges and sharing.
I. Oshri, J. Kotlarski and L. P. Willcocks [39]	2007	Cohesion; Identity; "One-team" spirit; Belonging.	The norms, identity and cohesion between team members develop through socialization; Apart from regular and frequent communication – teleconferences, videoconferences – short visits to remote locations are organized to maintain a "one team" spirit; It was challenging to maintain a "one-team spirit" in the long term after a F2F meeting; A team-building exercise gave the entire team and each site a feeling of belonging; English language lessons positively affected the feeling of belonging; Occasional F2F meetings between certain individuals and a restricted use of rich media tools resulted in discontent among members of the global team.
P. Pinjani and P. Palvia [40]	2013	Team cohesion; Team commitment; Relationships.	Developing cohesion among global virtual team (GVT) members is a challenge; Communication and collaborative technologies serve as additional bonds linking the members of a GVT; An increase in electronic interaction between team members leads to an increased sense of trust and belonging; Training should be provided to help in the process of relationship building among team members; Greater diversity entails relationship building among team members and leads to increased team effectiveness.
J. S. Sidhu and H. W. Volberda [41]	2011	Oneness; One team; Team spirit.	Tangible, work-connected changes may have an influence on the development of a sense of oneness; Involving both onshore and offshore team members in a project from the very start generates a sense of onshore–offshore equality and team spirit.

The results of the systematic literature review indicate that very few researchers have analyzed both, the aspect of teamness and the use of ICT within a single research project. Furthermore, none of them defines the link between the use of ICT and the level of teamness in globally distributed IT projects. Moreover, a definition of teamness in relation to globally distributed IT projects is missing.

4. Research objectives and research design

The research described in this paper attempts to examine the role of ICT in the creation of teamness in globally distributed IT projects. The following topic areas play an important role in the ongoing research: challenges related to culture and cross-cultural differences, conflict prevention and management, communication, trust, and a sense of unity in dispersed project teams. In each of these fields, information and communications technologies play a significant role. The scope of the paper as presented here is limited to the relation between ICT, communication, trust, and the one-team approach (teamness) in globally distributed IT projects

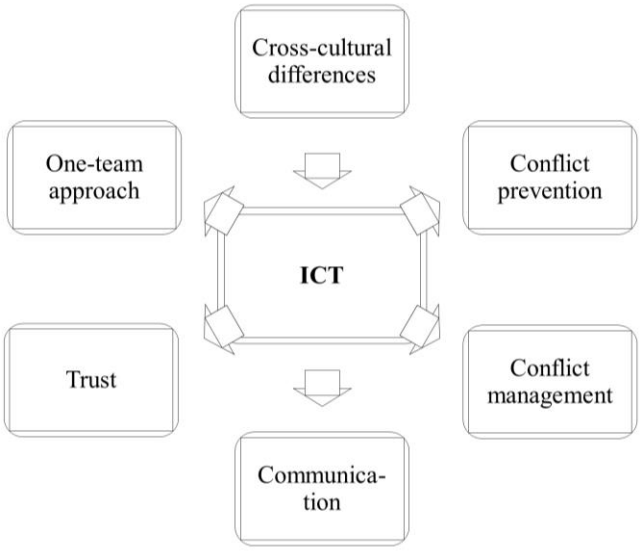

Fig. 2. The influence of ICT on global project related topics

This research has its basis in sociological orientations [42]. The empirical study follows explanatory research design based on a case study. Explanatory design aims at determining how events occur and which events may influence particular outcomes [43]. In addition, this research investigates the ways in which global project managers and team members use ICT tools in the communication process to improve the feeling of oneness within globally distributed projects. Yin (2008) distinguishes three types of case studies [44]: single; holistic; and multiple case studies. Since this research encompasses the analysis of responses offered by several project managers belonging to a single organization, this research is based on a single case with embedded units [44].

The data collection for this qualitative research was conducted by means of semi-structured interviews. The case study was conducted in India. The author spent two weeks visiting the case company's locations in three different cities, participating in the daily activities of project teams and conducting interviews with global project managers. The case company is a large, multinational enterprise, which has been providing IT services, business consultancy, and business process outsourcing for nearly two decades.

The case study contributes to the current literature by answering the following research questions:

Q1: How do information and communications technologies impact the fostering of teamness in distributed project teams?
Q2: What is the current trend toward ICT use in globally distributed projects?

Examining the interviewees' responses, the author attempts to analyze the influence of ICT on fostering a sense of team unity in globally distributed projects. The importance of ICT to such projects has been widely recognized and investigated. However, as confirmed by the literature review results, the relationship between the use of ICT and the level of teamness in globally distributed IT projects has so far been widely ignored by other researchers.

Participants responded to a set of questions, conveyed to them beforehand. Any additional comments not strictly related to the question were allowed. The interviewer was able to ask follow-up questions during the interview. All participants involved in this study were informed of the purpose of the research and gave their permission for interviews to be recorded. During interviews, additional notes were taken which could afterward be compared to the audio recording in case of possible ambiguities arising from the recordings.

The initial interview set consisted of seven interviews with eight global project managers (six one-on-one interviews and one group interview with two respondents) as well as one interview with a global project team member. The interview with the project team member is excluded from the study as presented here, though it will be included in future research. Furthermore, two interviews with global project managers are not included in this analysis – one due to a missing permission slip for audio recording, and one due to insufficient quality of the audio recording. As a result, the answers of six experienced global project managers were transcribed. Each interview lasted between one and two hours. The possible length of the interview was communicated to the participants beforehand. The first interview set resulted in approximately six hours of audio record and a 79-page interview transcript.

All interviewees are Indian, male, and employed by a single organization. Taking the experience of the company into consideration, the author believes that the corporate culture and carefully developed global communication procedures at this company may have impacted the interview results. As the interviewed project managers were positioned in different locations, the interviews were conducted in three different cities in south and south-western parts of India. Each interviewee has several years of experience as a project manager of both globally distributed and co-located IT projects (a span of 8-23 years of experience, which is visualized in Table 2).

Table 2. Overview of study participants

	Interviewee 1	**Interviewee 2**	**Interviewee 3**	**Interviewee 4**	**Interviewee 5**	**Interviewee 6**
Current position	Director – Projects	Program Manager	Associate Director	Director – CRM	Senior Project Manager	Senior Consulting Manager
Years of IT work experience	21	16	16	23	18	8
Engineering background	n/a	Yes	Yes	Yes	Yes	n/a

In order to analyze the interviewees' responses, the audio recordings were transcribed and coded line by line. A matrix was created to categorize the responses of each study participant. The categories were based on the interview questions and consisted of a definition of 'globally distributed IT project', communication, trust, cross-cultural issues, one-team approach, conflicts, communication and collaboration tools, and other challenges globally distributed IT projects raise. Subsequently, the audio recordings transcriptions were carefully analyzed, key words were marked, the relevant quotations inserted into the matrix, and the responses compared and contrasted.

Due to the very limited number of respondents and the strong homogeneity of their profiles, only a few patterns could be observed. A few early observations are presented in the following section.

5. Preliminary results

Research evidence has indicated that communication is still a dominant challenge for globally dispersed project teams. This was confirmed by all six interview partners. Furthermore, it is clearly stated that communication plays a major role in building trust and creating a sense of unity in distributed project teams (e.g. "The most important thing [in trust building] is that we consider a timely communication. It is very important!"; "Face-to-face meeting, regular communication and showing the importance to the customer build the confidence" [Interviewee 1]). Thus, these three factors – communication, trust, and teamness – are identified as salient factors influencing team performance in globally distributed projects. Due to the strong dependence of such teams on the use of information and communications technologies, all three aspects are heavily impacted by ICT (see Fig. 3).

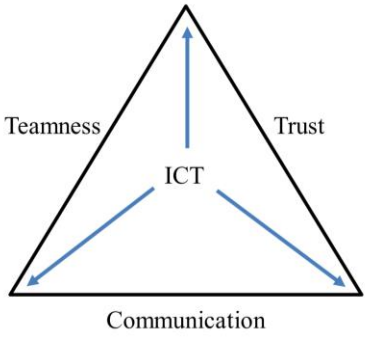

Fig. 3. The effective distributed teamwork triangle

The levels of trust and teamness depend on the quality or amount of communication. The better team members communicate, the stronger the bonds between them are and the higher the trust level in the project team is. As one participant stated, in a global project team "people do not see [each other] face-to-face, people talk on phone, but are not together. Sometimes the teams are so disposed that they [will never meet at one location]. But the management has to take conscious effort to bring them together because if they do not talk to each other, they do not feel each other, it will not work. The feeling of oneness is not there. Bonding is important, connecting is important, connection is important." This study participant indicated a substantial relationship between communication and the feeling of oneness. Since communication among distributed project team members is merely dependent on use of ICT, we can claim that an appropriate use of ICT positively impacts the level of teamness in distributed teams.

Interviewees were generally asked about typical challenges that they frequently face in their global projects and consider as crucial in global project management. After communication, the next notably challenging issue was fostering the feeling of oneness. Its significance was frequently highlighted by various interviewees, e.g. "Mostly this is the big challenge for me to make the whole team as one team." A lack of teamness and difficulties in establishing a feeling of belonging within teams has been also identified as one of the challenges revealed by several other researchers [25], [36], [45], [46]. Furthermore, Holmstrom et al. [47] revealed that due to geographical distance, establishing a feeling of trust and belonging, i.e. teamness, within global project teams is hampered. Despite the fact that the significance of teamness is generally neglected in prior literature on global project management, the interview results highlighted its role in globally distributed projects. The results demonstrate that project managers need to strive for a visible oneness in the project team in spite of its geographical dispersion.

Frequently, parts of the distributed teams become local teams during the project, but in relation to this team in another location they are disconnected. An interviewee emphasizes the problem the lack of teamness poses by stating: "That one-team approach is sometimes missing because distributed teams become local teams during that time and they do all this storming and performing and all that stuff within that team. But when it comes to this team in another location they

are disconnected." Thus, the best way to unite the entire team is to use information and communications technologies, which is emphasized by one interviewee: "The only way we can bring them [team members] together is through the video conference (…) What we have is weekly calls, monthly calls and we have a senior management, which is also within the location so that we interact and share the information." As stated by several study participants, the on-site management visits additionally support developing trust and the sense of oneness.

Furthermore, companies require convenient communication technologies and a structured communication process, as confirmed by an interviewee stating: "When we have this cross-cultural team across various time zones, it is necessary that there is an established or a structured communication process that happens between these teams, so that the project objective is tracked and it is seen that there is fulfillment of this objective. So this communication is of most importance, if you have to really manage these global distributed teams." Additionally, communication should be encouraged. An appropriate means of encouraging project team members to communicate regularly is to make various information and communications technologies available on demand and accustoming team members to the communication process. By frequent communication, the feeling of unity is strengthened.

Moreover, modern companies frequently adapt ICT to their employees' preferences and communication habits. Some project teams require daily calls, nightly calls, weekly status reports, etc., but some teams also create a Facebook page dedicated to a particular project, where they are also able to "keep sharing some good memories, e.g. photographs" [Interviewee 4]. Sharing experiences and photographs certainly increases a sense of oneness within the project team. This practice of setting up a photo gallery to help team members get an imagination of those they were communicating with is also confirmed by Herbsleb et al. [48]. Moreover, project members using social media can post an inquiry to the community and receive a response from that community. As one participant concluded, organizations should encourage communication through social channels as it has several benefits to the project team work across borders [Interviewee 3]:

- It enables us to reach out to many people;
- It becomes instantaneous;
- It creates a body of knowledge;
- It assures that the knowledge that already exists is disseminated to multiple people.

In globally distributed projects, the identification of roles and responsibilities is hampered and the awareness of other team members' knowledge and experience is not often transparent to all members. Globally distributed IT projects frequently involve multiple organizations, people work with each other for the first time, and what is more, they are dispersed across various locations. These factors can effectively hinder awareness of who knows what in the project. Therefore, reaching out to many people through social media can significantly facilitate communication and knowledge sharing in distributed teams.

Since frequent communication increases the level of trust in distributed project teams, using social channels undeniably has a positive influence on the feeling of oneness as well. In particular due to the fact that computer-supported social networks have low limitation in regard to distance and time [29], they can considerably diminish the cognitive distance between project team members. This can strengthen the shared knowledge between project members by reducing temporal and geographical limits as they affect the motivation for sharing knowledge [49].

The so-called 'millennial generation', i.e. the generation of 1980-2000, in particular tends to use cell phones to communicate. Adopting mobile or social channels enables them to communicate faster. Writing an e-mail and waiting for a response is seen as time consuming. Thus, project team members often prefer using instant messenger, the company's internal communicator, or even short messaging service (SMS) to contact the manager. According to one interviewee, this way of communication is frequently more efficient because "whenever somebody sends you a message through a communicator, you tend to respond instantly." This trend toward ICT use is confirmed by several study participants.

The same interviewee identified SMS as a tool that has recently started to be used for business communication. To offer an example, let us assume that a project manager is at a conference meeting and one of the team members requires his approval of a report he has prepared. As the global project manager stated: "I'm sure he might have sent an e-mail, [but] he wouldn't have gotten a response because we are in a meeting at this moment of time. In ten minutes he already sent me a message [SMS]" [Interviewee 6]. Thus, the recent trend toward ICT use is that "more tools are used for communication and tools where you get instant response are being used" [Interviewee 6].

Empirical evidence from prior literature confirms that tools such as instant messaging are important for project success. Casey and Richardson pointed out that instant messaging was not viewed as a business tool at the time of the projects under research [45]. This was perceived as one of the problems that challenged the project as an informal method of communication was quite clearly lacking.

Apart from instant messenger and social media, interviewees unanimously confirmed that phone calls, telephone conferences, forums, and video conferences belong to their major communication media used. Despite that, the most extensively used method is e-mail communication. E-mails are viewed as an official way of communicating as they are "standing in a court of law". However, project managers mention the problem of junk e-mails and the time required to screen the inbox every day, in particular when a person receives hundreds of e-mails. Another issue regarding e-mails is when "(…) the mail chain goes on and on and on… and it becomes too big and it is meaningless sometimes." [Interviewee 1]. Then the respondent takes the advantage of oral communication and clears the issue on phone. There are companies which introduced a "no e-mails" culture within the organization. Nonetheless, the study participants confidently claimed that the e-mail communication "is not going anywhere, anyway" [Interviewee 4]. It leaves a trail and is probably the most crucial means of communicating across geographical and time distance.

Global organizations have extensive communication platforms to support communication and information sharing, as well as to bridge cognitive distance within distributed project teams. As one interviewee concluded, "thanks to the network and the modern communication facilities, work can be done where there are people, who are skilled and [available] at the reasonable cost." However, especially in projects partially conducted in developing countries, it is important to pay additional attention to ensuring uninterrupted communication prospects. Sudden connection breakdown between the sites may have a negative impact on the feeling of oneness as unexpected silence on one site reflects the separateness of the team and cognitive distance.

In order to enable efficient and uninterrupted use of ICT, a backup power supply should be provided for. During the author's stay at the locations in India, the power supply was disconnected three times during one day. Each time, the company's backup power supply activated automatically, which enabled undisturbed work on running projects and continuous communication with other sites.

Silveira and Sbragia [50] studied communication practices in the global product development projects of Brazilian multinational firms and found a trend toward the use of more traditional ICT tools, such as telephone and e-mail, by companies that encourage formal communication. On the contrary, the companies that encourage informal communication foster among other things, instant messaging, which is perceived to be an informal communication practice [50]. The case study presented in this paper does not distinguish between formal and informal communication practices, but the interviews results confirm the trend toward the use of more instantaneous communication tools.

6. Conclusion and study limitations

Though a lack of teamness is occasionally mentioned in prior literature as one of the challenges facing global project teams, prior studies clearly undervalue this issue. Empirical study results indicated that developing a feeling of oneness appears to be particularly challenging to global project managers. Globally distributed project teams depend strongly on information and communication technologies. However, the link between the use of ICT and teamness in distributed

projects was not clear. Thus, the main purpose of this paper was to investigate the phenomenon of using ICT to foster a feeling of teamness among globally dispersed project team members.

This paper describes a theoretical and an empirical research in the field. First, a systematic literature review was conducted. Secondly, initial interviews with Indian project managers were conducted and examined. The author transcribed the interview audio record available at present and analyzed the results. An initial literature review on ICT use in global projects encountered significant gaps in previous research. In particular, the author found that previous research on the impact of ICT on globally distributed project team performance as well as research on the significance of creating a sense of unity in such teams is scarce. This study contributes to the research on globally distributed project teams and their unity.

However, the current state of the research exposes some limitations. First of all, prior interviews involved six project managers from one multinational company. The future research work will need to ensure a greater range of respondents. The single case study will be expanded into multiple case studies research involving other companies from the IT sector in Germany, Poland, and India, which will provide more evidence.

Given that corporate culture has a strong impact on information and communications technologies usage [28], project managers from multiple organizations should be involved in the research. Furthermore, all previous interviewees are global project managers from India. Since culture influences the attitude toward trust and group association (collectivism *vs.* individualism), practitioners from other countries will be involved in future interviews. With more respondents, the author expects to cluster and classify the study fields into clearly distinguished categories as well as to find common patterns [51].

The author believes that using ICT may be easier for team members engaged in IT projects as they are assumed to have a better understanding of new technologies and are more familiar with using IT in their every-day work. However, proving this empirically was beyond the scope of this research. Also, the impact of teamness on project success has yet to be examined. This gap is expected to be filled in future research work.

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The use of Game Theory to solve conflicts in the project management and construction industry

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The use of Game Theory to solve conflicts in the project management and construction industry

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Abstract:
A typical construction project involves a wide range of disparate professionals, in many cases geographically distributed, working together for a relatively short period of time on the design and construction of a facility. Since organizations are becoming flatter, culturally rich, geographically diverse and intensely competitive, the possibilities for conflict in such environments are greater. Negotiation is an important aspect of a project and plays an important role in resolving claims, preventing disputes, and keeping a harmonious relationship between project participants. Part of any project manager's role as a leader is to recognize conflict, understand the sources of conflict and manage it, and to do this a project manager must be able to understand the basics of negotiation theory and have sufficient competencies to lead in such situations. To address the complex technical and human issues in negotiation, different negotiation theories and models are available which mainly include game theory, economic theory, and behavior theory. Since Game Theory provides, by its very nature, the appropriate tools for the analysis and eventual solution of conflicts of any kind, this paper uses a model based on Game Theory in order to identify the activities that are responsible for the delays in a project and divide the costs among them.

Keywords:
project management; conflict; negotiation; Game Theory.

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1. Introduction

Nowadays, the construction industry suffers from several problems such as high fragmentation, complexity and dynamicity, resource discrepancies, cost and time overruns, conflicts and disputes, etc. Since projects are becoming large and complex, involving multiple participants located at different places, the resources and operations of a project are distributed by nature [1]. The wide range of stakeholders and multiple objectives in large-scale construction projects inevitably cause conflicts. Construction problems also involve complexity and dynamicity. The construction sector represents one of the most dynamic and complex industrial environments requiring the application of different technologies or technical approaches [2]. The components of these large, open, and complex projects are not known in advance, can change over time, and consist of highly heterogeneous agents implemented by different people, at different times and with different software tools and techniques [3]. Resource discrepancies are also a major cause of change. When the timing of the tasks is not well matched with the available resources, subcontractors may try to change the master schedule in order to accommodate their desires. This may cause conflicts because in tightly coupled project schedules any move affects the tasks of other subcontractors. In most cases, these conflicts cannot easily be resolved simply by delaying the succeeding tasks, since task delays could extend the project completion beyond the deadline [4]. In these cases, subcontractors hinder their own performance as well as that of other subcontractors and ultimately the entire project [5].

According to Lei et al. [6] the possible reasons for conflict in the construction industry are the following: (i) during the lifecycle of construction, especially in the planning phase, the participants are confronted with enormous issues and a multitude of implicit and explicit interests; (ii) there are obvious differences in mental behavior, culture, temperament, etc., among different negotiators. Thus, their abilities, knowledge and preferences for the same issue differ too; (iii) a huge amount of information is required for decision-making in the construction industry. Therefore, it is difficult for decision-makers to grasp all the information required, the information used by every participant is unilateral and deficient.

The construction industry has a long tradition of collaborative working between the members of a construction project. To ensure that interdependencies are properly managed, the global construction industry requires that project participants across the world are able to work more closely, to exchange project information in a more structured way, and to collaborate and co-ordinate with each other to perform construction activities in order to gain maximum competence [1], [3]. There is a need to develop a negotiation methodology for the project schedule optimization process that ensures overall optimality and resolves conflicts by negotiation among project participants [4]. The challenges are to find a new approach that enables project participants to identify schedule conflicts, consider alternatives, and resolve conflicts in a highly coupled network of related activities [5].

This paper uses a model based on Game Theory, defined as the study of mathematical models of conflict and cooperation between intelligent rational decision-makers [7], in order to identify the activities that are responsible for the delays in a project and divide the costs among them. The paper is organized as follows. In the next section, the conflict in the construction industry and the basics of negotiation theories are analyzed. In section 3, game theory and the Core of a game are presented and, in section 4, this concept is applied to a road construction project. Finally, there is a concluding section with the main findings of the paper and future research.

2. Conflicts in the construction industry

A project can be conceived as a single continuum or recurring negotiations with multiple participants with varying concerns [8]. A typical construction project involves a wide range of disparate professionals (clients, architects, structural engineers, contractors, etc.,), in many cases geographically distributed, and working together for a relatively short period of time on the design and construction of a facility [9]. Since organizations are becoming flatter, culturally richer, geographically diverse and intensely competitive, the possibilities for conflict in such environments are greater and project managers must have sufficient competencies to lead in such situations [10].

There are different views on conflict and the causes that originate it. Levinson [11] describes conflict as a dispute over resources, whereas other authors [12]-[14] believe that conflicts are either interpersonal (affective) or task/goal oriented (substantive). Interpersonal conflicts are clearly more intractable than task/goal conflicts and can lead to imbedded friction [10]. Rahim [12] contends that interpersonal conflict diminishes group loyalty, commitment, job satisfaction, and intention to stay in the organization. Jehn [15] and Rahim [12] suggest that while task/goal conflict may enhance performance under certain circumstances, the downsides are the same as for interpersonal conflicts. Conflict can arise from several causes such as cross-cultural differences. Many authors argue that cross-cultural training is a very strong mediator for avoiding and diminishing destructive conflict [16, 17]. Another method for reducing differences in cross-cultural conflict and to help to educate people in the richness of diversity is the use of metaphors and stories [18]-[20].

There is a limited coverage of conflict management and negotiation in the standards for project management. The Australian National Competency Standard for Project management, one of the most widely recognized and referenced project management standards based on the nine areas of the American Body of Knowledge [21], focuses on the mechanisms of communication within a project but the only reference to negotiation is that of contract negotiation. Conflict is covered in greater detail, with the establishment of procedures for conflict resolution, the management of inter and intra project conflict, the reduction of client conflict, management of the resolution of contract conflict and the escalating of conflict issues to senior personnel. According to Hudson et al. [10], conflict management competencies include: reducing conflicts within project teams, not hiding or avoiding conflict but facilitating resolution, identifying the social behavior reflected in conflict situations, supporting the creation of healthy argumentative cultures, and being able to find consensus with others, aiming for win-win situations, and reacting coolly to personal attacks and forgiving such attacks.

Part of any project manager's role as a leader is to recognize conflict, understand the sources of conflict and manage it, and to do this a project manager must be able to understand the basics of negotiation theory. Negotiation is an important aspect of a project and plays an important role in resolving claims, preventing disputes, and keeping a harmonious relationship between project participants [22]. In a multi-person decision- making process when there are a number of decision-makers involved in choosing a single alternative from a set of possible alternatives, multiple disciplines and teamwork, different concerns caused by different preferences, experiences and background, negotiation plays an important role for multi-person decision-makers to select unfinished projects that will be continued, postponed or terminated [23].

Negotiation is the process of joint decision-making [24]. It is communication, direct or tacit, formal or informal, between individuals who are motivated to converge on an agreement for mutual benefit [25]. According to Raiffa et al. [26], the basic structure of negotiations in different contexts is fundamentally the same and all negotiation situations share four common characteristics: (i) there are two or more parties; (ii) the parties can be creative and cooperate to arrive at a joint decision; (iii) the payoffs to any party depend either on the consequences of the joint decision or alternatives external to the negotiations; (iv) the parties can reciprocally and directly exchange information, honest or not.

It is widely admitted that a client and a contractor face significant difficulties in negotiating major projects. These major projects entail hundreds of issues and a multitude of implicit and explicit interests resulting in substantially complex negotiations between the client and contractor. However, project negotiations are not confined to the planning oriented phase culminating in contract signing. Serious bargaining often commences only after an initial settlement is reached and the most arduous negotiations are typically conducted during or after implementation [27].

Most project managers consider negotiation as the most time-and energy-consuming activity in claim management [28]. In addition, claim negotiation is commonly inefficient due to the diversity of intellectual background, many variables involved, complex interactions, and inadequate negotiation knowledge of project participants [28], [29].

To address the complex technical and human issues in negotiation, different negotiation theories and models are available which mainly include game theory, economic theory, and behavior theory [28]. Game theory is divided into two approaches, the axiomatic approach and the strategic approach. Under the latter, approach game theorists treat

economic theory as a part of game theory. On the other hand, negotiation theorists usually distinguish game theory (mainly referring to the axiomatic approach) from economic theory [30]. Game theory seeks to get to the essence of decision-making and the associated strategies in situations where two or more parties are interdependent, and where the outcome of their conflict and competition must be the product of their joint requirements and the interaction of their separate choices [31]. All the players in games are assumed to be rational, try to maximize their own utilities, and have complete information on the payoff function and utility function [32]. In contrast to the classical game theory approach, in economic theory there is no concern for the discovery of once-and-for-all strategies, but rather an intention to examine how the bargainers should interact in terms of their expectations of each other [33]. Economic models analyze the processes through which the demands of the participants converge in the course of offers and counteroffers toward some specific point on the contract curve [31]. In behavior theory, much attention is given to the nature of changing expectations and negotiators' tactics, and to the significance of uncertainties of information, perception and evaluation, all matters that tend to be ignored by game theory and economic theory [34]. Behavior theory attempts to analyze the negotiation processes in which negotiators influence each other's expectations, perceptions, assessments, and decisions during the search of an outcome.

3. Game Theory

Since game theory may provide, by its very nature, the appropriate tools for the analysis and eventual solution of conflicts of any kind in the construction industry, this paper adopts the negotiation theorist's approach. Game theory, defined as the study of mathematical models of conflict and cooperation between intelligent rational decision-makers [7], has the potential to address some of the problems facing the construction industry within a collaborative framework. In construction projects, conflicts among builders and owners are very common, particularly in a bidding or claiming situation, and game theory is a natural tool that can be used to analyze the situation systematically. Game theory focus on strategic interaction and conflict providing a way to think about the conflicting structure of collective decision making processes.

In project management, game theory is still in the beginning of its practical applications. Branzei et al. [35] proposed two coalitional games related to delay cost sharing problems to determine fair shares for each of the agents who contribute to the delay of a project so that the total delay cost is clear. Bergantinos and Sanchez [36] introduced a non-transferable utility game associated to the Program and Evaluation review Technique (PERT) problem to divide the floats of time among the different activities. In a second paper, Bergantinos and Sanchez [37] presented two different approaches, one based on serial cost sharing problems and the other in game theory, to distribute the cost caused by the delay of a project among the firms which are responsible for it. Estevez-Fernandez et al. [38] analyzed both delayed and expedited problems where the penalty (reward) function is proportional with respect to the total delay (expedition) of the project. In a second paper, Estevez-Fernandez [39] analyzed project problems with arbitrary but non-decreasing penalty and rewards functions taking into account whether an activity could be started before its planned starting time. San Cristobal [40] applied the Shapley value to the fair allocation of gains obtained by cooperation among several firms carrying out a vessel drydocking who form a coalition to expedite the project.

In a broad sense, game theory can be classified into two categories: non-cooperative game approaches, where a decision-making unit treats the others as competitors, and cooperative approaches where a group of decision-makers decide to undertake a project together in order to achieve their joint business objectives. In game theory, individuals or groups become players when their respective decisions, coupled with the decisions made by other players, produce an outcome. The options available to players to bring about particular outcomes are called strategies. Strategies are linked to outcomes by a mathematical function that specifies the consequences of the various combinations of strategy choices by all of the players in a game. A coalition refers to the formation of sub-sets of players' options under coordinated strategies.

In game theory the core is the set of feasible allocations that cannot be improved upon by a coalition. An imputation $x = \{x_1, x_2, \ldots, x_n\}$ is in the core of an n-person game if and only if for each subset *S* of *N*:

$$\sum_{i=1}^{n} x_i \geq V(S) \qquad (1)$$

where *V*(*S*) is the characteristic function *V* of the subset *S* indicating the amount (reward) that the members of *S* can be sure of receiving if they act together and form a coalition (or the amount that members of *S* can get without any help from players who are not in *S*).

Eq. (1) states that an imputation *x* is in the core (that *x* is undominated) if and only if for every coalition *S*, the total of the received by the players in *S* (according to *x*) is at least as large as *V*(*S*). The core can also be defined by Eq. (2) as the set of stable imputations:

$$C: \left\{ x = (x_1, \ldots, x_n) : \sum_{i \in N} x_i = V(N) \text{ and } \sum_{i \in S} x_i \geq V(S), \forall S \subset N \right\} \qquad (2)$$

If $V(S) > \sum_{i \in S} x_i$, we say that the imputation *x* is unstable through a coalition *S*, and we say *x* is stable otherwise.

The core can consist of many points. The size of the core can even be taken as a measure of stability or how likely it is that a negotiated agreement is prone to be upset. In order to determine the maximum penalty (cost) that a coalition in the network can be sure of receiving, the linear programming problem represented by Eq. (3) is used [41]:

$$\begin{aligned} &\text{Maximize} && x_1 + x_2 + \ldots + x_n \\ &\text{subject to} && \sum_{i \in C} x_i \leq V(C) \forall C \subset N \\ & && (x_1, x_2, \ldots, x_n) \geq 0 \end{aligned} \qquad (3)$$

4. Case Study

A vital section specified in any contract is the performance period of time of project execution. However, the real duration of the activities in a project is usually extended and the time required to complete it is frequently greater than the time specified in the contract. These overruns on time extension give rise to delays.

Delays may be defined as an act or event that extends the time required to perform the tasks under a constraint [42]. They occur in every construction project and their magnitude varies considerably from project to project [43]. Strikes, rework, poor organization, material shortage, equipment failure, a change in orders, an "act of God", are the main factors causing delays.

Delays are disruptive and expensive. There is a universal agreement that delay is acknowledged as the most common, costly, complex and risky problem, representing an area of leakage in the construction industry worldwide [44]-[45]. Peurifoy and Ledbetter [46] identify that the construction industry is one that deals with the conversion of plans and

specifications into a finished product. It comprises a mixed variety of organizations that face different situations and to some degree similar pressures. Many of these problematic situations (cash-flow problems, equipment failures, material shortage, etc.) are beyond control and often lead to delay. In addition, delays are interconnected, making the situation even more complex and the problem can be more evident in traditional types of contract which is awarded to the lowest bidder [47].

Because of the overriding importance of time for both the owner (in terms of performance) and the contractor (in terms of money), delays are the source of frequent disputes and claims among owners, clients and consultants leading to lawsuits [43]. Such situations usually involve questioning the facts, causal factors, contract interpretations, quantum of the claims, mistrust, arbitration, cash-flow problems, loss of productivity and even total abandonment or termination of contract [48].

When a project is delayed, the questions that emerge are: Does a particular delay warrant an extension of project duration and/or an extra cost? If an activity, whose real duration is greater than the planned duration, makes use of the expedition created by other activities, is this activity responsible for the delay? What is the maximal amount that an activity can be held responsible for? How can costs be divided among the activities? Despite the high number of papers published, most of these papers only focus on identifying factors, causes and effects of delays based on surveys of owners, contractors, or clients. Several papers analyze factors of delays focusing on the factors of delays in projects in different countries [49-53], factors that contribute to the likelihood of project delay using statistical methods [54], factors influencing contractor performance [55], factors affecting the analysis of inclement weather delays [56], and factors that lead to project delays and tools used to mitigate their effects [57]. Other papers deal with causes of delays focusing on the causes of these delays in projects in different countries [43], [45], [57]-[66], causes of delays and their importance according to project participants [67], causes of delays from the viewpoint of owners, contractors and architectural/engineering firms [68], causes of delays by looking at the responsibility of major parties [69], contributions of clients, contractors and others to time overrun [70], causes of delays with traditional type contracts, causes of delays to establish adequate evaluation prior to the contract award [71], causes of non-excusable delays identifying the factors contributing to those causes [72], perceptions of civil construction practitioners on how significant causes of delays are [73]. Several papers deal with other aspects of project delays as dispute resolution [74], tools to aid in analysis of delay claims [75], computational methods [76], delay analysis methodologies and their advantages or disadvantages [77]-[78], effects of project size, construction type, number of bidders on project delays [79] and effects on time and cost [80].

The purpose of this section is to determine the maximum delay that an activity of a project can be held responsible for, and subsequently, to share the penalty associated with the total delay of the project among the activities that have caused this delay. To explain the proposed approach, the road construction project shown in Fig. 1 and Table 1 is presented. Let us consider that, when drafting the contract, the following terms are included: "A coalition is defined as the activity or set of activities of the network that represent a sub-path within a path. Each coalition is considered a player. The activities that form a coalition and are in the same path can take advantage of the expedition of the activities or coalitions within the same path. Any coalition cannot be held responsible for more than the total delay of the project but will be held responsible for, at least, ten percent of the delay caused by these coalitions individually. Each day that the project is delayed a penalty of 500 dollars will be applied to a coalition".

As we can see, in the network there are three paths and four coalitions (*AB*; *CDE*; *GH*; and *F*). In order to calculate the delay and expedition of the activities, and real duration of the project, the following equations are used [39]:

$$d(i) = \max[r(i) - p(i), 0] \quad (4)$$

$$e(i) = \max[p(i) - r(i), 0] \quad (5)$$

where $p(i)$ and $r(i)$ represent the planned and real time, and $d(i)$ and $e(i)$ represent the delay and expedition functions of activity i respectively.

The planned, real duration and float of the paths are calculated as follows:

$$D(N_\alpha, p) = \sum_{i \in N_\alpha} p(i) \quad (6)$$

$$D(N_\alpha, r) = \sum_{i \in N_\alpha} r(i)_i \quad (7)$$

$$Float(N_\alpha, p) = D(l) - D(N_\alpha, p) \quad (8)$$

where $D(N_\alpha, p)$ and $D(N_\alpha, r)$ are the planned and real duration of a path N_α, $D(l)$ is the planned duration of the project (i.e., the maximum of $D(N_\alpha, p)$), and $Float(N_\alpha, p)$ is the maximum time that the path N_α can be delayed without altering the duration of the project. If a path has float zero, then we say that this path is critical.

Table 1. Tasks associated with the project

Task	Description	Predecessor
A	Demolitions	-
B	Walls	A
C	Transport of soil (dirt/gravel??)	-
D	Longitudinal and transversal drainage	C
E	Telecommunication infrastructures	D
F	Granular and asphalt capes	B,E
G	System of road signs	B
H	Markings on the road	G

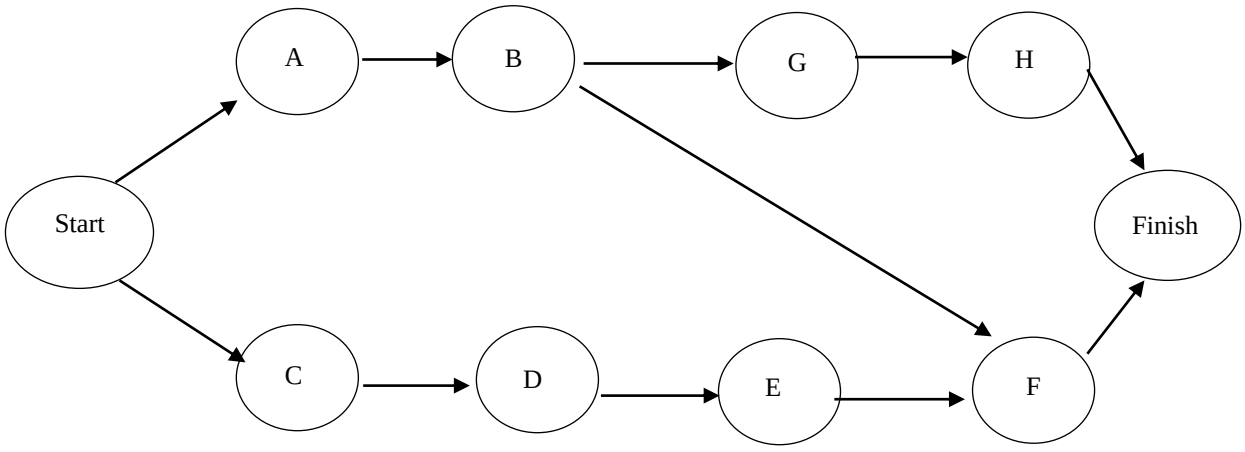

Fig.1. Network associated with the project

Table 2 shows the planned and real time (in days), and delay and expedition of the activities after the realization of the project, calculated using Eqs. (4) and (5), and the planned, real duration, and float of the paths calculated using Eqs. (6), (7) and (8) are shown in Table 3.

Table 2. Planned time, real time, delays and expeditions

Task	***p*(*i*)**	***r*(i)**	***d*(*i*)**	***e*(*i*)**
A	20	35	15	0
B	40	60	20	0
C	30	25	0	5
D	40	30	0	10
E	20	18	0	2
F	70	90	20	0
G	70	65	0	5
H	40	35	0	5

Table 3. Planned, real duration, and slack of the paths

Path	**Coalitions**	$D(N_\alpha, p)$	***Slack*** (N_α, p)	$D(N_\alpha, r)$
N_1	*AB-GH*	170	170-170 = 0	195
N_2	*AB-F*	130	170-130 = 40	185
N_3	*CDE-F*	160	170-160 = 10	163

Table 4. Coalitions, delays (days) and costs associated to each coalition

Coalition	**Delay**	**Cost**	**Coalition**	**Delay**	**Cost**	**Coalition**	**Delay**	**Cost**
AB	35	17,500	*AB,CDE*	35	17,500	*AB,CDE,GH*	25	12,500
CDE	0		*AB,GH*	25	12,500	*AB,CDE,F*	35	17,500
GH	0		*AB,F*	35	17,500	*AB,GH,F*	25	12,500
F	10	5,000	*CDE,GH*	0		*CDE,GH,F*	15	7,500
			CDE,F	0		*N*	25	12,500
			GH,F	0				

The planned duration of the project, *D*(*l*), is 170 days, the maximum duration of $D(N_\alpha, p)$ that corresponds to path N_1, but the real duration, *D*(*r*), is 195 days, the maximum duration of $D(N_\alpha, r)$ that also corresponds to path N_1. Thus the total delay of the project is *D*(*r*)-*D*(*l*) = 25 days. By adding the delays of activities *A* and *B*, we obtain that the delay of the coalition (*AB*) is 35 days. The delay of coalition (*F*) is 10 days (activity *F* is delayed 20 days minus a float of 10). However, these coalitions cannot be held responsible for more than 25 days, the total delay of the project, because other activities of the project have been expedited. Thus, coalition (*AB*) is responsible for 35 days on its own but when forming a coalition with (*GH*), they are only responsible for 25 days because they take advantage of the expedition of

activities *G* and *H* (10 days). The delay of coalition (*AB*,*CDE*) is 35 days because, although coalition (*CDE*) is expedited 17 days, these two coalitions are in different paths of the network. The delay of the coalition (*AB*,*F*) is 45 days, 35 days corresponds to the delay of coalition (*AB*) plus 10 days that corresponds to the delay of coalition (*F*).

Once we have the coalitions that can be created in the project and the total delay that these coalitions can be held responsible for, the next step is to allocate the total penalty among the delayed coalitions and activities. Using model (3) and the assumptions considered at the beginning of this section, we have:

$$\text{Maximize} \quad \left(X_{AB} + X_{CDE} + X_{GH} + X_{F}\right) \tag{9}$$

$$\text{subject to} \quad 1{,}750 \leq X_{AB} \leq 17{,}500 \tag{10}$$

$$500 \leq X_{F} \leq 5{,}000 \tag{11}$$

$$X_{AB} + X_{CDE} \leq 17{,}500 \tag{12}$$

$$X_{AB} + X_{GH} \leq 12{,}500 \tag{13}$$

$$X_{AB} + X_{F} \leq 22{,}500 \tag{14}$$

$$X_{AB} + X_{CDE} + X_{GH} \leq 12{,}500 \tag{15}$$

$$X_{AB} + X_{CDE} + X_{F} \leq 17{,}500 \tag{16}$$

$$X_{AB} + X_{F} + X_{GH} \leq 12{,}500 \tag{17}$$

$$X_{CDE} + X_{GH} + X_{F} \leq 1{,}500 \tag{18}$$

$$X_{AB} + X_{CDE} + X_{GH} + X_{F} = 12{,}500 \tag{19}$$

$$X_{CDE}, X_{GH} = 0 \tag{20}$$

$$X_{AB}, X_{CDE}, X_{F}, X_{GH} \geq 0 \tag{21}$$

where inequalities (10) and (11) are based on the assumption that any coalition that forms a sub-path and causes a delay in the project, will be held responsible for at least ten percent of the delay caused by these coalitions individually. Thus, coalition (*AB*) will be held responsible for at least 1,750 dollars and no more than 17,500 dollars (35 days) and coalition (*F*) will be held responsible for at least 500 dollars and no more than 5,000 dollars (10 days). Inequality (12) establishes that coalition (*AB*;*CDE*) cannot be held responsible for more than 17,500 dollars (35 days). Because coalition (*AB*) takes advantage of the expedition of coalition (*GH*), inequality (13) establishes that coalition (*AB*;*GH*) cannot be held responsible for more than 12,500 dollars (25 days). Inequality (14) establishes that coalition (*AB*;*F*) cannot be held responsible for more than 22,500 dollars (35 days plus 15 days). Inequalities (15)-(18) are calculated in a similar way,

inequality (19) establishes that, since the total delay of the project is 25 days, the maximum penalty to allocate among the coalitions is 12,500 dollars, and inequality (20) establishes that coalitions (*CDE*) and (*GH*) cannot be punished because these coalitions have been expedited. Finally, inequality (21) establishes the non-negativity constraint.

The solution to the above linear programming problem is X_{AB} = 11,000, X_{CDE} = 0, X_F = 1,500, and X_{GH} = 0. This solution implies that, since any coalition cannot be held responsible for more that the total delay of the project, the maximum penalty that coalitions *AB* and *F* are responsible for is 12,500 dollars. Thus, coalition (*AB*) that has been delayed for 35 days, taking advantage of the expedition of coalition (*GH*), is only responsible for 11,000 dollars, and coalition *F*, that has been delayed for 10 days, taking advantage of the expedition of coalition (*CDE*), is only responsible for 1,500 dollars. Coalitions (*CDE*) and (*GH*) are not responsible for any delay.

The last step is to share the cost allocated to a coalition (player) among the activities that form this coalition. This is the case of activities *A* and *B*, responsible for a cost of 11,000 dollars. This amount will be shared proportionally according to the delay of these activities (15 and 20 days respectively) to the total delay of the coalition (35 days). Thus, the cost allocated to activity *A* is 4,714 dollars and to activity *B* is 6,285 dollars.

5. Conclusion

Part of any project manager's role as a leader is to recognize conflict, understand the sources of conflict and manage it, and to do this a project manager must be able to understand the basics of negotiation theory and have sufficient competencies to lead in such situations. Negotiation plays an important role in resolving claims, preventing disputes, and keeping a harmonious relationship among project participants. The construction sector represents one of the most dynamic and complex industrial environments where conflicts among builders and owners are very common particularly in a bidding or claiming situation where owners, builders and contractors pursue their own interests at the expense of the others, leading to conflict or cooperation. The time required to complete the project is usually greater than the time specified in the contract and, because of the overriding importance of time for both the owner and the contractor, delays are the source of frequent disputes and claims among owners, clients and consultants, leading to lawsuits. There is a general consent between theorists that Game theory provides, by its very nature, the appropriate tools for the analysis and eventual solution of conflicts of any kind. The course of a conflict as well as its resolution depends on the decisions made by the various actors involved. Each party, when considering its decisions, should take into account the decisions made by all the other parties. Game theory is a natural tool that can be used in such interactive situations where the results of the interaction depend on all the players' decisions.

Using the model presented in this paper, a wide variety of project situations can be modelled and placed as contractual obligations when drafting the contract. For example, the contract could contain terms which ensure the maximum or minimum penalty that an activity and/or coalition can be held responsible for. This can be performed considering different values in the first and last terms of the constraints. For example, inequality (11) establishes that coalition (*H*) will be held responsible for at least 500 dollars (minimum) and no more than 2,500 dollars (maximum). If these values are replaced, the activity and/or coalition will be held responsible for an amount between the new maximum and minimum values. Limiting the period of delays can also be considered in the model by giving different values to the term *V*(*N*) in the model. In the application presented in this paper, the maximum amount that a coalition can be held responsible for is the maximum delay of the project, 25 days ($12,500). By replacing this value, the period of delays can be limited to the specified value.

Who takes advantage of the delays is also possible to be represented in the model. This can be easily introduced, for example, setting the value of an imputation, *x*, equal to zero. This states that an activity, that forms a coalition with other activities, will not be held responsible for any delays caused by the coalition. The model is also able to represent situations where an activity and/or a coalition can be penalized more than others or situations where players (i.e., contractors or subcontractors) are encouraged to form coalitions. These situations can be considered through the introduction of coefficients in the model equations, both in the objective function or in the constraints. In the objective function, if the coefficient of a variable (activity and/or coalition) is greater (less) than the unity, the corresponding

activity and/or coalition will be less (more) penalized than the rest of the activities. Similarly, contractors and subcontractors can be encouraged to form coalitions using these coefficients in the constraints of the model. The greater (less) the coefficient, the more (less) encouraged the contractors are, since they will be less (more) penalized than the rest of the contractors. Many other types of situations can be modelled using the model presented in this paper. The number of variables, equations, and inequalities needed to model these real-life situations will depend on the complexity of the problem.

In order to increase the attractiveness of game theory for decision support in construction project management, the limitations of the model presented must also be mentioned. In game theory all players are assumed to be rational, try to maximize their own utilities, and have complete information on the payoff function and utility function. The assumption that players are perfectly rational may never match a real-life situation in a construction project. Recent developments in game theory pay more attention to the behavioural aspects of the players including bounded rationality, emotions, and intuitive decision-making. Behavioural theory focuses on the complex human factors of negotiation trying to analyse the negotiation processes in which negotiators influence each other's expectations, perceptions, assessments, and decisions during the search for an outcome. Initially, game theory assumes that the players possess complete information about the strategies and payoff functions of the other players. Unfortunately, in practice this is not the case. To overcome this limitation, games with incomplete, imperfect or asymmetric information are studied more and more.

Classical game theory assumes that each player decides in advance, before the game actually starts, what move he/she will make to maximize his/her own gain in any possible situation. However, the superlative rationality paradigm may not be the best one. Players tend to classify units as good enough or not good enough in terms of their positive attributes (benefit) and their negative attributes (cost) with regard to the evaluation goal. Satisfying game theory is an approach that evaluates alternatives on a bipolar basis introducing supporting and rejecting options in terms of two measures, selectability and rejectability.

The example used in this paper to demonstrate the validity of the model is rather simple. When dealing with real project networks which may contain hundreds of interrelated activities, two main approaches have been proposed in order to transform complex networks into simpler and more synthetic networks. The method of modular decomposition, based on the identification of modules that can be synthetized by equivalent macro-activities, and the method of network reduction based on three different types of reduction, series, parallel and node reduction. Aggregation of project networks using these types of methods, can help to transform complex networks into simpler and more synthetic networks.

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