Complexity Theory in Construction Project Time Management

Atie Ahmadi¹, Mahmoud Golabchi²

¹. Department of Architecture, Tehran University, Tehran, Iran, at.ahmadi@ut.ac.ir
². Department of Architecture, Tehran University, Tehran, Iran, golabchi@ut.ac.ir

Corresponding author: Atie Ahmadi

ABSTRACT: Within the past two decades, management of construction projects is dramatically faced with the uses of different methods and techniques from multiple disciplines. This is mainly due to the rapid changes in project types and contracts, increased level of complicated expectations among stakeholders, and unprecedented factors. As a result, construction projects are increasingly encountering with schedule delays, increased costs and risks, poor quality and increased number of claims and litigations. As such, project managers' main concern is to complete project on time and within budget in such complex and chaotic environment. To this end, they mostly focus on dealing with operational and practical factors influencing complexity rather than analyzing the factors that surround the project environment and have greater impact on understanding the complexity of projects. This research aims at introducing complex environment of construction projects and shed light on better understanding the factors that cause project time management become a complex task. In order to achieve this objective, complex and chaotic environment in project management is investigated from difference perspectives: structural, social, dynamic, and uncertainties. Afterwards, project time management elaborated in PMBOK standard (Project Management Body Of Knowledge) is used to systematically identify inherent parameters of complexity and chaos. Finally, practical suggestions are provided for project managers and schedulers on how to consider and incorporate complexity-based parameters to other feasible factors in their project scheduling and controlling so that better project time management can be achieved. This research contributes significantly to the provision of managerial tools that have the potential benefit of supporting construction projects by better estimating project duration, as a crucial process in project management system. More effective estimation of activities duration by involving factors derived by complex and chaotic project environment can reduce risks and uncertainties and save enormous amounts of cost and time in construction projects.

Keywords: Chaos, Complexity, PMBOK, Project Time Management, System

Abbreviations: PMBOK (Project Management Body of Knowledge)

INTRODUCTION

Projects have been one of the principal means by which people effect social, cultural, and physical change. A prime example of this is the ancient Egyptians, who built their entire culture around the construction of pyramids. In their day, these structures were symbols of great power and control. There are many differences between then and now such as the social context, or condition of decision making, decisions were dictated as opposed to now where agreement reached by consensus. As a result of these differences, the rate of change was much slower than today, and the complexity of projects were simpler. It has been observed the principles and methods of project management that have served us well over the years are no longer as effective as they once were. “Even projects deemed a success these days sometimes fail to meet their targets . . . It is not as if project management is a new science . . . So why do so many still go wrong?” (Economist, 2005).

Projects and their nature have had many changes over time, that one of these changes is the complexity of project components and their relationships. In addition to the size and scope of the project, the large number of experts, project team members, project stakeholders, variety of software and specialized tools for each section and obvious or hidden relationship among them have increased the complexity. Complexity of management will become clearer when we want to scheduling and planning a virtual project that does not start yet. On the other side, despite
extensive researches in the field of project time management whether in planning, resource allocation and leveling, and whether in monitoring and control, we are faced with time delay than schedule. It seems some factors affect in this way those we have ignored the impact of them. Sumner stated, “Without question, effective management of these large projects is a new and unique challenge which requires the use of project management and control methods that have not been used extensively in the past” (Sumner, 2000). The conventional project management approach assumes a world of order and a predictable environment in which one can set and deliver a clear set of goals in a defined manner. The traditional approach is open to challenge . . . a paradigm shift in project management is essential for it to be relevant and effective in a complex society of this century. (Jaafari, 2003)

This research strives to critically analyze the current trend in construction project time management utilizing PMBOK standard, and emphasizes on important factors that cause complexity and are often ignored in the process of estimation project activities duration. To this end, complexity and chaotic nature are briefly explained and then the PMBOK time management processes are used to systematically identify and summarize complexity-based factors inherent in each process and element. These factors then complement the other factors and provide the schedulers and project managers with a comprehensive tool that allows them to better estimate project activities.

**Literature review- complexity types in project management**

The development of the concepts shows that types of complexity and its related factors, on the whole, were not deliberately built upon previous works in the field of project time management however, many researchers identified some types of complexity in project management. Important types of structural complexity, uncertainty, dynamic and social complexities are briefly explained in the following.

1- Structural complexity

Structural complexity, the most mentioned type of complexity in the literature, is related to a large number of distinct and interdependent elements (Williams, 1999). This is close to the original concept of complexity as a set of interrelated entities (Simon, 1962). The majority of the articles define structural complexity based on three attributes: size (or number) (Crawford et al., 2005; Dvir et al., 2006; Geraldi and Adlbrecht, 2007; Green, 2004; Hobday, 1998; Maylor et al., 2008; Muñier and Turner, 2007; Shenhar, 2001), variety (Baccarini, 1996; Eriksson et al., 2002; Geraldi and Adlbrecht, 2007; Maylor et al., 2008) and interdependence (Chapman and Hyland, 2004; Hobday, 1998; Little, 2005; Maylor et al., 2008; Williams, 1999; Xia and Lee, 2005).

2- Uncertainty

Uncertainty relates to both the current and future states of each of the elements that make up the system being managed. For managers, this is experienced as an inevitable gap between the amount of information and knowledge ideally required to make decisions, and what is available (Probst and Gomez, 1991). In the literature reviewed, the indicators expressed attributes of technology that is cutting edge, or uncommon contractual framework (Shenhar, 2001; Tatikonda and Rosenthal, 2000), the previous experience of an organisation, manager, team or stakeholder with such a project (Maylor et al., 2008; Mykytyn and Green, 1992), and availability of information (Geraldi and Adlbrecht, 2007; Hobday, 1998; Maylor et al., 2008).

3- Dynamics

Dynamic” is a prevalent behavior of complex systems. Dynamics refers to changes in projects, such as changes in specifications, management team, or the environmental context. These changes may lead the project to high levels of disorder, rework, or inefficiency, when changes are not well communicated or assimilated by the team and others involved. Projects not only change “outside-in” but also “inside-out”; team motivation levels may change, internal politics may emerge. Understanding the patterns underlying at least part of this dynamic may be a good strategy to avoid “chaos”. Maylor et al. (2008) defined dynamic complexity as how each attribute and indicator changed with time.

4- Social complexity

There are many researches in projects stressing that projects are carried out by human actors, with potentially conflicting interests and difficult personalities (Clegg and Courpasson, 2004; Goldratt, 1997; Maylor, 2001). Abstracting from these descriptions, this type of complexity emerges as a combination of political aspects and emotional aspects involved in projects. This complexity is expected to be high in situations such as mergers and acquisitions, organizational change, or where a project is required to unite different interests, agendas or opinions. (Maylor et al., 2008; Benbya and McKelvey, 2006; Cicmil and Marshall, 2005; Cooke-Davies et al., 2007).
FINDINGS

Complexity-Based Factors in Project Time Management

In this section, a new approach to consider complexity factors in project time management is presented. The goal is to assess what other factors indirectly impact project time management and how rational approach can be assisted to incorporate these factors to other conventional factors, given the chaotic nature of construction project as complex systems.

Time management in PMBOK guideline deals with the ability to plan and finish the project in a timely manner. The time management processes deal with defining activities, estimating the durations of activities, scheduling activities and ensuring adherence to the schedule. Time management is a crucial part of any successful project. Without careful planning, projects are set up to fail. According to PMBOK Project time management include the processes required to ensure timely completion of the project and consists of six main processes: Activity Definition, Activity Sequencing, Activity Duration Estimating, Activity Resource Estimating, Schedule Development, and Schedule Control.

Once the processes within the paradigm of PMBOK time management were determined, types of complexity, and their main characteristics were identified, complexity factors in project time management are identified. It is first important to change the attitudes toward complex environment in project and seek what factors are missing and how we can integrate them in estimation of project activities duration. Utilizing project time management processes defined in PMBOK standard and types of complexity defined above, complexity factors within each process are defined in Table 1 and related discussion provided below. It should be noted that activity duration estimating and activity resource estimating processes have been placed in one column due to similar nature.

With respect to the structural complexity, for example, three main characteristics are considered: size or number, variety, and interdependence. Therefore the large number of parameters such as scope, the project budget size, the project team size, number of concurrent projects, input variation, and so on can be considered within structural complexity factors, as shown in the first row in Table 1.

It should be mentioned that complexity-based factors related to project dynamic is not listed in Table 1. This is due to the difficulties in well understanding the nature of dynamic in construction project in order to identify relative complex factors. In other words, planning for a dynamic system is difficult due to changes in environment and circumstances. It is even more difficult to estimate when considering dependent on environmental conditions and other unknowns. There is an ongoing research in this regard and more details need to be revealed and findings explored.

CONCLUSIONS

Project management systems are considered dynamic systems, similar to those in nature, which means they change over time and are hard to predict. This increasingly fast-paced system is creating a complexity explosion, which is affecting the way project managers need to govern. Although they are changing, there is usually an underlying predictability that can be identified. Project time management is an important component in professionally managing project in which many complexities and uncertainties occur and as a result, many activities in a project are often behind the schedule. The primary objective of this research was to better understand complex and chaotic nature of construction projects, and in particular, explore factors inherently causing complexity in project time management according to the processes defined in PMBOK standard. Using a logically consistent approach, various types of complexity such as structural and social were identified within each process, critically analyzed, and results systemically tabulated.

This research significantly contributes to the provision of complexity in projects that not only considers the relations of components within a project but also focuses on the relations between a project as a whole and other phenomena and environment that have surrounded the project. Such provision can help project managers better comprehend a broader range of factors affecting management of a construction project. Growing rate of failures in completing complex construction projects on time indicates that considering only conventional factors in project time management may not be enough and complexity and interaction of projects with surrounding environment needs to be taken into account. Last but certainly not least; this research may help in addressing the increasing demand for shifting from conventional perspective to a more comprehensive provision when project time management is undertaken. Such shift may result in more realistic estimation for construction project durations; reduce risk and uncertainties, and increase project efficiency and overall productivity.
### Table 1. Complexity factors identified within processes of project time management

<table>
<thead>
<tr>
<th>Type of complexity</th>
<th>Activity Definition</th>
<th>Activity Sequencing</th>
<th>Activity Duration and Resources Estimating</th>
<th>Schedule Development</th>
<th>Schedule Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>Scope: there are many ways of achieving a solution number of locations and their differences number of separate and different actions or tasks to produce the end product of a project interdependence of distinct processes Size/ budget of the project technologies involved in product embedded software in product number of specialties involved in a project, number of roles and level of labor skills team size number of concurrent projects, number of linkages from-to projects level of concurrent similarly complex programs</td>
<td></td>
<td>number and diversity of inputs and/or outputs technological differences and interdependence variety of skill and engineering inputs number of stakeholders and their interdependency intensity of involvement and interdependence of stakeholders</td>
<td>data misfit, technical and infrastructural integration integration of project elements process integration processes defined and standardized key experts are available when needed large number of resources multi-cultural, multi-language, multi-gender organizational vertical differentiation and interdependence – hierarchical structure organizational horizontal differentiation and interdependence organizational units</td>
<td></td>
</tr>
<tr>
<td>Uncertainty</td>
<td>clear and well-defined vision, requirements, business case, scope, work packages, goals and success criteria and its measurements experience of project manager project data are accurate, timely, complete, easy to understand, credible, degree to which technological and organizational aspects are new team members are knowledgeable in technical, project management issues and understand project management methodology the team members worked together before unidentified stakeholders, previous experience of stakeholders in general and with project management, experience to work with stakeholder, stakeholders’ understanding of the implications of the project the client organization provides resources in a timely manner project data available at the right level of detail</td>
<td></td>
<td>uncertainty in methods clarity in respect to organizational and technological setting maturity level of organization with effective change, risk and quality management</td>
<td>realistic expectation of stakeholders ambiguity of performance measurements new organizational structure</td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>conflicting requirements project information adequately communicated Senior management support project competing priorities shared resources across different projects</td>
<td></td>
<td>appropriate tools project management methodology is used “for real” standardized project processes</td>
<td>shared understanding of aims of project realistic expectations of timescale and budget trust and empathy appropriate authority and accountability stakeholders’ commitment (un)helpful interference, resistance, ownership, appropriate authority and accountability conflicts, power struggles and hidden agendas between stakeholders</td>
<td></td>
</tr>
</tbody>
</table>

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