



## Research article

## Analysis of factors affecting project communications with a hybrid DEMATEL-ISM approach (A case study in Iran)

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## ARTICLE INFO

## Keywords:

Project management  
 Communications management  
 Fuzzy DEMATEL  
 Interpretive structural modeling (ISM)  
 MICMAC Analysis  
 Construction engineering  
 Human resource management  
 Industry management  
 Business management  
 Behavioral psychology  
 Business

## ABSTRACT

One of the main factors in the success of projects is communications management and proper and timely distribution of information among all internal and external project stakeholders. Despite of emphasizing on the importance of project communications in the literature, there are few studies identifying factors influencing project communications. This research aims to address this shortcoming by identifying and determining sequences and relationships factors affecting project communications and their clustering. The informed communication strategy allows managers to structure the information flow in a better and more controlled manner and to avoid the costs caused by lack of effective and timely communication. The present study is conducted to help clarify the views of the organization's managers and project managers on project communications, and to identify factors affecting it and how they effectively communicate to successfully accomplish the projects. First a number of factors influencing project communications are identified on the basis of previous studies and interviews with experts and project managers working in oil, gas and power plant construction megaprojects in Iran. Then, these factors are analyzed by using the combination of fuzzy DEMATEL and Interpretive Structural Modeling (ISM) techniques. The relationships and sequence between the indicators are determined so that it can be effective in project communications planning and project success through providing an insight for senior managers and project managers.

## 1. Introduction

Communications is a process whereby concepts are exchanged among individuals through a system of generic signs and words. Project communications management defines necessary processes for ensuring proper and timely production, collection, dissemination and distribution of project information (Senaratne and Ruwanpura, 2016). Communication plays a role throughout the life cycle of a project and has a great contribution to its success (El-Saboni et al., 2009). The greater the number of people in the project team and its stakeholders, the more important the project communications management will be. Project managers use a variety of tools to establish communication and coordination among project team members; this diversity and multiplicity of tools affects proper and timely dissemination of project information. Research has shown that because of the mistakes made in communication by the employees and the stakeholders, large amounts of money are

imposed on organizations that will reduce the efficiency of project team members.

Project management is highly important within organizations that guide their business with a project-based approach. So far, many studies have been conducted on project success in which communications management is basically on top of the list. Though communication planning in project teams is one of the basic tasks of project managers, there are few studies on the accurate measurement of the communication process and its elements (Dziekoński, 2017; Muszyńska, 2018).

Despite of great knowledge and experience about project communications management, it has not been adequately addressed in its various dimensions. Applying the comments and views of the active experts in this field can be effective in forming and operating the project communications. As Dziekoński (2017) recommend that future research should identify the components of communication and its impact on communication process. Therefore, it is essential to provide a comprehensive

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model for identifying and clustering effective and influenced factors. In this study, our goal is to identify the factors affecting project communications with the help of library studies and interviewing experts in order to better plan the communications by considering the sequences and relationships between the identified elements and their more appropriate understanding, according to a Fuzzy Decision-making trial and evaluation laboratory technique (FDEMATEL)- Interpretative Structural Modeling (ISM) approach. Both ISM and fuzzy DEMATEL are appropriate for analyzing sophisticated problems with hierarchical and communicative structure. ISM divides the factors into different clusters, and fuzzy DEMATEL examines cause-effect relationship. ISM is used for analyzing the sophisticated systems and has a holistic approach, while DEMATEL is applied in determining direct and indirect relationships and has a part-based approach.

The scope of the research is Iranian power plant, oil and gas industries. The statistical population consists of project managers who work in this industry and are familiar with the subject. They were selected through non-random purposeful method, with a requirement of experience and expertise for more than 10 years. A total of 28 project managers working in this area were selected as the sample.

A paired comparison questionnaire was used for data collection. The respondents' views were collected through verbal expressions. After the questionnaire was completed by the experts, for calculation purpose, linguistic variables (verbal expressions) were converted to triangular fuzzy numbers. Validity of the questionnaire with content analysis approach and face validity was confirmed. Also, its reliability was examined through calculating the inconsistency rate and since the inconsistency rate measured to be 0.0392 which is less than 5%, the response matrix has a good inconsistency. The rest of the paper is organized as follows. In the second part of the paper, the research background on communications management and the factors affecting it are investigated. Third part (Materials and Methods) explains reliability, the composition of fuzzy DEMATEL and ISM, and MICMAC analysis. In the fourth part, Results & Discussion, and in the fifth part, conclusion and future recommendations are presented.

## 2. Literature review

### 2.1. Project success

In a report in 2000, PA Consultation Group announced that 70% of organizations continue to fail in delivering their projects (De Mascia, 2012). These figures were very unfortunate, so many researchers conducted many studies on the causes of success and failure of the projects. For example (Hyväri, 2007), stated that experience of project managers in managing changes as well as their ability to communicate is very crucial in the success of any project.

De Wit (1988) separated the success of the project from the success in the project management, stating that the project success is related to the goals and benefits that a project creates for its organization, while the success in the project management is associated with direct action of project manager in controlling the range, critical times (deadlines) and costs of each project. And this case was also examined by Cooke-Davies (2002); Musawir et al. (2017).

Previous studies show that communication is an important factor for the success of projects (Anantamula, 2015). In their study, Yap et al. (2017) acknowledged that effective communication is an important aspect of project-based management that is considered as an essential prerequisite for successful project management. With this in mind, effective communication to control the time and cost of a project is very important. Team factors, technical factors, organizational factors, and environmental factors are four variables that can be described as indicators of improving the performance of projects through effective communication channels between project stakeholders. Important factors for project success are communication, team factors, technical factors, organizational factors, and environmental factors (Maqbool, 2018).

### 2.2. Project communications

Project Communications Management includes activities that facilitate the creation, distribution, receipt, validation and understanding of information (Senaratne and Ruwanpura, 2016). PMI (2017) has recognized as one of the main fields of knowledge of the scientific management of the project. Communications management is a path to individual and organizational learning, as well as to building trust and shared work values (Senge, 2006). Communications management is one of the most significant and complicated elements of project management, which is affected by a variety of factors including: cultural differences, trust, communication support tools, IT infrastructure, geographic distance, time interval, stakeholders, monitoring, measurement and analysis, planning, continuous improvement, models and policies, and curriculum (Muszyńska, 2018). An effective communications management plan creates a culture of collaboration in a converging project team (Livesey, 2016). Effective communications management creates a common culture that promotes coherence in a project team and also promotes participation in decision-making (Anantamula, 2015).

Team knowledge and its coherence are strengthened through effective communication (Liu and Cross, 2016). Poor communication between the members of the project team is one of the main reasons behind the increase in project costs (Ceric, 2014; Mahamid, 2016). Weak communication is one of the most common risks of the project (Cerić, 2003).

In their study, Liu and Cross (2016) stated that communication plays a vital role in improving the effectiveness of a project. The authors also emphasized on effective internal and external communication.

### 2.3. Factors affecting project communications

#### 2.3.1. Leadership

Campbell (2011) says: "good communication and strong leadership move hand in hand." Studies on leadership styles indicate that leader's personality, maturity of the followers and environmental requirements determine leadership style. An efficient leader will be able to implement one or a combination of leadership styles that fit the environment. Each style may be effective at its own time and place. The style of communicating will vary from one leader to another and from one project to another; however, the issue of communicating remains the inherent part of leadership. Choosing the most effective leadership style for different situations requires the ability to correctly assess the situation and apply the appropriate style to communicate effectively (Zulch, 2014). "Leadership styles that promote upward and downward communication, have been shown to foster a plethora of positive outcomes within the workplace, group collaborations, and team contexts" (Kelly and MacDonald, 2019).

In teams with a participative leadership structure, team members may need to communicate with each other (Bergman et al., 2014). More repeated leader communication leads to raise leader-team relationship development, greater levels of information swapping (Henderson et al., 2016).

Type of leadership style by the project manager creates a successful and effective communication (Zulch, 2014). Stevenson and Starkweather (2010) confirm that leadership and communications are "extremely important" indicators for the successful completion of the project. Heldman (2011) says, "The better the project manager communicates, the project will proceed better and easier." This confirms the importance of communication. Leaders guide teams through communication. Good communication skills create the understanding and trust needed to encourage others to follow the leader.

The difference between leadership as a skill to communicate and communicating as a leadership skill is defined as follows:

- Leadership as a skill to communicate: Steyn (2012) refers to leadership as doing things and tasks by others (project team). Leadership

involves delegating, coordinating and communicating at all levels (Walt et al., 1996). Therefore, leadership is a skill to communicate.

- Communicating as a leadership skill: A leader must be sure that he will implement strategy resources and the decisions, and s(he) should necessarily have strong communication skills. This skill is an integral part of leadership skills.

Clutterbuck and Hirst (2002) said that “leaders who do not communicate well are not really guides and leaders.”

### 2.3.2. Trust

The first challenge for a project manager is to build trust among team members. The second challenge is to maintain the established trust so that it will not be lost. The behavior of team members directly affects the level of trust in interpersonal relationships (Decker, 2015) and since the project manager cannot communicate with all team members face-to-face, trust will be a major factor (Daim et al., 2012). Hakanen and Soudunsaari (2012) state that trust is a very important part of team building, just like team performance. In the absence of trust, team members are not interested in talking about what they have in mind, putting forward their ideas, being volunteer to express their opinions, or even asking questions. Team members hide their true feelings and are not interested in helping each other. Most studies have emphasized the need for “trust” among members to enhance communication. One of these reasons is different cultural background among team members that leads to effective communication (Dreesen et al., 2016). Social relationships heavily influence the effectiveness of communication. Trust creates a strong relationship, and knowledge and communication have a great influence on social capital of the team (Furnell and Scott, 2014). Brewer and Strahorn (2012) say that when you think about the human aspect of project management, trust is recognized as the most important indicator of the success of the project. Without trust, it's almost impossible to create coherent processes in the project environment. Roudias (2015) states that, “the ability to build trust in project team and other stakeholders is a very important part in the effective leadership of the team.” Trust is accompanied with collaboration, information sharing, and effective resolution of issues. Without trust, it is difficult to establish a positive and necessary relationship between the various stakeholders involved in the project. Trust is a psychological concept or expression that has a subjective (non-objective) nature. The capability to build and maintain it is an interpersonal skill that can be promoted over time by communicating with others. Newman et al. (2019) say “trust plays a significant role as a moderator to leader communication with teams in affecting team performance”. Through trust, communication teams can share more information and cover the potential knowledge gaps within project teams where communication is weak (Pullin, 2010). To promote trust and build strong relationships, methods like these are suggested: 1. daily and monthly standup meetings, 2. continuous communication (especially tools that can be a good alternative to face-to-face contacts, such as conference calls), and 3. social networks (especially tools that include conference techniques) (Dreesen et al., 2016). Trust has huge potential impacts on project management performance. These include: a better relationship, reduced sales time, reduced outsourcing risks and thus reduced project costs as well as effective. However, as the researchers have argued, what makes trust worth discovering is actually communication itself. Because communication failures are not all but the biggest contributors to project failure. The set of actions that build stakeholder confidence must occur at the beginning of the project because they have shown to be effective in the project (Strahorn et al., 2017) The three types of trust (intuition, integrity and competence) associated with stakeholder management are effective and significant. Therefore, it is important that the project manager considers actions such as empathy in communications from project initiation (Francisco de Oliveira and Rabechini, 2019).

### 2.3.3. Stakeholders

People in organizations need information and instructions. Establishing communication is considered the “highway” of projects, since it establishes a link between the management, customers, project team members, and other stakeholders. This “highway” focuses on who needs what information in what format and when (Pheng, 2018). Managing project stakeholders is an important part of project management. Aligning the goals, interests, and expectations of stakeholders is directly attributed to the success of the project (Aaltonen, 2011) Creating and maintaining relationships between project team members and different stakeholders through effective communication is one of the requirements of successful project management (Hysa and Spalek, 2019). The objective of project stakeholder management is to enhance the understanding of the project management team from various stakeholders and their ability in engaging stakeholders in order to maintain their support and aligning their goals with the goals of the project (Yang et al., 2014). Effective communication creates a bridge between various stakeholders involved in the project, so it plays an essential role in project stakeholder management (Welch and Jackson, 2007). Because the role of communication in a project is decisive, the various communication needs in the life cycle of the project must be known and proper planning must be done for them (Lohikoski et al., 2005).

Thus, the success of the project depends heavily on communication and collaboration between stakeholders, such that project managers spend most of their time communicating effectively with team members and other project stakeholders (van den Hooff and de Ridder, 2004). Project managers must understand and work with different stakeholders. Therefore, it must be clearly specified how they can use communication to meet the needs and expectations of project stakeholders. Further, project managers should work out a way for identifying problem solving (Golabchi, 2012). IPMA (6th edition) points out that each project has stakeholders that are affected by the project, or they can positively or negatively affect the project. Some stakeholders have little ability to influence project performance or results, and others have a special effect on the project and its expected results. Academic research is important in terms of a structured approach to identifying, prioritizing and engaging the stakeholders. The ability of project manager and project team in correctly identifying and engaging the stakeholders indicates the difference between project success and failure. Winning stakeholders' satisfaction should be recognized as one of the goals of the project. The key to stakeholders' active involvement is focusing on continuous communication with them. In IPMA (4th edition), it is suggested that communication planning be used as a method of designing a strategy for treating stakeholders. According to this edition (4th edition), cases such as why, what, when, how often, how (through communication channels) and who should communicate as well as a level of communication details are explained.

Ho (2013) finds that attitudes and beliefs should be understood as an answer to the communication. And stakeholders' perception of their role is effective in establishing communication. He also explains that formal communication mechanisms should be understood according to the organization's communication system, attitudes and beliefs, and a proper communication channel must be established.

The greater the number of stakeholder is, the more complex the communication will be, since with increasing number of stakeholders, the paths and channels of communication are further enhanced and, consequently, the complexity of communication is increased. The number of potential communication channels for N stakeholders equals  $N(N-1)/2$ , hence in projects with a large number of stakeholders, it is necessary to determine who produces and transmits information and who receives it (Čulo and Skendrovic, 2010). The greater the number of people through whom the message passes, the more likely it is to distort the message. Anyone who receives a message interprets it from his/her own point of view; and after the message is received by the last person, its

content is completely distorted. The use of multiple layers reduces performance in all aspects, including quality, time, cost, and communication performance and coordination (Tam et al., 2011).

#### 2.3.4. Geographical dispersion

Globalization and the free market philosophy are the forces that shape the current economy. Reduced cost of access to the Internet and communications, information technology and access to the virtual world networks encourages organizations to focus on decentralization and network structure (Lee-Kelley, 2006). Organizations are in a position to use talented individuals from anywhere in the world at lower costs. Employing virtual teams for business management is an important option, as it enables organizations to overcome obstacles such as language and geography (Lipnack and Stamps, 1999). In multinational projects, people from different countries with different cultures, tasks and specialized knowledge levels work together to solve strategic issues (Adenfelt and Lagerström, 2006). A major challenge in project management has always been to gain coordination between activities, stakeholders and team members that may be in different cities, provinces, and countries. In project communications management processes, it is attempted to collect, store, retrieve and eventually summarize the information and knowledge generated in the project in a timely and appropriate manner and be used by different types of stakeholders. It should be noted that communication in the project is the exchange of specific project information with an emphasis on building a common understanding between sender and receiver. Based on the above reason, one should immediately consider an effective communication for the projects, since it is important for all stakeholders to strengthen their project communications management structure. More than 60 years ago, Chester Barnard stated that communication is the first stage of any implementation, and communication with employees is an important and critical skill, given their concerns, problems, ideas and suggestions about the organization. Hill et al. (2009) state that various researches suggest that geographic dispersion may hamper information sharing, coordination, problem solving, trust building, and constructive conflict resolution with others in the team. Despite of continuous advancement in communication technology, employees' geographical dispersion remains a challenge to impressive workplace interactions and, particularly, to teamwork (Han and Beyerlein, 2016).

Eisenberg et al. (2019) say "In contrast to collocated teams, in highly geographically dispersed teams, transformational leadership's influence on team communication progressively decreases as the teams become more and more dispersed".

#### 2.3.5. Culture

Currently, relationships are influenced by political, economic, and differences as well as different social contexts that shape people's perception of culture in international management (Buckley et al., 2009). Cultural factors represent the fundamental aspect of international business management (Sluyts et al., 2011). One of the main challenges for project managers is managing projects effectively in international contexts, environments in which people from different cultures and with different perspectives need to work together to achieve the project's success (Mesly, 2015; Wang et al., 2016). IPMA (4th edition) summarizes the importance of culture and language for a modern project manager, and explains that "in a multicultural project, a person may need to guide multiple value and cultural norms in communication." Researchers have argued that project managers should be aware of the background and culture of all international stakeholders in the project, especially customers, suppliers and partners (Zwikael, 2009). Organizational culture is based on beliefs and determines the behavior of project team members (Rubenstein-Montano et al., 2001). Weak communication in the project can be another result of the company's culture and may cause misunderstandings and lack of information (Ankrah et al., 2009). Zakaria (2017) introduces intercultural communication as an interaction

between individuals with a distinct cultural background and a distinct communication pattern. Cultural patterns alternatively affect perceptions, cognition, and actions (Meyer, 2015). Culture often manifests itself in individuals' communication behaviors. Several studies show that communication behaviors vary widely between different cultures (Cardon, 2008; Kittler et al., 2011; Warner-Söderholm, 2013). Differences between societies and languages affect the understanding of communication faces. Socio-cultural differences can be due to the social status of individuals, religion, state policy, financial conditions, etc. The socio-cultural difference between members with geographic dispersion can cause various communication problems and barriers (Manoj Ray and Samuel, 2016). Hofstede (1984) emphasizes that a management technique or philosophy that is appropriate for a national culture is not necessarily appropriate for another.

Cultural differences often cause misunderstandings in communication. The main issue is that messages are created or encoded in a cultural context and then they are received or decoded in another cultural context (Roudias, 2015). Avoiding misunderstanding and misinterpretation requires understanding not only what is said, but also how it is expressed, for example, the communication method used to create ideas, exchange views, share knowledge and express ideas (Goettsch, 2014). Cultural dimensions also affect beliefs and behaviors such as trust, fear, non-involvement, non-commitment, and lack of sharing of relevant information (Lückmann and Färber, 2016).

#### 2.3.6. Skills

Organizations spend a lot of money on improving the communication skills of their employees. As an example, about 1–3 billion dollars is spent annually on promoting staff writing skills by organizations (Guffy, 2007). Executive managers believe that 14% of individuals' working hours are wasting due to weakness in communications (about seven work weeks a year). That's why communication skills are considered when hiring employees and help individuals to get, perform, maintain and promote a job (Merrier, 2005). To successfully manage projects, project manager must have different skills such as interpersonal skills, technical competencies, and cognitive talent and of course, along with the ability to understand the position of the people and dynamically coordinate the appropriate leadership behaviors (Pant and Baroudi, 2008). In his study, Henderson (2004) acknowledges that skills of project manager and project team in communication are one of the factors that will affect the success of communication and consequently the success of the project. He conducted a study on 186 different projects and showed that communication skills of the project manager have a positive impact on the productivity and satisfaction of the project team and increases it. In his research, he investigated the skill of the project manager in encoding and decoding messages on the productivity and satisfaction of the project team and found a positive correlation between them.

Culo and Skendrovic (2010) reports that extensive training and learning should be implemented to make sure that to make sure the proposed communication systems are consistent with the experience and expertise of the people involved in the project. (Perumal and Bakar, 2011) show that conventional, written, and verbal skills are almost equally important. Welch (2015) emphasizes that internal communication requires the development of skills and knowledge of experts.

In his study, Henderson (2008) found that the competence of project managers in transferring information significantly contributes to the satisfaction and efficiency of team members. Communication is a competence and project managers can grow it to succeed; however, most project managers forget soft skills like communication, or teach it apart from other project management skills (budgeting, domain definition, or WBS creation) (Brill et al., 2006). Accordingly, the authors called for the development of training programs for managers to obtain the required competencies regarding message development, negotiation and dispute resolution (Alam et al., 2010; Brill et al., 2006).



### 2.3.7. Communication tools

Items including communication features, communication tools, project manager's point of view about communication habits and how to communicate with others, and identifying the project's existence philosophy for stakeholders can be considered as a group of factors influencing project communications management (Berggreen and Kampf, 2015).

In addition to the temporal nature of project activities, the creation of a unique product or service is also a feature of it. This uniqueness of product or service requires a communication system that is capable of being rapidly implemented and easily used by teams of related organizations in order to share information with the least amount of training and management. The use of communication channels primarily refers to factors such as availability, skill, or ability to use or personal biases, and one can define communication channels as many as stakeholders or customers, which is very tedious (Reed and Knight, 2013). Increased geographical dispersion causes challenges for the project team and stakeholders, and project managers need to exploit a wide range of tools and methods (Furnell and Scott, 2014). In addition to providing a communications program that is among the main pillars of implementing, monitoring and controlling communications with stakeholders, the choice of selected tools can also be considered as of high importance (Lee-Kelley and Sankey, 2008). One of the things that help to increase the effectiveness of communication is the communication tool that needs to be appropriately selected and used. The choice of appropriate communication tools depends on different factors such as audience characteristics, information transfer speed, information confidentiality, accuracy of information transfer, reliability, transmission cost, availability of communication tools, degree of formality, importance and urgency, stakeholder expectations, and duration and environment of the project (Rai and Rai, 2014).

Of main barriers to communication are the type of successful communication between the receiver/sender, the message content, the nature of the message, and the message transfer tool. In order to improve the quality of communication, it is recommended that the skill of project team members in communication be enhanced, the communication program be developed and communication tools be selected according to the type of project (Manoj Ray and Samuel, 2016). In an analysis of web-based document management and communication tools used by project managers, Rozman et al. (2017) showed that the way communication tools and management systems are served as motivating factors supports decision-making in teams. The authors also conducted studies on some tools for managing virtual teams, which helped to solve problems such as knowledge management, coordination, collaboration, socio-cultural distance, and lack of trust in the work team.

### 2.3.8. Communication variety

Communication skills are one of the most important skills required for project success. High quality communication occurs when project team members have enough time to communicate with each other and to exchange information formally or informally (Hysa and Spalek, 2019). The main difference between formal and informal communications is that, unlike informal communication, formal communication occurs in a controlled environment (Kandlousi et al., 2010). Formal communication has predefined structures and specified instructions and is made with predetermined persons (Kraut et al., 1990), while informal communication takes place with unspecified plans and with random individuals (Kandlousi et al., 2010). Informal communication does not happen at a specific date, time or place. Informal communication is formed on the basis of social relations and its purpose is rather personal, while formal communication is in the direction of the company's goals. Previous studies have shown that formal communication is positively correlated with productivity (Litterst and Eyo, 1982). However, it has been proven that informal communication helps the project's productivity in the form of groups for work coordination, updating and solving minor problems (Kandlousi et al., 2010). Informal communication can help increase

information sharing; it can also bring about familiarity, relationships, dependencies and trust among team members (Pullin, 2010). Expectations regarding formal and informal communication practices should be considered in communication planning (Pheng, 2018). The result of a research showed that the combination of formal and informal communications with the goal of increasing communication, cooperation and trust among managers and other project agents improved the level of understanding in project managers, contractors and customers by 73.8, 52.9 and 81.3%, respectively (Bond-Barnard et al., 2013). A significant part of the time spent by staff at the workplace is associated with communication: face-to-face communications, phone calls, emails, reports, and more. Therefore, project communications management plays a key role in organizations (Pheng, 2018).

However, too many meetings are also a risk. In projects where the number of meetings is high, people work less and do not have the proper spirit to work. Lack of communication or inappropriate communication for projects that use virtual teams is riskier than those with full-time employees (Reed and Knight, 2010). Communication channels are an important factor that must be controlled by the project manager. The more the number of communication channels is, the more complex the communication issues will be. A project manager should move towards formal and written communication methods (Daim et al., 2012).

### 2.3.9. Knowledge

Communication is the transfer of information and knowledge between two or more destinations. Data consists of numbers and realities. Information about a situation or scenario and knowledge is created when information is combined with the experience gained in practical situation. Knowledge is based on personal experience of individuals and information about interpreted facts is observations and judgments. Therefore, knowledge is created from information that in turn results from data. Knowledge is responsible for the deployment of information in tangible assets (Alavi and Leidner, 2001). The competencies of the project manager can include knowledge, talents, attitudes and behaviors that are required to carry out parts of the work (Boyatzis, 1982).

Research has shown that due to the wrong perceptions being made in the communications by employees and stakeholders, huge amounts of money are imposed on organizations and it will also lead to reduced efficiency of the project team members. Eliminating the gap in the shared understanding between the buyer and suppliers depends on increasing knowledge (Andersson, 2016). Shortage of knowledge regarding the safety and capabilities of communication media (social media) is a source of fear of using the media (Macnamara and Zeffass, 2012).

### 2.3.10. Organizational structure and participation

The constructive aspect of communication emerges through talks and decisions of members of the organization, planning, activities and effects of the integrity of the organization's reality (Fairhurst and Putnam, 2004). Several factors affect communication planning, including organizational culture and organizational structure (Pheng, 2018). Organizational structure has the greatest impact on project communication requirements (Daim et al., 2012). A key tool for identifying communication needs is the organizational chart that shows the hierarchy of who should report to whom (Pheng, 2018). Mavuso and Agumba (2016) also considered the organizational structure and participation as factors influencing the improvement of communication management performance. As Steinheider and Al-Hawamdeh (2004) says, problems in efficient communications management, especially in large technology companies with hierarchical structure, are more evident. As project organizations grow larger and the complexity of project goals increases, effective communications management in project teams becomes more difficult (Remidez and Jones, 2012). Perumal and Bakar (2011) reveal that organizational structure has a great influence on the coordination and flow of organizational systems. An appropriate organizational structure should be formed to encourage good flow of information and promote effective communication in the organization.

Pinto and Pinto (1990) found that teams that work much together, as compared to teams that work less together, are different both in terms of using informal methods for communication and in terms of reasons for communication. Griffin and Hauser (1992) observed that successful project teams largely act properly in coordination and communication, and overcome issues related to physical devices, personnel movements, and organizational structures.

### 2.3.11. Infrastructure

In communication planning, if there is information communication, the existing technology infrastructure should be available to facilitate the dissemination in project organizations. For example, in rural projects, internal servers and Internet access should be considered. And also, human resources suitable for production, collection, dissemination, and storage of information must be considered (Pheng, 2018). Pullin (2010) believes that poor technology infrastructure is also one of the reasons that renders communication tools ineffective in some undeveloped areas.

### 2.3.12. Technology

The use of modern communication and information technologies can significantly reduce the cost of information transfer and have a significant impact on the effectiveness of participation and easy transfer and safety of it (Hoffmann and Schlosser, 2001). Ćulo and Skendrovic (2010) states that the implementation of a suitable system or technology can improve communication. In their investigation, Perumal and Bakar (2011) acknowledge that applying appropriate systems helps individuals in organizations to effectively establish their internal and external communications within the organization. Meid (2015) emphasizes that a community or company that is hiding behind technological advancement reforms will be pushed out from global economic activity. Over the last decade, Information & Communication Technology (ICT) has established collaboration platforms - hardware and software solutions that have connected people in a secure community and environment and produced useful tools for creating, organizing, researching as well as exchanging documents, information, ideas, calendars, and more, so as to be a leverage for controlling the effectiveness and efficiency of processes, and a guide to direct towards the alignment of activities with project objectives and alignment of staff goals with the strategic goals of the organization. ICT technologies offer useful solutions to enhance the coordination between processes and activities. Over the past decade, especially in office automation tools, concurrent with the popularity of the Internet and ICT development, new ways have been provided to share ideas, information and documents, so that in addition to reaching individuals and their individual details, complex projects could be managed. These collaboration platforms are called "digital platforms", "digital spaces", "collaboration platforms", "group tools", "and virtual communication", and they have been found to be useful tools for supporting group work, especially in workgroups, virtual communication, and inter-organizational relationships (Mancini and Ferruzzi, 2016). These tools that are able to share content with other employees across the organization, organize information, documents and activities for a certain individual or group, searching for information and individuals and analyzing data from multiple sources in graphical form (van den Hooff and de Ridder, 2004). ICT collaboration tools include a wide range of tools such as wiki (editable blogs), cloud-based file sharing (wide row of computers connected to each other), social media, blogs, and micro blogs like Twitter. The main driver for the increasing growth of ICT common collaboration tools is to increase virtual teams of the project, with team members dispersed all over the world. Applying ICT collaboration tools, on the other hand, is rising due to increased use of ICT by external groups including customers, suppliers, universities, competitors, founders and managers of companies. Increasing access to and dissemination of new ways of communication as well as cooperation in our personal and professional lives means that ICT tools play a growing role (Marion et al., 2016). Therefore, ensuring good quality communication between the project team members is crucial that makes it possible to use

different social networks. This is especially important when project members are experts in different fields and in different countries. Social media can boost communications through reducing meeting duration, both online and offline environments are an integral part of project management (Hysa and Spalek, 2019). Social media plays a crucial role in project activities. Social media tools help communicate with stakeholders and support dissemination of information. Therefore, increase the sustainability of results of the project (Pivec and Maček, 2019).

The success of implementing IT for project communications depends on organizational culture, which can act as an obstacle or effective factor in communicating effectively. Corporate culture is an attitude belonging to the company (Ankrah et al., 2009).

### 2.3.13. Levels of information provision and information updating

The role of communication is known as a stimulus for the success of the project, therefore its management as a strategic tool among stakeholders at all levels of a project should be considered which can bring about possible successes (Aiyewalehinmi, 2013). Different stakeholders may have different expectations about the format and time of the received information. A balance between providing adequate and timely information and stakeholder needs and the formats in which the information is published should be reviewed and updated. Also, for effective communication planning, the project management information system should be considered in real time (Pheng, 2018). Garbharran et al. (2012) emphasize that consideration for the transfer instructions are part of the communication, so the project perspective needs to be constantly updated and shared as the project progresses.

A common topic in studies on communication, which is one of the competencies of the project manager, is the process of transferring information to project stakeholders and also, planning is based on different and distinct requests (Pinto and Pinto, 1990). In their research, they emphasize the necessary networks and information, the transfer of information and the amount of information that must flow among team members. Naqvi and Aziz (2011) inferred that project management remains effective when there is: an effective communication in managing the team, good structure information flow and time-dependent information, establishing a reporting hierarchy among team members of each project, and a formal communication framework.

## 3. Materials and Methods

Theoretically, communication is considered to be a very complex system that incorporates a set of interdependent elements. As a result, a model that is unable to account for these relationships cannot be appropriate for analysis.

Wu (2008) stated that the Analytical Network Process (ANP) has been used in numerous studies, but is not ideal and accurate for analyzing interactive relationships. ISM and DEMATEL methods appear to be suitable techniques for empowering hierarchical structures, and both methods provide a clear display of the relationships within the system (Chauhan et al., 2018; Wang et al., 2018) In this study, we apply a hybrid Fuzzy FDEMATEL-ISM model; ISM is used to prioritize factors and DEMATEL is applied to determine the priority and intensity of quantified relationships among factors. The reason for using both approaches is that ISM only determines the level of influence of the factors on each other, and helps to identify the interrelationships among the factors, and it is an appropriate technique to analyze the impact of one factor on other factors, and it helps to prioritize and determine the level of factors in a system, but it does not quantify the intensity of interactions and relationships among the factors, a deficiency which is resolved when ISM is combined with DEMATEL. On the other hand, decision making under uncertainty is the disadvantage of DEMATEL, which can be overcome by using the Fuzzy DEMATEL technique. The Fuzzy DEMATEL method uses fuzzy linguistic variables to facilitate decision making under uncertainty. This technique is applied to the fields of production, organization management, information systems, and social sciences (Zhou et al., 2011). In

addition, this technique can solve all the problems faced by organizations by applying group decision making in fuzzy conditions (Reyes et al., 2011). The hybrid Fuzzy ISM-DEMATEL approach provides relationships among the criteria in the best possible way (Chuang et al., 2013).

Hogarth (1978) used two analytical models to examine the minimum number of experts in a judging panel. In his analysis of Cochran (1963) and Kish (1965) sampling theory, as well as Zajonc (1962), Eysenck (1939), and Preston (1938) theory, he concluded that the expert group should be between 6 and 25 people, depending on the correlation between their opinions and the average. The more experts are different from each other, the more numbers should be included in this combination. Ashton (1986) stated in his research that Hogarth's model offers an excellent approximation. He examined the effect of increasing experts in a statistical group. He stated that only three specialists could be added to improve the results. Einhorn and Hogarth (1977) recommended the benefits of using the average opinion of experts if they weighed the same.

Lin et al. (2016) demonstrated in the decision-making approach that even if there are a small number of experts, they would be sufficient if they had expertise with more than 10 years of experience. They considered a sample of 22 people. The number of experts in the previous studies has been at least over 10 (Kumar et al., 2017; Fang et al., 2019; Raj and Sah, 2019; Wu et al., 2019). If the participants are homogeneous, at least a total number of 10–15 experts would be sufficient (Asgharpour, 2010). The focus group of experts should comprise 12–20 experts (Northcutt and McCoy, 2011).

In this study, an excel worksheet was used to carry out the DEMATEL-ISM methodology (Singh and Bhanot, 2019). Steps to conduct this study are as follows:

**Step 1- Identification of Factors Affecting Project Communications and Preparation of Pair-Wise Comparison Questionnaires:** In this study, through reviewing the existing literature and conducting open interviews with 28 experts, the factors affecting project communications management were identified. The criteria for selecting experts were as follows: having experience in project management for more than 10 years, having an international PMI degree and willingness to participate in the research.

### 3.1. Face and Content Validity

To build face and content validity, after reviewing the theoretical foundations and field of study, the face and scope of the content and items for making a checklist were developed. By submitting the questionnaire to university professors in the area of industry and receiving their opinions, face validity of the questionnaire was confirmed (Chen, 2016); then, to confirm the content validity of the checklist, experts in the field of project management were asked to complete the checklist; and finally, experts responded as “necessary”, “useful but not necessary” or “unnecessary” to the suitability of each item. Content validity is calculated according to Formula (1), and given the level required for statistical significance ( $p < 0.05$ ), at least a value of 0.75 for each item for CVR should be obtained to be accepted (McKenzie et al., 1999). Hence, content validity was confirmed.

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad (1)$$

**Table 1.** Verbal phrases used in the research and their equivalent values.

Verbal phrase	Fuzzy value
No effect	(1,1,1)
Very low effect	(2,3,4)
Low effect	(4,5,6)
High effect	(6,7,8)
Very high effect	(8,9,9)

Where, N is the total number of panels, and  $n_e$  is the number of panels that responded as “necessary”. Finally, in order to determine the effective factors on communications management, 18 criteria were specified and approved by the experts. These criteria are presented in Table 2.

**Step 2- Formation of Pair-Wise Comparison Matrix:** In pair-wise comparison matrix, indicators are compared two by two and respondents should use codes of verbal expressions. The names of these verbal phrases and their equivalent fuzzy values are shown in Table 1.

$$D = \begin{bmatrix} \overset{p1}{\underset{\sim}{d}}_{11} & \dots & \overset{pJ}{\underset{\sim}{d}}_{1j} & \dots & \overset{pn}{\underset{\sim}{d}}_{1n} \\ \vdots & & \vdots & & \vdots \\ \underset{\sim}{d}_{11} & \dots & \underset{\sim}{d}_{1j} & \dots & \underset{\sim}{d}_{1n} \\ \vdots & & \vdots & & \vdots \\ \underset{\sim}{d}_{n1} & \dots & \underset{\sim}{d}_{nj} & \dots & \underset{\sim}{d}_{nn} \end{bmatrix} \quad (2)$$

In the above Eq. (2):  $p_i$  represents (i)th element;  $d_{ij} = (l_{ij}, m_{ij}, u_{ij})$  indicates the effect of (i)th element on (j)th element;  $l_{ij}$ ,  $m_{ij}$  and  $u_{ij}$  are lower, middle and upper limits of the triangular fuzzy number, respectively; and  $D$ ,  $d_{ij}$  is paired comparison matrix. After paired comparison matrix, the inconsistency rate is calculated according to Eq. (3). And if the value of inconsistency rate is less than 5%, then the matrix of responses has good consistency (Jeng, 2015).

$$IR = \frac{1}{n(n-1)} \sum_{i=1}^n \sum_{j=1}^n \left| \frac{t_{ij}^r - t_{ij}^{r-1}}{t_{ij}^n} \right| * 100\% \quad (3)$$

Where,  $IR$  is consistency rate,  $n$  is the number of criteria, and  $t_{ij}$  is the average score of the (r)th individual to the (i)th criterion relative to the (j)th criterion for  $1 \leq i \leq n$  and  $1 \leq j \leq n$ .

**Step 3- Formation of Judgment Matrix:** After the formation of paired comparison matrices, by integrating opinions using the geometric mean and with the help of Eq. (4), we form ideal decision matrix or judgment matrix.

$$\tilde{g}_{ij} = \left( \tilde{d}_{ij}^1, \tilde{d}_{ij}^2, \dots, \tilde{d}_{ij}^k \right)^{\frac{1}{k}} \quad (4)$$

Where,  $K$  represents the number of experts.

**Step 4- Determining the Weight of Experts:** Determining the experts' weights is based on the distance between the individual's decision with the ideal decision, so that the closer this distance, the higher the expert's weight (Yue, 2012).

$$\{1, 2, \dots, t\} k \in T \quad \text{and} \quad N = \{1, 2, \dots, n\} j \in N \quad \text{and} \quad M = \{1, 2, \dots, m\} i \in M$$

$$D_k = \left( d_{ij}^k \right)_{m \times n}$$

$$r_{ij}^k = \frac{d_{ij}^k}{\sqrt{\sum_{i=1}^m \left( d_{ij}^k \right)^2}} \quad (5)$$

If the increase of the criteria is favorable for us, it is better to use Eq. (5), and in the case that the decrease of the criteria is desirable for us, it is better to use Eq. (6).

$$r_{ij}^k = 1 - \frac{d_{ij}^k}{\sqrt{\sum_{i=1}^m \left( d_{ij}^k \right)^2}} \quad (6)$$

Then, using Eqs. (7) and (8), we unscale paired comparison matrix. We call the resulting matrix “ $Y_k$ ”. Afterwards, we display the average expert opinions or matrix of the ideal decision with  $Y^*$ . The more each  $Y_k$  is closer to the ideal matrix, the higher the expert weight will be. We calculate the expert weight from Eqs. (9) and (10).

$$\text{proj}_{Y^*}(y_k) = \frac{\sum_{i=1}^m \sum_{j=1}^n Y_{ij}^{(k)} y_{ij}^*}{\sqrt{\sum_{i=1}^m \sum_{j=1}^n (y_{ij}^*)^2}} \quad k \in T \quad (7)$$

Where, the weight of the (k)th expert is represented by  $\lambda_k$  and measured from Eq. (6).

$$\lambda_k = \frac{\text{proj}_{Y^*}(y_k)}{\sum_{k=1}^t \text{proj}_{Y^*}(y_k)} \quad k \in T, \text{ such that } \lambda_k \geq 0 \text{ and } \sum_{k=1}^t \lambda_k = 1 \quad (8)$$

**Step 5- Multiplying the Weight of Experts in Paired Comparison Matrix**

$$\lambda = (\lambda_1, \lambda_2, \dots, \lambda_t)^T Y = \sum_{k=1}^t \lambda_k Y_k = (y_{ij})_{m \times n} \quad (9)$$

$$y_{ij} = \sum_{k=1}^t \lambda_k Y_{ij}^{(k)} \quad i \in M \quad j \in N \quad (10)$$

**Step 6- Fuzzy DEMATEL:** DEMATEL which consists of a variety of decision-making based on paired comparison is obtained through utilizing experts' judgment in extracting factors of a system and systematically constructing them by applying the principles of the Graph Theory and hierarchical structure of the factors present in the system along with mutual influential and affected relationships of the elements, in such a way as to numerically determine the intensity of the effect of these relationships and their significance.

In order to consider the opinion of all the experts, we get geometric means according to Eq. (4).

Eqs. (11) and (12) are used to normalize the resulting matrix.

$$\tilde{H}_{ij} = \frac{\tilde{z}_{ij}}{r} = \left( \frac{l'_{ij}}{r}, \frac{m'_{ij}}{r}, \frac{u'_{ij}}{r} \right) = \left( l''_{ij}, m''_{ij}, u''_{ij} \right) \quad (11)$$

Where,  $r$  is obtained from the following equation:

$$r = \max_{1 \leq i \leq n} \left( \sum_{j=1}^n u_{ij} \right) \quad (12)$$

After calculating the above matrices, the matrix of total fuzzy relations is obtained according to formulas (13),(14),(15),(16).

$$\lim_{k \rightarrow +\infty} (\tilde{H}^1 \oplus \tilde{H}^2 \oplus \dots \oplus \tilde{H}^k) \quad (13)$$

Where, each entry of that fuzzy number is represented by  $\tilde{t}_{ij} = (l^t_{ij}, m^t_{ij}, u^t_{ij})$  and is measured as follows:

$$\left[ l^t_{ij} \right] = H_l \times (I - H_l)^{-1} \quad (14)$$

$$\left[ m^t_{ij} \right] = H_m \times (I - H_m)^{-1} \quad (15)$$

$$\left[ u^t_{ij} \right] = H_u \times (I - H_u)^{-1} \quad (16)$$

In the above equations,  $I$  is unit matrix and  $H_l, H_m$  and  $H_u$  are  $n \times n$  matrices whose entries respectively form lower number, middle number and upper number of triangular fuzzy numbers of  $H$  matrix.

The fuzzy numbers obtained in the previous Step are defuzzified by using the Eq. (17).

$$B = \frac{(a_1 + a_3 + 2 \times a_2)}{4} \quad (17)$$

$B$  is the defuzzified form of  $\tilde{A} = (a_1, a_2, a_3)$ .

Calculating the sum of rows and columns of the matrix.

The sum of rows and columns of the matrix  $T$  is obtained by the Eqs. (18) and (19).

$$D = (D_i)_{n \times 1} = \left[ \sum_{j=1}^n T_{ij} \right]_{n \times 1} \quad (18)$$

$$T = (R_i)_{1 \times n} = \left[ \sum_{i=1}^n T_{ij} \right]_{1 \times n} \quad (19)$$

In which  $D$  and  $R$  are  $n \times 1$  and  $1 \times n$  matrices respectively.

In the next stage, the importance of the indices  $(D_i + R_i)$  and the relationships among the criteria  $((D_i - R_i)$  are determined.

If  $D_i - R_i > 0$ , the criteria belong to the cause group, and if  $D_i - R_i < 0$ , the criteria belong to the effect group.

**Step 7- Measuring Threshold Limit and Forming Accessibility Matrix:**

Decision makers need to set a threshold limit for filtering minor effects. The threshold value ( $\gamma$ ) is obtained by expert judgement or the mean of the numbers in the total influence matrix ( $H$ ) (Song et al., 2015).

$$H = Tc + I = [h_{ij}]_{n \times n} \quad (20)$$

In the above equation,  $I$  is the identity or unit matrix, and  $Tc$  is the total relation matrix.

The influence matrix ( $K$ ) is obtained by the following equation:

$$K = [K_{ij}]_{n \times n} \quad \begin{cases} K_{ij} = 1, \text{ if } h_{ij} > \gamma \quad (i, j = 1, 2, \dots, n) \\ K_{ij} = 0, \text{ if } h_{ij} \leq \gamma \quad (i, j = 1, 2, \dots, n) \end{cases} \quad (21)$$

**Step 8- Determining the level of Indices:** To determine the level of the criteria, two sets including Accessible or Output Set ( $R_{ei}$ ) and Predecessor or Input Set ( $A_{ei}$ ) are defined and then, their intersection is obtained. Thus, the accessible set for each element is a set in which rows of the final Accessibility Matrix appear as "one". And the Predecessor Set is a set where columns appear as "one". By obtaining the intersection of these two sets, the joint set  $(R_{ei} \cap A_{ei})$  will be obtained. The elements in which the joint set is the same as accessible set, take the first level of priority. By removing these elements and repeating this step for other elements, the level of all elements is determined.

**Step 9- Drawing Interpretive Structural Model:** The model is drawn based on the specified levels. Relationships between variables are also determined according to the Accessibility Matrix.

**Step 10- MICMAC Analysis:** In order to segment the criteria, the final Accessibility Matrix must be calculated for each element of driving power 1 and dependency power 2. The driving power of an element or criterion is the number of criteria that are affected by the relevant criterion, including the criterion itself. The dependency power is also the number of criteria that affect the relevant criterion and lead to its achievement. These driving and dependency powers are used in MICMAC analysis in which the criteria are divided into four groups: autonomous, dependent, hybrid and driving (independent). The purpose of the MICMAC analysis is to analyze the driving power and dependency power of the variables. The variables are divided into four clusters.

The first cluster includes autonomous criteria that have weak driving and dependency powers. These criteria are relatively separate from the system, which, in fact, has few links with other elements of the system, though their links may be strong.

The second cluster includes dependent criteria that have poor driving power but high dependency power.

In the third cluster, there are hybrid criteria with both strong driving and dependency powers. These criteria are in fact non-permanent or non-



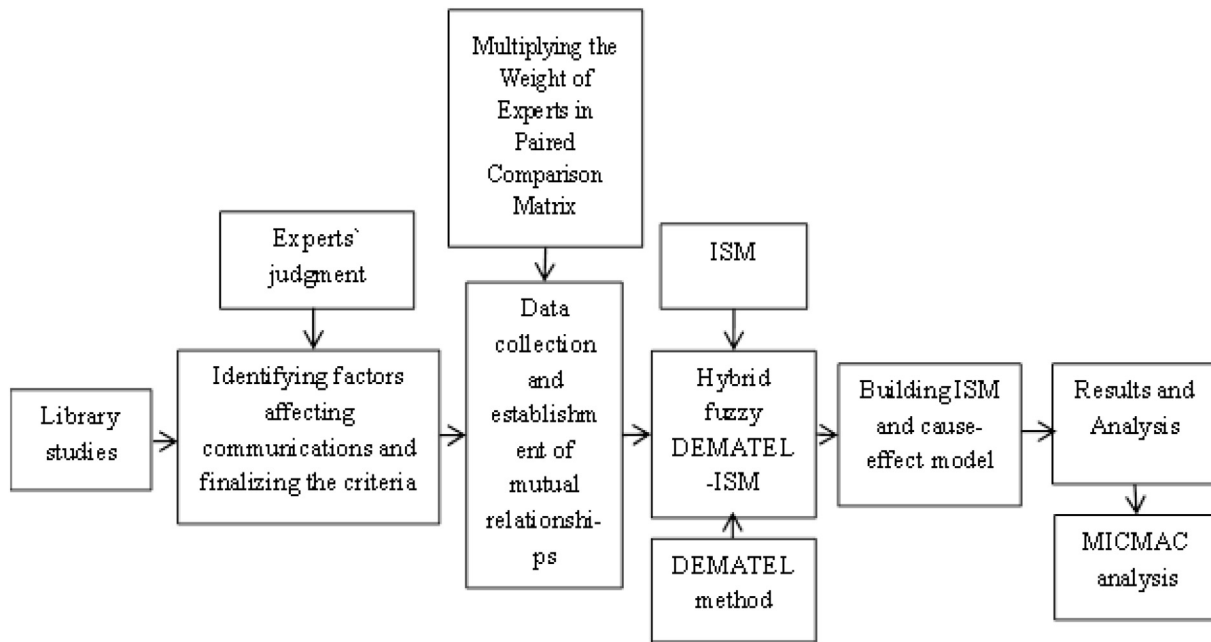


Figure 1. Conceptual model of the research.

stable, because any action on these criteria will have an impact on other criteria or a feedback to itself.

The fourth cluster includes independent criteria that have high driving power with low dependency power.

As seen, a criterion with strong driving power is called a key criterion, and is in the category of independent or hybrid variables. The conceptual model of the research is shown in Figure 1.

#### 4. Results

##### 4.1. Criteria validation

At this stage, in order to assess the content validity of the factors affecting project communication management, a questionnaire was

Table 2. The results of validity check for each criterion.

Criterion	Number of evaluators who agree with the question	Calculated CVR	Minimum acceptable CVR
Number of stakeholders	9	1	0.75
Organizational size	8	0.78	0.75
Culture	8	0.78	0.75
Communication Variety	8	0.78	0.75
Organizational structure	8	0.78	0.75
Geographical dispersion	9	1	0.75
Technology	9	1	0.75
Communication tool	9	1	0.75
Skill	9	1	0.75
Participation (engagement)	8	0.78	0.75
Leadership	9	1	0.75
Knowledge	8	0.78	0.75
Levels of providing information	9	1	0.75
Trust	9	1	0.75
Nationality and ethnicity	8	0.78	0.75
Infrastructure	9	1	0.75
Updating the plan	8	0.78	0.75
Implementing the communication plan	8	0.78	0.75

distributed among 9 experts (PMP-certified project managers with over 15 years' experience). The results of each criterion were validated as shown in Table 2.

ISM and DEMATEL share some similar characteristics and both investigate the cause and effect relationship among multiple criteria, so combining ISM and DEMATEL makes an effective and powerful tool that assists the decision-making group (Mousavizade and Shakibazad, 2019). In this research, data collection tool was a questionnaire designed based on 18 factors influencing project communications management, which were gathered through library reviews and experts' opinions, presented in Table 3.

##### 4.2. Implementation

The questionnaire was given to 22 experts and analyzed after completion by them. In this methodology, in pair-wise comparison matrix, indicators were compared two by two using codes of verbal expressions (Table 4). The names of these verbal phrases and their equivalent fuzzy values are shown in Table 1.

##### 4.3. Determining the Weight of Experts

Collecting opinions and formation of judgment matrix (ideal) was performed by using Eq. (3) (Table 5), then the experts' weights were measured by using Eq. (4), (5), (6) and (7). The weight of the experts is given in Table 6.

It can be concluded based on the results that the experts were also homogeneous and, the number of experts is sufficient (Asgharpour, 2010).

##### Fuzzy Decision-making trial and evaluation laboratory technique

By applying the weight of each expert in the decision matrix by using Eqs. (8) and (9), the FDEMATEL calculations were started.

- Forming weighted judgement matrix: After constructing the matrices of pairwise comparisons by integrating the views using the geometric mean of the comments with the Eq. (3), the ideal decision matrix or the weighted judgement matrix is formed,
- Normalizing the weighted judgement matrix: The Eqs. (10) and (11) are applied to normalize the obtained matrix (Table 7),

**Table 3.** The factors influencing project communications management.

Abbreviation	Criteria	Brief description	Reference
C1	Number of stakeholders	Number of stakeholders (internal stakeholders and external stakeholders): People involved in the project, such as project team members, managers as internal stakeholders and customers and supplier as external stakeholders (Costa and Menichini, 2013).	(Pheng, 2018), (Aaltonen, 2011), (Yang et al., 2014), (Welch and Jackson, 2007), (Lohikoski et al., 2005), (van den Hooff and de Ridder, 2004), (Golabchi, 2012), (Culo and Skendrovic, 2010), (Hysa and Spalek, 2019), and experts
C2	Organizational size	Organizational size is given as the number of employees at any defined geographical location.	Experts
C3	Culture	Value norms and beliefs (PMBOK, 6th version, 2017)	(Buckley et al., 2009), (Sluyts et al., 2011), (Mesly, 2015); (Wang et al., 2016), (Zwikael, 2009). (Rubenstein-Montano et al., 2001), (Ankrah et al., 2009), (Zakaria, 2017) (Meyer, 2015), (Cardon, 2008), (Kittler et al., 2011), (Warner-Söderholm, 2013), (Manoj Ray and Samuel, 2016), (Hofstede, 1984), (Roudias, 2015), (Goetsch, 2014), (Lückmann and Färber, 2016). experts
C4	Communication Variety	Formal and informal communications	(Hysa and Spalek, 2019), (Kandlousi et al., 2010), (Kraut et al., 1990), (Litterst and Eyo, 1982), (Pullin, 2010), (Pheng, 2018). (Bond-Barnard et al., 2013), (Reed and Knight, 2010), (Daim et al., 2012)
C5	Organizational structure	Task allocation, coordination, and supervision are directed toward the achievement of organizational aims. determines how information flows between levels within the company (Perumal and Bakar, 2011; Pheng, 2018)	(Fairhurst and Putnam, 2004), (Pheng, 2018), (Daim et al., 2012), (Mavuso and Agumba, 2016), (Steinheider and Al-Hawamdeh, 2004) (Remidez and Jones, 2012), (Perumal and Bakar, 2011), (Pinto and Pinto, 1990), (Griffin and Hauser, 1992)
C6	Geographical dispersion	A geographically dispersed team, refers to a group of individuals who work together from different geographic locations and rely on communication technology (Lipnack and Stamps, 2000).	(Lee-Kelley, 2006), (Lipnack and Stamps, 1999), (Adenfelt and Lagerström, 2006), (van den Hooff and de Ridder, 2004), (Han and Beyerlein, 2016), (Hill et al., 2009), (Eisenberg et al., 2019) and experts
C7	Technology	Contains any communication device, software, hardware, internet network, mobile phones, satellite systems and so on, also the various services and appliance with them.	(Perumal and Bakar, 2011), (Meid, 2015), (Mancini and Ferruzzi, 2016), (van den Hooff and de Ridder, 2004), (Marion et al., 2016), (Hysa and Spalek, 2019), (Pivec and Maček, 2019), (Ankrah et al., 2009) and experts
C8	Communication tool	A wide variety of communication tools are used for external and internal communication. communication, face-to-face communication is one and online-based communication is another. These tools include telephones, mail, email, cell phones, computers, social networking, daily standup meetings, timely status reports, correspondence and etc. (Kataria et al., 2013)	(Berggreen and Kampf, 2015), (Reed and Knight, 2013), (Lee-Kelley and Sankey, 2008), (Rai and Rai, 2014). (Manoj Ray and Samuel, 2016), (Rozman et al., 2017), and experts
C9	Skill	Technical skills and leadership skills, project management skills, personal skills (Zavadskas et al., 2008)	(Guffy, 2007), (Merrier, 2005), (Pant and Baroudi, 2008), (Culo and Skendrovic, 2010), (Perumal and Bakar, 2011), (Welch, 2015), (Henderson, 2008), (Brill et al., 2006) (Alam et al., 2010), (Brill et al., 2006), and experts
C10	Participation (engagement)	Share knowledge and information, develop understanding, enhance engagement which promotes accountability and transparency (Mavuso and Agumba, 2016)	(Mavuso and Agumba, 2016) (Pinto and Pinto, 1990), and experts
C11	Leadership	Style of leadership, An effective leader will be able to adapt a style or combination of styles of leadership to suit the circumstances. Any one of the styles might be effective in the right situation (Zulch, 2014)	(Campbell, 2011), (Zulch, 2014), (Bergman et al., 2014), (Stevenson and Starkweather, 2010), (Heldman, 2011), (Steyn, 2012), (Walt et al., 1996), (Clutterbuck and Hirst, 2002), and experts
C12	Knowledge	Know how to communicate in the most effective way to meet the information and communication needs of stakeholders	(Alavi and Leidner, 2001), (Boyatzis, 1982), (Andersson, 2016), (Macnamara and Zerfass, 2012) and experts
C13	Levels of providing information	Different stakeholders may have different expectations about the format and time of the received information. A balance between providing adequate and timely information and stakeholder needs and the formats in which the information is published (Pheng, 2018)	(Aiyewalehinmi, 2013), (Pheng, 2018), (Pinto and Pinto, 1990), (Naqvi and Aziz, 2011)
C14	Trust	Building trust in stakeholder relationship, trust is accompanied with collaboration, information sharing, and effective resolution of issues (Roudias, 2015)	(Decker, 2015), (Daim et al., 2012), (Hakanen and Soudunsari, 2012), (Furnell and Scott, 2014), (Brewer and Strahom, 2012), (Roudias, 2015), (Pullin, 2010), (Dreesen et al., 2016), (Strahom et al., 2017), (Francisco de Oliveira and Rabechini, 2019)
C15	Nationality and ethnicity	Nationality is a legal relationship between an individual person and a state. Ethnicity is the identification of a person with a particular racial, cultural, or religious group.	Experts
C16	Infrastructure	In communication planning, the existing technology infrastructure should be available to facilitate the dissemination in project organizations.	(Pheng, 2018), (Pullin, 2010), and experts

(continued on next page)

Table 3 (continued)

Abbreviation	Criteria	Brief description	Reference
		Appropriate infrastructure should be defined based on the level of project team dispersion (Pheng, 2018; Muszyńska, 2018).	
C17	Updating the plan	As the plan is being implemented, effectiveness of the tactics should be continually evaluated and any appropriate revisions should be made (Pheng, 2018).	(Pheng, 2018), and experts
C18	Implementing the communication plan		Experts

Table 4. Response matrix of expert 1.

	C1	C2	C3	C4	...	C15	C16	C17	C18
C1	0	H	VH	VH	...	H	L	H	VL
C2	H	0	NO	VH	...	L	L	L	H
C3	VH	VH	0	L	...	H	L	L	L
C4	L	L	L	0	...	H	L	L	L
C15	H	L	VH	VL	...	0	VL	L	L
C16	H	L	L	VL	...	L	0	L	L
C17	L	L	VL	L	...	L	L	0	L
C18	L	L	VL	L	...	L	L	L	0

Table 5. The judgment fuzzy matrix.

	C1	C2	C3	...	C16	C17	C18
C1	(0, 0, 0)	(4.8, 5.9, 6.8)	(4.6, 5.8, 6.7)	...	(4.5, 5.5, 6.5)	(5.1, 6.1, 7)	(5.1, 6.1, 7)
C2	(5.3, 6.4, 7.3)	(0, 0, 0)	(4.1, 5.1, 6)	...	(4.9, 5.9, 6.8)	(3.9, 4.9, 5.9)	(3.9, 4.8, 5.7)
C3	(3.5, 4.7, 5.7)	(3.6, 4.7, 5.7)	(0, 0, 0)	...	(3.2, 4.3, 5.3)	(3.4, 4.5, 5.5)	(3.3, 4.2, 5)
C16	(4.5, 5.5, 6.5)	(5.1, 6.1, 7)	(5.1, 6.1, 7)	...	(0, 0, 0)	(5, 6, 7)	(3.8, 4.6, 5.2)
C17	(4.8, 5.9, 6.8)	(3.9, 4.9, 5.9)	(3.9, 4.8, 5.7)	...	(3.9, 5, 6.1)	(0, 0, 0)	(4, 4.9, 5.7)
C18	(3.2, 4.3, 5.3)	(3.4, 4.5, 5.5)	(3.3, 4.2, 5)	...	(3.9, 5, 6.1)	(3.9, 5, 6.1)	(0, 0, 0)

Table 6. Experts' weight based on milliunit.

Expert Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Expert Weight	37	36	35	36	36	36	36	36	36	36	36	35	35	35
Expert Number	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Expert Weight	40	35	35	36	36	35	35	35	35	36	36	35	36	35

Table 7. The normalized the weighted judgement fuzzy matrix.

	C1	C2	C3	...	C16	C17	C18
C1	(0, 0, 0)	(0.04,0.05,0.06)	(0.04,0.05,0.05)	...	(0.04,0.05,0.05)	(0.18,0.22,0.25)	(0.04,0.05,0.06)
C2	(0.04,0.05,0.06)	(0, 0, 0)	(0.03,0.04,0.05)	...	(0.04,0.05,0.06)	(0.14,0.18,0.21)	(0.03,0.04,0.05)
C3	(0.03,0.04,0.05)	(0.03,0.04,0.05)	(0, 0, 0)	...	(0.03,0.04,0.04)	(0.12,0.16,0.2)	(0.03,0.03,0.04)
C16	(0.04,0.05,0.05)	(0.04,0.05,0.06)	(0.03,0.04,0.05)	...	(0, 0, 0)	(0.04,0.05,0.06)	(0.03,0.04,0.04)
C17	(0.03,0.04,0.05)	(0.03,0.04,0.05)	(0.02,0.03,0.04)	...	(0.03,0.04,0.05)	(0, 0, 0)	(0.03,0.04,0.05)
C18	(0.03,0.04,0.05)	(0.03,0.04,0.05)	(0.03,0.03,0.04)	...	(0.03,0.04,0.05)	(0.03,0.04,0.05)	(0, 0, 0)

- Computing the total relation matrix (T): The total relation matrix is computed by using the Eqs. (12), (13), (14) and (15) (Table 8). Total relation matrix can reflect the comprehensive direct and indirect influence among the factors,
- Defuzzification: The fuzzy numbers obtained in the previous Step are defuzzified by using the Eq. (16) (Table 9),
- Calculating the sum of rows and columns of the matrix: The sum of rows and columns of the matrix T is obtained by the Eqs (17) and (18) (Table 10),

The assumptions of FDEMATEL technique should be applied as follow to determine the relationship between factors:

- If  $Di - Rj < 0$  and  $Di + Rj = M$  ( $M$  is a large number),  $i$  is the main problem of the situation and should be solved.
- If  $Di - Rj > 0$  and  $Di + Rj = M$  ( $M$  is a large number),  $i$  solve the main problem of the situation and it should be prioritized.
- If  $Di - Rj < 0$  and  $Di + Rj = S$  ( $S$  is a small number),  $i$  is a dependent factor and affected by other factors.

**Table 8.** The Total relation fuzzy matrix. (T).

	C1	C2	C3	...	C16	C17	C18
C1	(0.07,0.17,0.6)	(0.1,0.22,0.65)	(0.1,0.2,0.61)	...	(0.1,0.22,0.66)	(0.11,0.23,0.68)	(0.11,0.22,0.65)
C2	(0.1,0.21,0.63)	(0.06,0.16,0.58)	(0.09,0.19,0.58)	...	(0.1,0.21,0.64)	(0.10,0.21,0.65)	(0.09,0.20,0.62)
C3	(0.08,0.18,0.57)	(0.08,0.18,0.57)	(0.05,0.13,0.49)	...	(0.08,0.18,0.58)	(0.08,0.19,0.59)	(0.08,0.18,0.56)
C16	(0.1,0.21,0.63)	(0.10,0.21,0.63)	(0.08,0.19,0.58)	...	(0.06,0.17,0.58)	(0.11,0.22,0.65)	(0.1,0.2,0.61)
C17	(0.09,0.19,0.58)	(0.08,0.18,0.57)	(0.07,0.17,0.53)	...	(0.09,0.19,0.59)	(0.06,0.15,0.55)	(0.09,0.19,0.57)
C18	(0.09,0.19,0.58)	(0.08,0.18,0.57)	(0.07,0.17,0.54)	...	(0.09,0.19,0.59)	(0.09,0.19,0.6)	(0.06,0.15,0.53)

**Table 9.** Defuzzied matrix of total relation matrix numbers based on centiunit (Numbers by hundredth).

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	D
C1	25	30	28	32	30	29	30	33	31	32	34	32	33	30	26	30	31	30	547
C2	29	24	26	30	30	27	29	31	30	30	33	31	32	29	25	29	29	28	522
C3	25	25	20	28	26	25	26	28	27	28	29	28	28	26	23	25	26	25	470
C4	29	28	26	27	29	27	30	32	30	31	32	31	32	29	25	29	30	29	525
C5	28	28	25	28	24	27	28	30	29	31	32	31	31	28	24	29	29	28	511
C6	29	29	28	31	29	23	29	31	30	30	33	30	31	28	26	29	30	29	526
C7	28	29	26	31	30	27	26	33	31	31	33	33	32	29	24	30	31	29	533
C8	28	28	26	31	29	27	30	27	30	31	33	32	32	28	24	29	30	29	524
C9	28	28	26	30	29	26	30	31	25	30	33	31	32	28	24	28	29	28	515
C10	28	28	26	30	30	27	29	31	30	26	33	31	32	30	25	29	30	29	522
C11	30	31	28	32	32	29	32	33	32	33	30	34	34	32	26	31	32	31	564
C12	29	29	27	32	31	27	31	32	32	31	34	27	33	29	25	29	31	29	538
C13	28	29	26	31	30	27	30	32	31	31	33	32	27	29	24	29	31	30	532
C14	27	27	25	28	28	26	28	29	28	30	31	29	30	23	24	27	28	27	495
C15	26	25	25	27	26	26	27	28	27	28	30	28	28	26	19	26	26	26	474
C16	28	29	26	30	30	27	30	31	30	30	33	31	32	28	24	24	30	28	522
C17	26	25	23	27	27	24	27	29	27	28	30	29	30	26	22	26	23	26	474
C18	26	26	24	27	27	24	27	29	27	28	29	29	30	26	22	26	27	22	476
R	499	499	461	531	517	477	519	550	527	539	574	548	560	507	432	507	522	502	

**Table 10.** Arrangement of elements in different approaches of FDEMATEL technique.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
D + R	1046	1020	930	1055	1028	1002	1052	1073	1042
D-R	48	23	09	6-	7-	49	14	25-	12-
D ranking	2	9	18	7	13	6	4	8	12
R ranking	14	15	17	6	10	16	9	3	7
D + R ranking	8	12	17	6	11	13	7	4	9
D-R ranking	2	4	7	8	9	1	6	15	12
	C10	C11	C12	C13	C14	C15	C16	C17	C18
D + R	1060	1138	1086	1092	1002	905	1030	996	978
D-R	17-	9-	10-	28-	11-	42	15	46-	26-
D ranking	10	1	3	5	14	16	11	17	15
R ranking	5	1	4	2	11	18	12	8	13
D + R ranking	5	1	3	2	14	18	10	15	16
D-R ranking	14	10	11	17	13	3	5	18	16

- If  $Di - Rj > 0$  and  $Di + Rj = S$  ( $S$  is a small number),  $i$  is an independent factor and affects a small number of factors (Mousavizade and Shakibazad, 2019).

The highest sum of rows in total relation matrix ( $Di$ ) shows the order of elements that have a strong impact on other elements (the factor of Leadership) (Table 9).

The highest sum of the columns ( $Rj$ ) represents the order of the elements influenced (the factor of Leadership) (Table 9).

The cause group has positive  $Di-Rj$  value and other factors are in the effect group.  $Di + Rj$ , represents the sum of the intensity of an element both in terms of influencing and being influenced.

Based on the FDEMATEL results, the factors of Number of stakeholders, Organizational size, Culture, Geographical dispersion, Technology, Nationality and ethnicity and Infrastructure have the positive  $Di-Rj$  value and can be classified as the cause group, and other factors are in the effect group because the  $Di -Rj$  of these factors is negative.

Number of stakeholders and Technology solve the main problem of the situation and it should be prioritized. Nationality and ethnicity is an



independent factor and affects a small number of factors. Leadership is the main problem of the situation and should be solved.

4.4. The hybrid fuzzy FDEMATEL-ISM

- The Initial reachability matrix; the threshold limit should be calculated and the influence matrix should be formed (The threshold limit is 0.29).

The threshold value is obtained by expert judgement or the mean of the numbers in the total influence matrix (*H*) by using the Eqs. (19) and (20). The values below the threshold are of minor importance and will not be displayed.

- The Final reachability matrix: The total influence matrix (*H*) must be raised to the power of  $M+1$ , to achieve a stable state:  $K^M = K^{M+1}$  (Table 11) (Bernoulli multiplication and addition are used here, so that  $(I=I\oplus I, I=I\otimes I)$ ).
- Determining the level of the criteria

From the final reachability matrix, the number of 1s in each matrix row is the accessible or output set (RC), and the number of 1s in each matrix column is the predecessor or input set (AC). After determining the input and output sets, the intersection of the two sets is determined for each factor. Factors in which the output set and joint set are exactly the same are at the highest level of the hierarchy of the Interpretive Structural Model as shown in Table 12 (Figure 2). After the first repetition, the highest actions will be eliminated from others. And this will be repeated until the level of all factors is determined. In this study, 6 replications were performed as shown in Table 13.

- MICMAC Analysis was used to classify factors based on their driving and dependence power as represented in Table 11 (Figure 3). Factors are categorized into four sectors as follow: (Mousavizade and Shaki-bazad, 2019).
  - Autonomous: These are the factors with a weak driving power and a weak dependence power.
  - Dependent: These are the factors with a weak driving power but a strong dependence power.
  - Linkage: These are the factors with strong driving and dependence power.

- Independent: These are the factors with a strong driving power but weak dependence power.

Communication Variety (C4), Technology (C7), Communication tool (C8), Skill (C9), Participation (C10), Leadership (C11), Knowledge (C12), Levels of providing information (C13) and Infrastructure (C16) have high influence and dependency are in Linkage factors of MICMAC chart (Figure 3) and have highest scores of *Di*, *Rj* so any action on these variables leads to a change in other variables. The important point is that Leadership (C11), which has the highest factor of *Di + Rj*, *Di-Rj* (Table 10) and most impact on other variables.

Although the *Di-Rj* score of Culture (C3) and Nationality and ethnicity (C15) is positive, both the *Di* and *Rj* scores are not high enough (Table 10). In addition, based on the MICMAC analysis (Figure 3), this factor is located among the Autonomous factors. It is obvious that these factors are an independent factor and does not have a notable impact on other factors.

Moreover, based on the analysis of *Di- Rj* values in FDEMATEL, trust (C14) is listed as effect group and have tendency to be easily impacted by others (The effects in Table 11 are significant in the C14 column).

The results of MCMAC analysis (Figure 3) confirm that Geographical dispersion (C6), Number of stakeholders (C1) and Organizational size (C2) are independent factors, but Technology (C7) is classified in linkage factors.

Further examination reveals that C7 is located close to the border between independent and linkage factors. As shown in Table 10, their impact factor (*Di*) are relatively high. This factor has a high impact on other factors, and it must be properly classified as independent group.

After determining the level of all the factors affecting communications project, the results are depicted in Figure 3. As seen in Figure 2, Geographical dispersion at Level 6 and the Organization's size at Level 5 have the highest effect on other factors. The levels of Providing communication, Leadership, Knowledge, Information updating and Implementation of the communication plan are located at Level 1, which indicate that these factors are affected by other factors.

Based on the above results, the following recommendations are provided for implementation communication management in project:

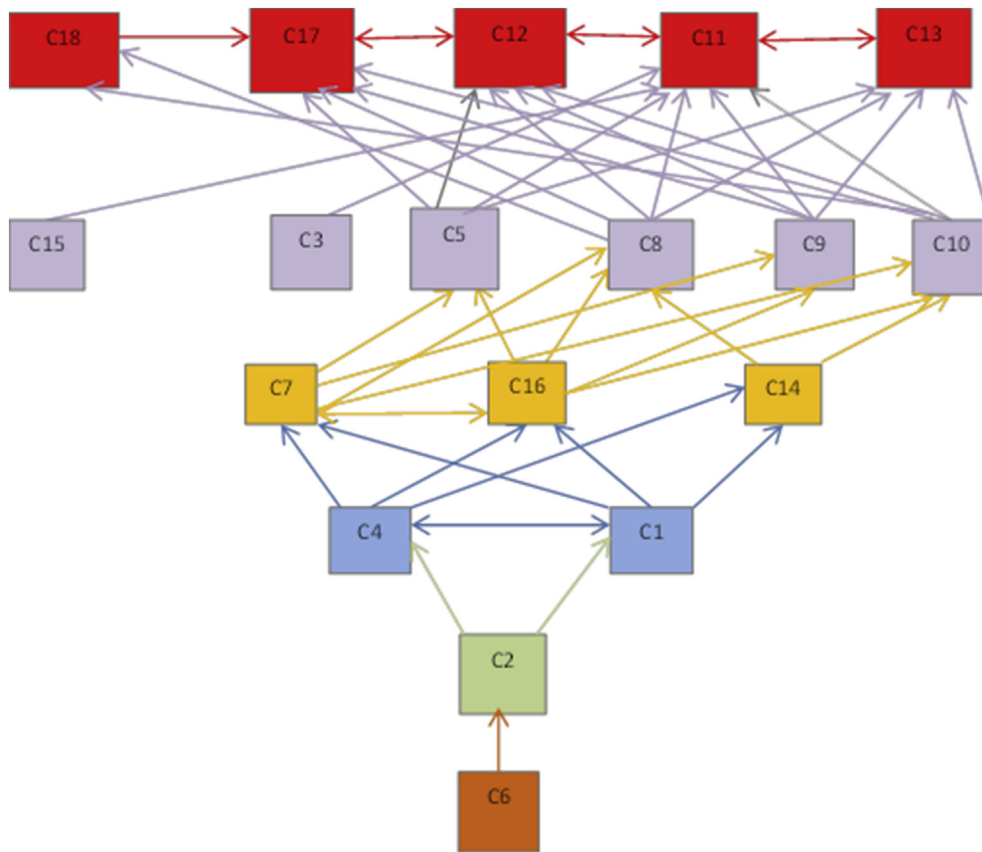
- Geographical distribution is the fundamental aspect of the model and should be considered in planning. This finding is supported by other studies such as Hill et al. (2009).

Table 11. The Final reachability matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	Driving Power
C1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	16
C2	1	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	14
C3	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
C4	1	0	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	14
C5	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0	0	1	0	8
C6	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	14
C7	0	1	0	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	13
C8	0	0	0	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	12
C9	0	0	0	1	1	0	1	1	1	1	1	1	1	0	0	0	1	0	10
C10	0	0	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	13
C11	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	16
C12	1	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	15
C13	0	1	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	14
C14	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	6
C15	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
C16	0	1	0	1	1	0	1	1	1	1	1	1	1	0	0	1	1	0	12
C17	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	4
C18	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	1	5
Dependency Power	6	8	1	12	13	3	12	15	13	14	18	16	16	8	1	11	14	9	

**Table 12.** First repetition of Interpretive Structural Modeling in order to achieve Different levels of factors affecting project communications.

Factors	Output Set (RC)	Input Set (AC)	Joint Set	Level
C1	C1C2C4C5C6C7C8C9 C10C11C12C13C14C16 C17C18	C1C2C4C6C11C12	C1C2C4C6C11 C12	
C2	C1C2C4C5C7C8C9C10 C11C12C13C14 C16C17	C1C2C6C7C11C12C13C16	C1C2C7C11C12C13 C16	
C3	C3C11	C3	C3	
C4	C1C4C5C7C8C9C10C11 C12C13C14C16C17C18	C1C2C4C6C7C8C9C10C11C12 C13 C16	C1C4C7C8C9C10C11 C12C13C16	
C5	C5C8C9C10C11C12C13 C17	C1C2C4C5C6C7C8C9 C10C11C12C13C16	C5C8C9C10C11C12 C13	
C6	C1C2C4C5C6C7C8C9 C10C11C12C13 C16C17	C1C6C11	C1C6C11	
C7	C2C4C5C7C8C9C10C11 C12C13C16C17C18	C1C2C4C6C7C8C9C10C11C12 C13 C16	C2C4C7C8C9C10C11 C12C13C16	
C8	C4C5C7C8C9C10C11 C12C13C16C17 C18	C1C2C4C5C6C7C8C9 C10C11C12C13C14C16C18	C4C5C7C8C9C10C11 C12C13C16C18	
C9	C4C5C7C8C9C10C11 C12 C13C17	C1C2C4C5C6C7C8C9 C10C11C12C13C16	C4C5C7C8C9C10C11 C12C13	
C10	C4C5C7C8C9C10C11 C12C13C14C16 C17C18	C1C2C4C5C6C7C8C9 C10C11C12C13C14C16	C4C5C7C8C9C10C11 C12C13C14C16	
C11	C1C2C4C5C6C7C8C9 C10C11C12C13 C14C16C17C18	C1C2C3C4C5C6C7C8 C9C10C11C12C13C14 C15C16C17C18	C1C2C4C5C6C7C8C9 C10C11C12C13C14C16 C17 C18	1
C12	C1C2C4C5C7C8C9C10 C11C12C13C14 C16C17C18	C1C2C4C5C6C7C8C9 C10C11C12C13C14C16C17C18	C1C2C4C5C7C8C9C10 C11C12C13 C14C16C17C18	1
C13	C2C4C5C7C8C9C10C11 C12C13C14C17C18	C1C2C4C5C6C7C8C9 C10C11C12C13C14C16C17C18	C2C4C5C7C8C9C10C11C12C13 C14 C17C18	1
C14	C8C10C11C12C13C14	C1C2C4C10C11C12 C13C14	C10C11C12C13 C14	
C15	C11C15	C15	C15	
C16	C2C4C5C7C8C9C10C11 C12C13C16C17	C1C2C4C6C7C8C10 C11C12C13C16	C2C4C7C8C10C11C12 C13C16	
C17	C11C12C13C17	C1C2C4C5C6C7C8C9 C10C11C12C13C14 C16C17	C11C12C13C17	1
C18	C8C11C12C13C18	C1C4C7C8C10C11C12C13C18	C8C11C12C13 C18	1



**Figure 2.** Relation map based on FDEMATEL-ISM approach. Note: Due to the complexity of the relationship between the factors, only the relationships between each level with its next level are plotted. The relationship between the factors is shown in Table 11.

**Table 13.** Second to sixth repetition of Interpretive Structural Modeling to achieve different levels of factors affecting project communications.

Factors	Output Set (RC)	Input Set (AC)	Joint Set	Level
C1	C1C2C4C5C6C7C8C9C10C14C16	C1C2C4C6	C1C2C4C6	4
C2	C1C2C4C5C7C8C9C10C14 C16	C1C2C6C7C16	C1C2C7C16	5
C3	C3C11	C3	C3	2
C4	C1C4C5C7C8C9C10C14 C16	C1C2C4C6C7C8C9C10C16	C1C4C7C8C9C10 C16	4
C5	C5C8C9C10	C1C2C4C5C6C7C8C9C10 C16	C5C8C9C10	2
C6	C1C2C4C5C6C7C8C9C10C16	C1C6	C1C6	6
C7	C2C4C5C7C8C9C10C16	C1C2C4C6C7C8C9C10C16	C2C4C7C8C9C10 C16	3
C8	C4C5C7C8C9C10C16	C1C2C4C5C6C7C8C9C10C14 C16	C4C5C7C8C9C10C16 C18	2
C9	C4C5C7C8C9C10	C1C2C4C5C6C7C8C9C10 C16	C4C5C7C8C9C10	2
C10	C4C5C7C8C9C10C14C16	C1C2C4C5C6C7C8C9C10C14 C16	C4C5C7C8C9C10C14 C16	2
C14	C8C10C14	C1C2C4C10C14	C10C11C12C13C14	3
C15	C15	C15	C15	2
C16	C2C4C5C7C8C9C10C16	C1C2C4C6C7C8C10C16	C2C4C7C8C10C16	3

- Organizational size is an affecting factor and its importance is almost equal to Geographical dispersion, so it is worth much more attention.

If project managers are working in large organizations, they need to pay close attention to communication planning and complexity in order to avoid failure.

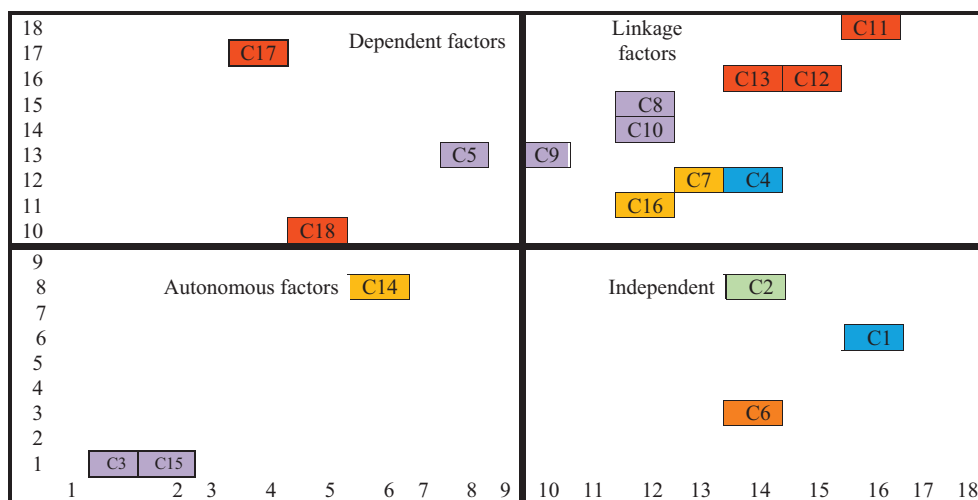
- Project managers should always consider the number of their stakeholders and communication variety (formal or informal). At this stage, the use of technology with environmental facilities and infrastructure is recommended to meet the project stakeholders' communication and information needs. This is important in gaining the trust of stakeholders.
- Because leadership has the most impact on the other variables, it is suggested to project managers to use situational leadership according to the type of project, number of stakeholders and other influencing factors.

It should be noted that these findings are supported by other studies such as Steyn (2012) and Zulch (2014), van den Hooff and de Ridder (2004); Hill et al. (2009); Ćulo and Skendrovic (2010); Tam et al. (2011); Bond-Barnard et al. (2013); Pheng (2018); Hysa and Spalek (2019); Perumal and Bakar (2011); Marion et al. (2016) and Pivec and Maček (2019).

### 5. Discussion and conclusions

Studies show that the number of failed projects is on the rise. Despite the fact that the number of project managers has increased significantly, what causes projects to fail? Various factors have been studied and analyzed, including the distribution of project teams and the complexity of communication networks that differ by the nature of the projects. Project managers are required to improve this process and reduce the number of failed projects, which is possible through establishing effective communication in projects. Communication planning, based on the association of effective factors with each other, really helps us establish better communication among stakeholders, especially in complex projects in different geographical regions. In fact, the establishment of a good communication strategy will specifically increase the likelihood of a successful project.

We know that each project has its own environment and conditions, and each industry has its own particular conditions to be considered. Every day, lots of information should be exchanged in projects, but the basic approach to communication requirements is essentially the same. Therefore, the informed communication strategy allows us to structure the information flow in a better and more controlled manner and to avoid the costs caused by lack of effective and timely communication. Managers should know that the budgets allocated to establishing communication are used to improve or change the most effective factors,



**Figure 3.** Clustering factors affecting project communications by using MICMAC analysis.

respectively, so that they could reduce the costs of project failures as well as the costs of losing the resources and interests of the organization.

For this purpose, this study was conducted to help clarify the views of the organization's managers and project managers on project communications, and to identify factors affecting it. According to the experts' opinions, library studies and validation of factors by the experts, 18 main factors were confirmed and selected. Then, a hybrid of Fuzzy DEMATEL-ISM was used to analyze the relationships between them and presenting a structural model for them. According to the analyses, geographical dispersion has the greatest impact on factors influencing project communications. It was found by using MICMAC analysis that the number of stakeholders and size of the organization is the most important factor among factors affecting project communications. Therefore, in projects where different parts of the project are located in different geographical locations or where the number of project stakeholders is high, more attention should be paid to linkage and dependent factors associated with these factors.

The factors "information updating, implementing the communication plan, and organizational structure" are affected by linkage factors. Focus should be on the effective linkage factors including leadership, knowledge, levels of providing information, communication variety, technology, infrastructure, variety of communication tools, participation (engagement), and skills and improving them. Among these linkage factors, according to Figure 2, communication variety is at the third level, so it has a greater impact on other factors. Next are infrastructure and technology - factors that are at the fourth level, affecting levels 5 and 6, and require more investment and attention. However, the most influential and affected factor is leadership (driving power = 16, dependency power = 18), which needs to gain the highest attention. Next are levels of information provision, knowledge, and participation (engagement), which will also require attention and care in communication planning.

However, the factors "trust, nationality, ethnicity and culture" are autonomous, meaning that they have low driving and dependency power and perhaps it is not necessary that the project manager concentrate on these factors in designing his project plan as compared to other factors.

This research can provide a new insight regarding the nature of the factor affecting the project communications in power plant, oil and gas megaprojects in Iran. Given the main logic of the method used, which is method for analyzing the system, factors that have the most impact on other factors are identified as the most important factors, and dependent factors must be considered by managers and policy makers to be improved by other factors, including the organization's policies in the geographical dispersion of different project sectors and the number of project stakeholders.

Also, special attention should be given to leadership as the highest influential (effective) and affected (influenced) factor. In order to improve leadership, it is necessary to sufficiently invest in the required skills and knowledge of project managers.

Project communication has a great influence on the success of the project. Considerable consideration and investment should be given to the factors affecting project communications and their effects on each other in order to have a positive impact on project communications and project success. Enhanced knowledge of project managers on the effect of these factors during project communications planning can be very efficient and prevent the loss of time and cost. Since no importance weights were obtained for the factors in this study, it is suggested that a combination of this method with a weighting method like Analytic Network Process (ANP) or weighting with prioritization like DANP method, etc. be used.

We can also examine the structural relations of the present model with Structural Equation Modeling (SEM) technique. It should be noted that the implementation of each of the factors is likely to have many barriers and conflicts. Researchers can investigate these problems in future studies. The first limitation that can be stated is the number of criteria that can be greater than this number and also the results should

be evaluated using larger samples across a variety of organizations and countries.

## Declarations

### Author contribution statement

M. Khalilzadeh: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data.

H. Shakeri: Contributed reagents, materials, analysis tools or data; Wrote the paper.

### Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Competing interest statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

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