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Project Complexity, Approaches, Related Criteria and Challenges

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Abstract: Certain features of a project may indicate proper management actions to complete it successfully. Complexity can be an example dealing with these features. The present study aimed at reviewing the available research on project complexity. Researches carried out during 1996-2015 on such areas of complexity as primary definitions, dimensions, etc. were considered. Available researches were studied and categorized according to their subjects and settings. This categorizing allows us to know which research on what areas has been carried out. Thus, through studying their approaches and points of view, it would be possible to address the faults and gaps for future research or project complexity.

Key words: Complexity, project complexity, dimensions of complexity, modeling complexity, management of project complexity, Iran

INTRODUCTION

Complexity has always played an important role in all scientific and technological areas. Although, mankind was perpetually struggling with this great problem from past till the present time, now a days its emergence and dimension is coming to be formed so rapidly. Though facing against the complex phenomena has not been confined to certain time, mankind's involvement in studying and mathematic modeling of them created a long and continued chapter in the significant book of man's science and knowledge. If we accept numbers to be as the primary simple models of mathematics, then creation of algebra and usage of variables to order computations can be considered as the steps taken for the first time to modeling science and management of the complexity.

Definition of the complexity: Many managers may be familiar with concept of complexity, however, the concept could not be understood in the same way. The term itself, has a degree of ambiguity. The difficulty involving its concept points to the different interpretations developed by individuals of different education levels. The word complex in English was derived from Latin word, "complexus" meaning a number of pieces piled on one another. Complex can be referred to entities consisting of at least two or more sections, pieces, parameters, etc. This can be interpreted as follows: to have a set you need two or more members which may be separated with difficulty. Similarly, Oxford dictionary defines what is complex as "consisting of many different and connected parts".

It is quite useful to distinguish between the terms "complex" and "complicated" (Whitty and Maylor, 2009). If one system, despite the fact that it may be comprised of many components could be given a full description from their comprising components viewpoint such as a system, it is literally complicated. For instance, jumbo jets and computers are complicated. "In a complex system, the interaction happens between the system components and also between the systems. The environment of a system has such a nature that the system as a whole cannot be completely understood only by analyzing its relevant components. This could result in exquisite features which are often referred as emergent properties. For instance, brain, a native language are complex systems" (Cilliers 1998).

Project complexity: By definition, project is a temporary attempt to develop a product or service with a unique result. Examples of diverse projects are: developing a new product or service influencing on changing a structure, employees or an organizational style developing or utilizing a new informational system construction project executing a new business process, etc.

Research question: The main question of this study is for researches done on the project complexity which categories could be defined?

Research approach: According to the research question, this study is a review paper and for this purpose, the resources including Science Direct, Scopus, Emerald and IEEE were used and search action was done with key

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Table 1: Statistical summary of articles

Row	Categories	Numbers
1	Number of articles	49
2	Qualitative articles	42
3	Quantitative articles	7
4	Distribution based on year published	
	1996-1999	3
	2000-2002	1
	2003-2005	6
	2006-2008	9
	2009-2011	14
	2012-2013	12
	2014-2015	4

words such as complexity, project complexity, dimensions of complexity, modeling complexity, management of project, measurement, management of complexity and articles reported from 1996-2015 were reviewed. Selected studies were refined and filtered several times. Among the indices of filtering the studies being scientific and relative to the project complexity were considered. The studies describing a specified scaffolding and material were also reviewed and finally 49 articles were selected and studied precisely. Table 1 shows the statistical summary of the articles.

MATERIALS AND METHODS

Classification of project complexity researches: Based on the investigations, a way of classification was developed to categorize the reviewed research. It is worth noting that the very method of classification seems to be innovative one given the results of literature review. The classification of the studies was done as follows:

- Definitions, dimensions, modeling and developing scaffoldings of project complexity
- Measuring project complexity (qualitative and quantitative)
- Models of behavior analysis or controlling complexity (examining causes of complexity in the project performance)
- Management of project complexity

The first class; definitions, dimensions, modeling and developing scaffoldings of project complexity: Definitions about project and project complexity are different from each other. Managers frequently use "complex projects" whereas there is not a clear definition of what they mean. There seems, however, to be a consensus that it might be more than a "Big project". Beccarini (1996) developed a good definition about project complexity and suggested that it may be a number of various kinds of related sections which can be operated through differentiation and interdependency. He defined dimensions of complexity as organizational and technological on the basis of his definition, so that these two dimensions are also studied from two aspects of differentiation and interdependency (Baccarini, 1996). For example, dimension of organizational complexity from differentiation point of view can be divided into two categories: vertical separation and horizontal separation.

- Vertical separation; pertaining to depth of hierarchical structure of the organization and the number of levels
- Horizontal separation; can be defined in two ways; the number of organizational units and task structure (Division of labor and Personal specialization)

And organizational complexity from dependence point of view: Another feature of organizational complexity in a project is a degree of operational dependences and interaction between the organizational factors of the project. Thompson recognized three types of dependency between the organizational units including pooled, sequential and reciprocal dependency.

Williams (1999) considered all dimensions suggested by Baccarini as structural dimension and suggested another dimension named uncertainty on the basis of studies conducted by Turner and Cochrane (1993). He started from Baccarini's definition of structural complexity and continued with another structural dimension which causes complexity to be increased as follows (Williams, 1999).

Increasing the number of objectives, completing the project by specified time with the minimum costs, for example. Defining the project with multiple objectives and sometimes conflicted ones (i.e., specified time and minimum costs) may add to the (structural) complexity.

Existing different stock holders rather than a specific customer that is, most projects have complexity within their stock holders. Most projects have lots of stock holders, customers each with unclear goals managers of the project, teams of the project, owners, champions, people sometimes the public, etc. This category, like multiple objectives can add to the (structural) complexity.

Another, suggested dimension was uncertainty. Some scholars believe that uncertainty may increase the complexity of the project. Thus it can be considered as the dimensions composing the project complexity. There are some other theories suggesting that uncertainty and complexity are distinctive concepts whereas both of them generally can create "problem" and "ambiguity" in a project which is called project complexity. The idea of

uncertainty in project was well-known by Turner and Cochrane (1993). They classified projects using two parameters: how well goals defined and how well methods defined.

According to the descriptions mentioned above, there are two main factors (structural complexity, uncertainty) in the first level each of which extended to two other factors (size: number of elements and interdependence of elements, uncertainty in goals and uncertainty in methods).

Hass (2009) interpreted uncertainty as lack of awareness of incidents and causality, inability to pre-evaluation and inability to know what will be happened. In fact, they all dealt with indicating the evidences of uncertainty.

Geraldi and Adlbrecht (2007) looking at the available research, developed the concept of complexity patterns and presented their suggested pattern. The following is three dimensions of suggested pattern: complexity of faith, complexity of fact and complexity of interaction.

Complexity of faith and uncertainty look alike. The complexity emerged with high uncertainty when something is going to be created, new problems going to be solved or buying and selling things. In these conditions, no one knows what the result of the project will be but they believe in it or at least pretend to, i.e., developing a new medicine in which the result and processes are indefinite, especially in conceptual phase.

Complexity of fact is similar to that of structure. Its challenge is to have a comprehensive approach to the problem rather than quantities of factual details. Building a refinery is a project influenced by the complexity of the kind. There are many restrictions and many people are involved. These are, however, not indefinite (uncertainty) but facts/realities.

Complexity of interaction: it usually emerges pertaining to the points (places, people) and can be described by clarity, frequency of reference and empathy. Organizational change may be occurred by this kind of complexity in which the interests of the groups are often ambiguous and contradictory and communication between men induced and empathy can play an important role.

Dvir *et al.* (1998) developed a diamond model to compare the projects on the basis of the fact that all the projects of an organization cannot be in the same form. In this model four dimensions of technology, novelty, complexity and pace were defined:

- Technology, in terms of how much new technology is used. Technology has the following levels: low-tech, medium-tech, high-tech, super high-tech
- Novelty, in terms of how novel the product in market and for consumer is. Novelty is divided into the following types: derivative, platform, new-to-the-market, new-to-the-world
- Complexity, in terms of how complex the product and/or the organization of the project is. It has the following levels: material/component, assembly /subsystem, system, array/system of systems
- Pace, meaning how critical your time frame is. Pace represents the urgency to complete the project. It has the following levels: regular, fast/competitive, time-critical, blitz

As seen in Fig. 1, the complexity is one of the axes of the model whereas each presented axis is one dimension of the project complexity.

Hass (2009) presented a project complexity model. They developed a framework of identifying the elements of complexity (which was considered in specified project) so that the project team can make decisions proper to complexity management. Spider diagrams are used to illustrate the complexity of the project and three levels of independent complexity, moderate complexity and high complexity have been defined. Some dimensions of project complexity of this model are such as time and project value, size and composition of team, required schedule of project, cost and range of flexibility, clarity of problem and solution, required stability, strategic importance, stakeholder's influence, level of organizational and business change, external constraints and dependencies, political sensitivity and unproven technologies.

Remington *et al.* (2009) have presented a definition for a complex project based on which they defined the complexity of project (Remington and Pollack, 2008). They defined the complex project as something indicative of a number of its features or intensity level causing the prediction of project results and project controlling or managing to become difficult.

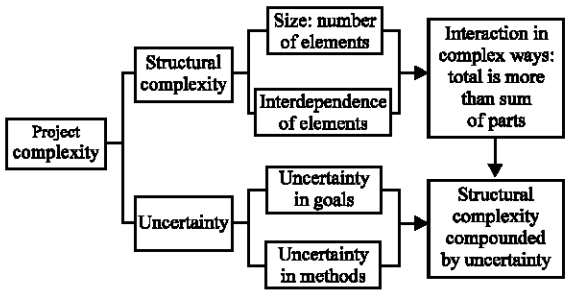


Fig. 1: Project complexity model of Williams (1998, 2002)

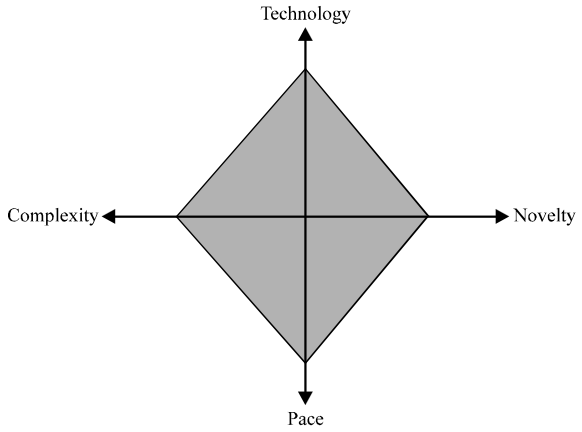


Fig. 2: Diamond model of Dvir *et al*. (1998)

These features include a high level of connection, non-linearity, inconformity and emergence. The complexity model of their project was focused on the intensity factors, the factors which could worsen the complexity and the dimension factors, the factors which are indicative of the nature of complexity or a combination of both.

Another, definition for the project complexity has been proposed by Vidal *et al*. (2011a, b). Based on their definition, "the project complexity is a project property which makes the comprehension, prediction and controlling its whole behavior to be difficult through giving the logical complete information about the system (Fig. 2). The drivers of project complexity are project size, project variety, project interdependence, elements of context".

Xian and Xue-Qing (2011) developed a Construction System Complexity Concept Model (CSCCM) for construction projects. The dimensions of this model are as follows:

Definition dimension, there are two levels of definition of complex systems, namely difference and interdependency.

Character dimension, includes autonomous elements, undefined and nonlinear values. Perspective dimension is description of different views of construction system, i.e., engineering perspective of technology, organizing the structure from the stockholder's perspective, task perspective, engineering information perspective, project goals perspective and project environment perspective.

Fitsilis introduced a model of complexity for software projects (Damasiotis *et al*., 2012). This model suggests using the whole knowledge of project management, modeling on the basis of Geraldian typology of complexity, i.e., complexity of faith, fact and interaction Table 2 shows this model.

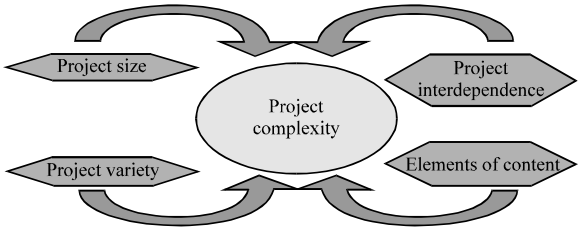


Fig. 3: Drivers of project complexity suggested by Vidal *et al*. (2011a,b)

Table 2: TOE framework (Technical, Organizational and Environmental) suggested by Bosch-Rekveldta *et al*. (2011)

Subcategories of TOE		
Technical	Organizationl	Environment
Goals	Size	Stakeholders
Scope	Resources	Location
Tasks	Project team	Market conditions
Experience	Trust	Risk
Risk	Risk	

Bosch-Rekveldt *et al*. (2011) suggested TOE (Technical, Organizational, Environmental) model on the basis of large engineering projects. They used 18 interviews and 6 real projects to develop this model. This model introduces the factors of complexity from both theoretical and practical point of view. The question of the research was put as what elements of complexity are participated concerning the project complexity and how these might be embedded in a pattern so that the project complexity can be described in large engineering projects. To answer to these questions they used deduction approach, interviews and some practical projects. Extracting complexity factors from literature as well as interviewing with 18 experts and examining 6 large real engineering projects they introduced three factors of complexity, namely Technical, Organizational and Environmental (TOE), then organized 50 factors of complexity out of literature, interviews and projects into these three categories.

Azim *et al*. (2010) highlighted the effective elements of complexity to understand project complexity using qualitative method and semi-structured interviews with the experts involving real projects concentrated on aerospace industry. The participants were selected through different projects with different levels of complexity. Their analysis showed "people" as the most important level and they emphasized the importance of software skills of management of complex projects and suggested triangle of project complexity people, product and process as three main settings of project complexity (Fig. 3 and 4).

Owens *et al*. (2012) observed that management of complex projects need to be changed fundamentally and

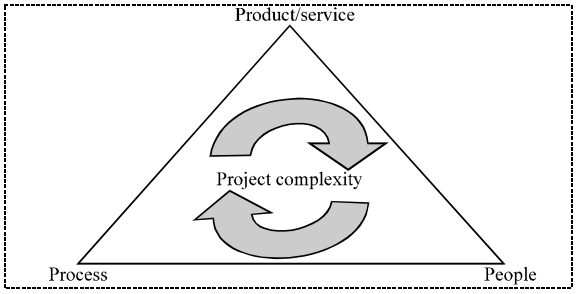


Fig. 4: Triangle of project complexity people, product and process-suggested by Azim *et al.* (2010)

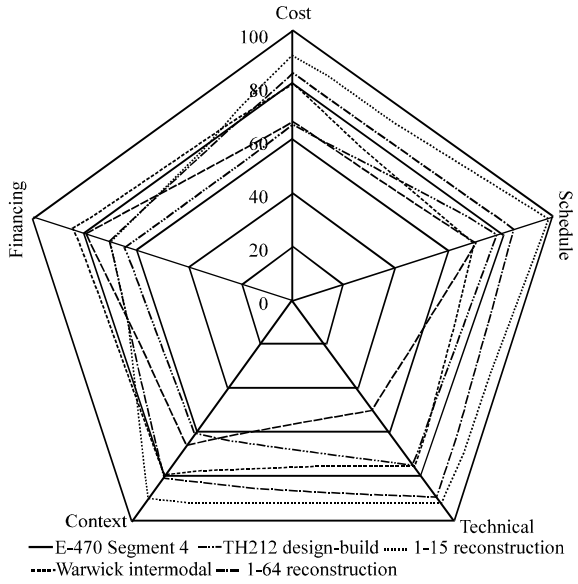


Fig. 5: Diagram of complexity radar suggested by Owens *et al.* (2012)

traditional tools (cost, schedule and design) do not work anymore. They presented a model with 5 dimensions including context, finance, schedule, cost and technique on the basis of comprehensive studies on complex transportation projects. They studied literature of these 5 fields, first and then gathered all factors addressed on these fields. On the next step, they introduced their final model through case study (5 projects were selected) and interviews with the managers of the projects. Then they showed the complexity of the projects by using radar diagram. To do this, they asked the experts (the managers of the projects) to give scores between 10-100 to each project involving any of these fields while no project can receive zero score. Given this the following figure (Fig. 5) was designed for 5 projects (Owens *et al.*, 2012).

Sanati and Noori had an attempt to describe the complexity of project using three approaches; research

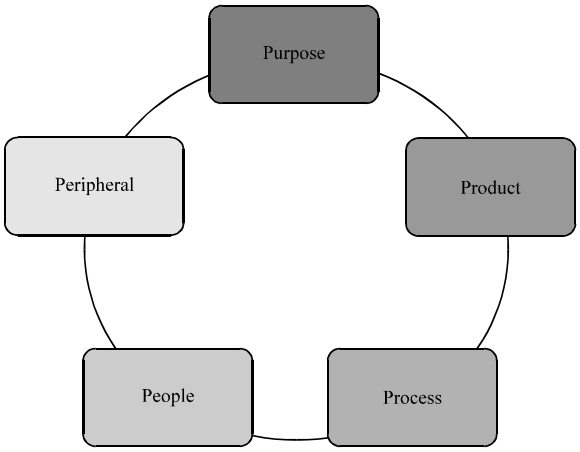


Fig. 6: 5P Model suggested by Shafia and Shakeri (2010)

literature (manufacturing and project complexity), interviews (deep interview with 20 experts) and questionnaire. Their research was conducted on the Complex Product and System (CoPS) projects and in conclusion, a 5P Model (purpose, product, process, people, peripheral) was introduced (Shafia and Shakeri, 2010) (Fig. 6). Table 2 shows a summary of other studies conducted on definitions and dimensions of project complexity.

The second class: measuring project complexity (quantity and quality): A number of researchers intended to study project complexity in terms of modeling and tools to measure it. This will be discussed in following section.

Vidal *et al.* (2011) tried to measure project complexity which may be suitable to rank the projects in project portfolio on the basis of dimensions they defined themselves using AHP tool. The defined dimensions which mentioned in previous section included size of project, project variety, project dependency and project concept (objectives and values).

Nassar and Hegab (2006) introduced a method to measure complexity of project schedule (Remington and Pollack, 2008). Their method was to measure the degree of relation between the activities of project schedule in which complexity is expressed in percentage, the fact that could be understandable for the managers. Measuring task can be done by software added to MSP.

Schlock suggested a measuring model in projects involving new products titled as "Effective Measure Complexity" (EMC) for NPD projects (Schlick *et al.*, 2007). In this research, it was assumed that the project has p activities being done simultaneously, thus, work transformation matrix is formed first with p×p element. Each column of matrix indicates remained tasks by time t and each element of matrix can take three values:

- Work on the activity i
- The zero value means that the activities j and i have no direct effect on each other
- The negative value indicates that doing one unit of work of j at time of t may cause α_{ij} of completion and progress of the activity i

After formation of WTM matrix the specific values of (λ_k) matrix can be calculated and then the value of project complexity can be calculated by using the following relation:

$$EMC = -\frac{1}{2}\sum_{k=1}^{p}\log\left(1-|\lambda_k|^2\right) \quad (1)$$

Castejon-Limas *et al.* (2011) developed two models to estimate complexity. They used data set of international standard software to do analysis operation. The first was a linear model on the basis of 8 parameters estimated by linear regression. Then they altered this linear model and developed it on the basis of three variables which have the highest coefficient in the primary linear model. They continued to produce another model using neural network which has 8 input parameters and one complexity parameter as output. A limit number of neurons were experimented to indicate the number of layers and the model was finalized as a model with minimum error of estimation. Finally, they compared the linear and artificial neural network models. The results showed that neural network model yield precise estimation and less error than the linear models.

Xia and Chan (2012) developed complexity measure of CI to measure complexity in constructing projects by using Delphi method. They selected 20 people from university experts as well as project managers. First, using available resources they provided them with a list of complexity factors and asked them to select 5 most important factors out of the list then score them from 1-5 on the basis of likert scale. As a result, main measures of complexity were extracted according to their point of view and they defined for each measure a linear relation between the measures and project complexity by using resulted weights. The weight of each factor and CI measure might be defined as follows (Xia and Chan, 2012):

$$W_{cmi} = \frac{M_{cmi}}{\sum_{i=1}^{6} M_{cmi}} \quad (2)$$

Where:

W_{cmi} = The weight importance of 6 measures selected primarily

M_{cmi} = The mean importance given to 6 measures selected primarily by the experts

$$CI = \sum (W_{cm} \times CM) \quad (3)$$

CM shows the standard of the selected complexity. Shafiei-Monfared and Jenab (2012) suggested a measurement model of relative complexity for enterprise maintenance projects on the basis of fuzzy logic graph using a collector to reduce contradiction of expert's view on complexity relation (Shafiei-Monfared and Jenab, 2012). They used a matrix of fuzzy relation representing reliable degree of complexity and drew a small Cartesian graph which could show the degree of relational complexity of the projects. They also presented an example of applying the model dealing with different projects of maintenance.

Qing *et al.* (2012) used ANP method to measure effective factors on complexity and SD (Super Decisions) software to calculate the weight of complexity factors. They also identified the most important factors to better management of the projects (Fig. 7).

Third class behavioral analysis models or controlling of complexity (reviewing causes of complexity in project performance): Tatikonda and Rosenthal (2000) studied the relations between the features of developing product project and the project results. They described developing product projects in terms of technological novelty and complexity level of the projects. They thought of two hypothesis, the first was that technological novelty may have negative effect on project achievement and the second was that complexity of the project may have negative effect on project achievement. They conducted a cross-sectional study of 120 projects of developing new product for montage products and tested the relations between the features of the project and project achievement. The achievement standards from their point of view can be named as technical performance, unit-cost, time-to-market and overall achievement of project goals. Their study showed that technological novelty may have a significant relation with weak results of unit-cost and time-to-market and complexity of the project may have a significant relation with weak results of unit-cost (Fig. 8).

Xia and Lee (2004) examined the complexity factors in project performance and observed that the managers of the projects should consider organizational dimensions as much as they pay attention to technical dimensions. This research was carried out on IS Development Projects (ISDPs) (Fig. 9).

Camci and Kotnour (2006) reviewed complexity factors and management style of the projects. They studied the challenges and achievements of the projects from 1996 up to 2000 and then reported that technical factor seemed to be the most important one.

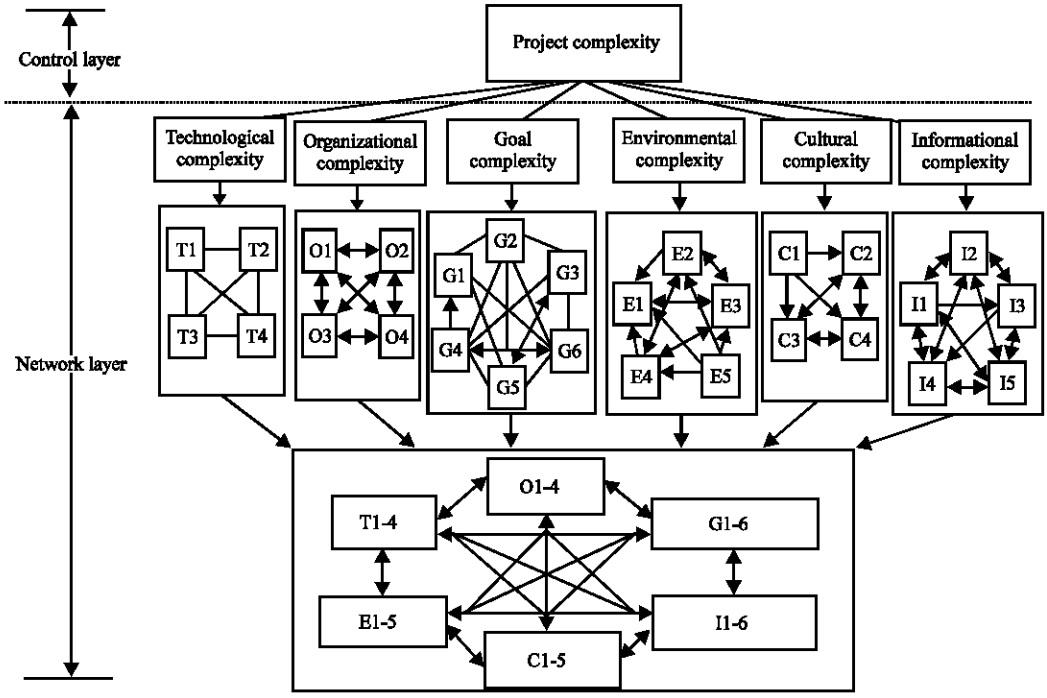


Fig. 7: ANP structural model of project complexity defined by Shafiei-Monfared and Jenab (2012)

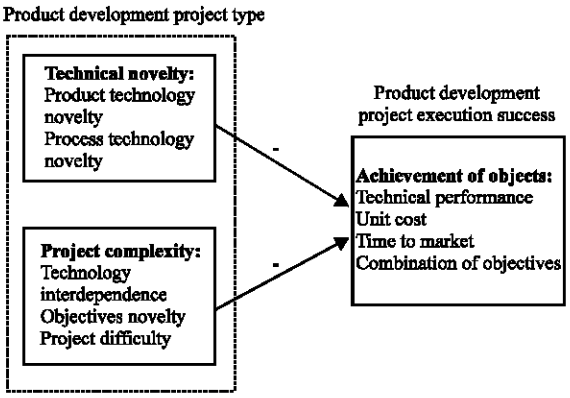


Fig. 8: Conceptual pattern of the features of the projects in project achievement by Tatikonda and Rosenthal (2000) and Shafiei-Monfared and Jenab (2012)

They divided the very factor into two factors of product and method and then continued to define the variables of product complexity as following:

- Newness/novelty of product
- Number of product sub-assemblies

The impact of a design change of one sub-assembly on another sub-assembly and the variables of method complexity were put as following:

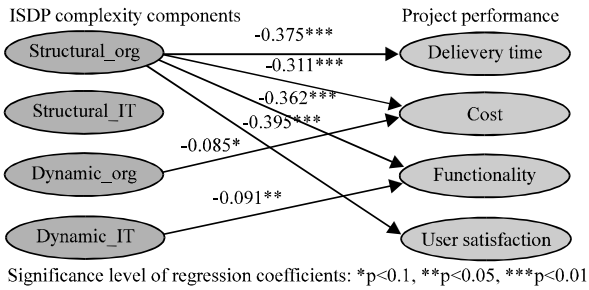


Fig. 9: The effects of complexity of IS development projects on project performance and their measurements (Xia and Lee, 2004)

- The newness of the production technologies
- The number of production processes
- The impact of a change in one production process on other production processes

They considered a style between Newtonian view and complexity concerning management style and scientific paradigms and defined the variables of management style on the basis of Deming cycle, i.e., designing, applying, studying and starting. Then they designed 18 questions with the help of questionnaire and considering the expert's view. Factor analysis was done using Sequential Equation Modeling (SEM).

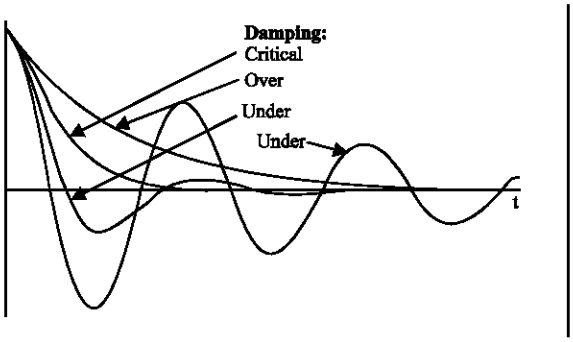


Fig. 10: Coordinated oscillator under damp, Antoniadis *et al*. (2011)

One model to control changes in construction projects was presented by Shabati Isaac and Ronny Navon. This model works to identify the effect of changes in customer's primary goals, cost, time and performance using available information of the project (Isaac and Navon, 2009).

Dimitris *et al*. studied the effect of Socio-oregano complexity on project performance on the basis of behavior modeling of under damped control systems. They believed that the behavioral effect of this factor on project performance seemed to be similar to the behavior of under damped control systems. Thus, they could identified the equations of this factor in project performance by using behavioral equations. The main question of the research was if socio-oregano complexity has a reversed relationship with performance of project schedule. They analyzed this factor by using simulation method to find the answer (Antoniadis *et al*., 2011) (Fig. 10).

YanLu and Nai-Ding (2012) studied developmental mechanism of NPD project complexity on the basis of Complex Adaptive System theory (CAS). They observed that CAS theory claimed that adaption causes complexity. Thus, NPD projects have an adaptive transformation with different sections to adapt for external environment creating diverse complexity factors on the basis of open systems composed of big elements and their relations. By definition of complexity concept of developing new product projects, they identified three main factors of developing new product projects as product complexity, environment complexity and process complexity. They also reported that on the basis of CAS theory, the reason for a NPD project to be successful is that it might be able to change properly its complexity in different steps of life cycle of environment. According to Rybakov who suggested that an organization can reach its optimum state when its complexity has a good match for environmental complexity, they believed that changes occurred in environment may cause the organization to respond and adapt itself with the environment through absorbing and transforming the effects resulting from the environment as well as having a proper structure and cooperation.

Finally, they classified development process of complexity in NPD projects into three steps: external triggering, divergent and choosing and internal response which can be shown in Fig. 11.

The fourth class-management of project complexity: Snowden and Boone (2007) suggested a framework that they called "Cynefin" to manage complexity. It allows managers to understand complexity concepts and notice problems and opportunities of the real world while they look at new things from new viewpoint. The suggested method has a cause and effect relation and shown in Table 3.

Little (2005) dealing with management of complexity on the basis of Boston matrix, developed Houston matrix to manage complexity and uncertainty. First, he defined complexity factors (i.e., size, crisis mission, place of team, maturity of team, knowledge gaps and dependency) then scored them in a table between 1-10 (1 to very little complexity and 10 to very high complexity). He did the same for uncertainty of project and defined its factors then prepared a table to do scores. Finally, according to the calculated values he suggested the following Houston matrix for complexity and uncertainty (Fig. 12).

Todd Little divided the projects into weasel, dog, foal, cow and buffalo depending on the region of the projects and then defined a confronting strategy on agility point of view.

Yugue and Maximiano (2012) studied knowledge and concept of complexity in line with project management techniques. They did this through questionnaire with 313 participants who were project managers. Analyzing data showed that complexity of the projects was managed by goals susceptibility and can influence using of project planning processes and human resources management.

Kim and Wilemon (2003) studied the factors causing complexity in NPD projects and their performance. They observed that most previous research had emphasized on negative dimension of complexity whereas they considered both negative and positive aspects of complexity and that complexity management can be in considered as a basic merit concerning projects. They

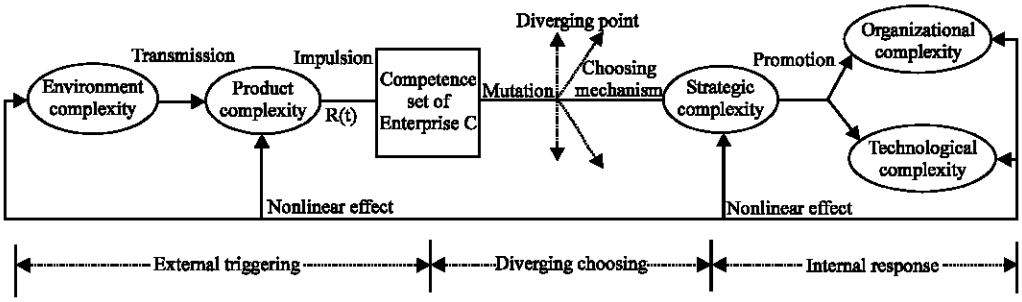


Fig. 11: Development process of complexity in NPD projects suggested by Yan-Lu and Nai-Ding (2012)

Table 3: Summary of research on definitions and dimensions of project complexity

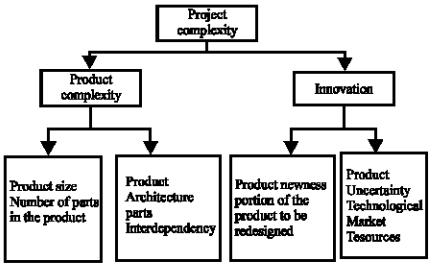
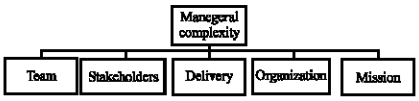
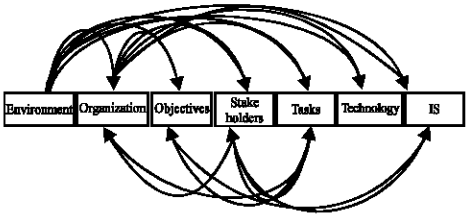
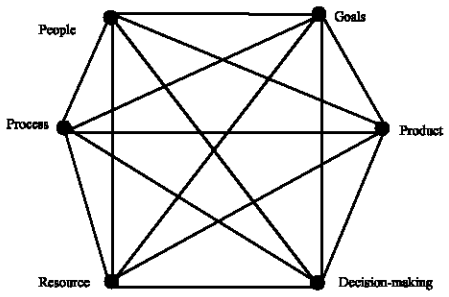
Developed by years	Defined dimensions	Description
Xia and Lee (2004)	Dynamic complexity	Studying dynamic complexity in the projects of informational systems to identify dimensions of complexity. The methodology was questionnaire (Xia and Lee, 2004)
Lebcir (2006)		Emphasis on innovation in NPD projects Lebcir (2006) and Lebcir (2011)
Maylor *et al.* (2008)		Defining factors with emphasis on managerial aspects of project complexity, Maylor *et al.* (2008)
Remington and Pollack (2008)	Structural, technological, directional and temporal	Adding two dimensions of directional and temporal complexity, Remington and Pollack (2008)
Gul and Khan (2011)	Structural, uncertainty, humanity uncertainty	Human factor was emphasized, Gul and Khan (2011)
Sedaghat-Seresht (2012)		Factors were presented by using Delphi technique and their effects on each other were examined by DEMATEL method, Sedaghat-Seresht *et al.* (2012)
Hagan *et al.* (2011)		Factors such as goals, product, decision making, people, process, and resource were introduced on the basis of multi projects environment, Hagan *et al.* (2011)
Albrecht and Spang (2014)		They proposed facts of project complexity in their case could be: size of project team, common

Table 3: Continue

Developed by years	Defined dimensions	Description
		working history of project team, geographical dispersion of project team, overall company's size Number of company-internal departments/units involved in project, number of company-external stakeholders involved, geographical distance to project's client, common working history of company and/or project manager with project's client (change in) technological uncertainty Albrecht and Spang (2014)
Dunovic *et al.* (2014)		They completed researches of Baccarini and Williams and presented new model with 3 major factors: structural complexity, uncertainty and constraints (environment, resources and objectives) Dunovic *et al.* (2014)
Ding *et al.* (2014)		They proposed project complexity factors :Project scale, technical difficulty, project target, uncertainty of environment Ding *et al.* (2014)

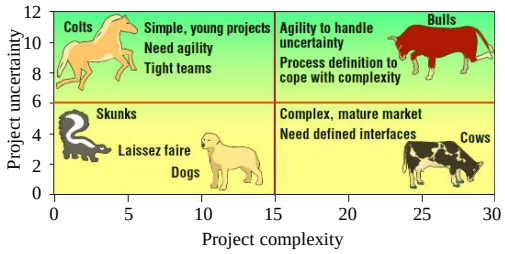


Fig. 12: Complexity and uncertainty pattern suggested by Little (2005)

conducted their heuristic research with a set of questions and deep interviews with 32 participants active in NPD New York. 84% of interviewed people reported that their projects have become more complex and 54% reported pursuing new opportunities, adapting to market changes and technological conditions to be the most important factors involving complexity. The following table shows a list of negative and positive factors in their research (Kim and Wilemon, 2003, 2012):

Positive factors:

- Achieving competitive advantage
- Increasing organizational learning
- Developing innovation culture in company

Negative factors:

- Low-moving of development
- Losing the opportunities
- Rising costs of development

They presented a pattern that describes how complexity resources can influence overall complexity of the project and practice its negative or positive effect. It was also shown feedback resulting from complexity consequences for complexity management approaches. Generally, they said that it is required to have a comprehensive understanding about the consequences of complexity in order to have a successful management (Fig. 13).

Daniliidis *et al.* (2012) developed a step-by-step approach to manage complexity involving product development. First, they defined four factors for complexity then suggested a goal definition process in which facing complexity can be occurred (Fig. 14).

According to their model, the product architect may be directed to choose a proper strategy to face complexity of product development by defining the objective precisely. In the first step, micro objective can be defined which shows the general pathway, than the objective continues to be more precise in next steps. Finally, by defining measuring scales, architect will be led to design product to manage complexity through reducing, controlling and avoiding complexity.

Haider and Haider (2012) studied issues of complexity management in pressed technological projects. They especially emphasized on the components of complexity including project manager's function, tools, techniques and models of complexity management in the projects. Considering previous research they addressed reducing and managing complexity and observed three points dealing with complexity reduction.

Complexity level of an operational system is related to both productivity and effectiveness. Thus, it is possible to improve them by reducing complexity.

Two levels can help the manager to face project complexity. First, reducing complexity through decreasing

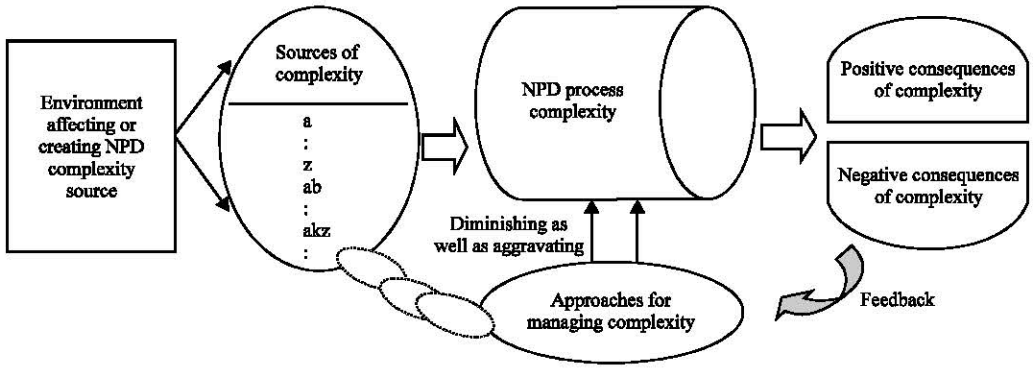


Fig. 13: Complexity relations in NPD projects according to research by Kim and Wilemon (2012)

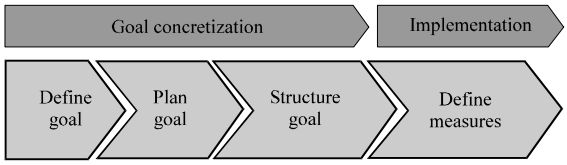


Fig. 14: Step-by-step approach to define goal to manage complexity suggested by Daniliidis *et al*. (2012)

physical level and second, managing complexity that reduces the effects of physical complexity on performance.

Controlling complexity tends to influence two categories of productivity (cost) and effectiveness of performance (services). This important feature shows that controlling complexity can change the productivity balance of a company and thereby can be affective. They observed that literature of research shows that business managers are required to create their strategies involving four columns, i.e., strategy, clearness, the whole value chain and stability to be able to manage complexity.

RESULTS AND DISCUSSION

Complexity is one of important features of the project which can be both advantageous and dis advantageous. This feature is multidisciplinary. In this study, previous research on complexity were reviewed. The 49 final papers were studied and classified in 4 groups. Table 4 shows the resulted statistic.

This research is a comprehensive review of conducted studies on the general field of complexity. Our categorizing here allows us and other researchers of the field to know which research on what areas has been carried out on the one hand and helps us to know the deficiencies and settings for future research on the other.

According to suggested classification, it seems to be clear that most ideas stated on complexity may refer to the researcher's application and their point of view and there is no comprehensive impression dealing with complexity. In fact, many of known perspectives of complexity in literature are related to the objectives of the research and can be of much extension. There is also no consensus on dimensions and factors of complexity and as mentioned before, they relate to the objectives of the research. The following table shows a summary of the research. As seen, 57% of the articles involved this field and modeling (Table 5).

As discussed before, many researchers during the past years studied on complexity factors and more than ten factors were identified and depending to their application, the researchers have selected some of them. Some researchers emphasized on one factor while others paid little attention to it. Adding or reducing one factor was the fact depending on the researcher's point of view. Thus, lacking a comprehensive approach dealing with definition and factors of complexity can be felt. Here we need to have a broad look at the factors of complexity and use a proper logic to accept and/or reject and/or priority over the factors, the fact lacking all previous research.

There were only 14% of the articles dealing with measuring (quantitative and qualitative) the project complexity.

As seen, there is a few research conducted concerning the project complexity measurement and different method were suggested, the fact indicating that this field needs more research.

Concerning other fields of project complexity (behavioral analysis and complexity management), there are also a few research all of which have qualitative aspect and there should be done more quantitative research.

Table 4: Interesting method of Cynefin suggested by Snowden and Boone (2007)

Context	Context characteristics	Approach
Simple	Repeating patterns and consistent events	Sense, categorize, respond
	Clear cause effect relationship	Ensure proper process in place
	Known knows	Best practices and clear communication
Complicated	Expert diagnosis required	Sense, analyze, respond
	Cause and effect relationship not apparent	Create panels of experts
	Known unknowns	Listen to conflicting advice
Complex	Unpredictably and competing ideas	Probe, sense, response
	No right answers	Increase level of interaction and communication
	Unknown unknowns	Use methods to generate ideas
Choatic	High turbulence	Act, sense, respond
	No clear cause and effect relationships	Look for what works instead of seeking right answers
	Many decisions to make and no time to think	Provide clear direct communication

Table 5: Distributed of articles in each group

Row	Groups	Numbers	Scores (%)
1	Definitions, dimensions, modeling and developing scaffoldings of project complexity	28	57
2	Measuring project complexity (qualitative and quantitative)	7	14
3	Models of behavior analysis or controlling complexity (examining causes of complexity in the project performance)	6	12
4	Management of project complexity	8	17

CONCLUSION

In conclusion, it is required to describe the features of complexity without considering a specific goal. The final goal in this respect should be not only reducing negative effects but also maximizing the advantages. Furthermore, it is required to have a comprehensive definition of project complexity and identify standards and drivers of complexity as well as conduct more analytical and behavioral research on complexity factors being effective on project performance and on complexity management. Finally, dynamics of project complexity and resulted scenarios can be considered as a setting for future research.

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