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Measuring project complexity using the Analytic Hierarchy Process

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Abstract

Project complexity is ever growing and needs to be understood and measured better to assist modern project management. The overall ambition of this paper is therefore to define a measure of project complexity in order to assist decision-making. A synthesised literature review on existing complexity measures is proposed in order to highlight their limitations. Then, we identify the multiple aspects of project complexity. We then propose a multi-criteria approach to project complexity evaluation, through the use of the Analytic Hierarchy Process. In the end, it permits to define a relative project complexity measure. Complexity scales and subscales are defined in order to highlight the most complex alternatives and their principal sources of complexity within the set of criteria and sub-criteria which exist in the hierarchical structure. Finally, a case study within a start-up firm in the entertainment industry is performed. Conclusions and research perspectives are given in the end.

Keywords: Project; Complexity; Evaluation; Multi-criteria; Analytic Hierarchy Process (AHP)

1. Introduction

A project is a temporary and unique endeavour undertaken to deliver a result. This result is always a change in the organization, whatever it is in its processes, performance, products or services. This transformation consists then in a gap between a start and a final state. Time and resources are consumed to produce results, which may be deliverables and/or performance improvement and/or resource improvement (skills and knowledge). Each project is unique because there is always at least one of the following parameters that changes: targets, resources and environment. This makes making project management an even more complex process.

For all practical purposes, lots of studies have been done, based on statistical calculations or surveys. Limits and lacks have been detected in research as well as in industry about the project predictability. Namely, usual parameters (time, cost and quality) are clearly not sufficient to describe properly the complete situation at a given time. As a whole, the conclusion of these studies is that current methods have shown their limits, since they cannot face anymore the stakes of ever growing project complexity, which results in damages or failures for the projects (Williams, 1999, Whitty and Maylor, 2009). In other words, project ever growing complexity is an ever growing source of project risks. Identifying existing project complexity sources and levels of project complexity has thus become a crucial issue in order to assist modern project management. The main objective is then to build up a project complexity index so it can be used as an indicator, notably when facing the issue of project selection in multi-project environments.

2. Measuring project complexity: a literature review

2.1. Project complexity definition

Research works on the concept of complexity have been conducted for years. The difficulty is that there is actually a lack of consensus on what project complexity really is. As Sinha et al. (2001) underline it, “there is no single concept of complexity that can adequately capture our intuitive notion of what the word ought to mean”. Complexity can be understood in different ways, not only in different fields, but has also different connotations within the same field (Morel and Ramanujam, 1999). As for us, we propose the following definition for project

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complexity based on some additional works (Baccarini, 1996; Edmonds, 1999; Marle, 2002; Austin et al., 2002; Vidal et al., 2008): "project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system."

2.2. Existing project complexity measures

As far as this research work is concerned, a literature review on existing (project) complexity measures was performed. A total of 42 measures were listed, notably thanks to the works of Edmonds (1999), Latva-Koivisto (2001) or Nassar and Hegab (2006). If interested, one should directly refer to them for more information on complexity measures and formulations. As a whole, there are basically three kinds of project complexity measures which can be found in the literature.

The first group gathers measures which correspond to the computational complexity of some project management issues, such as the sequencing and scheduling problem (Akileswaran et al., 1983).

The second group gathers measures which are related to a model of the project structure as a graph (task graph, organization graph, etc.). For instance, we can think of:

- The Coefficient of Network Complexity (CNC) defined by Kaimann (1974) applies to both PERT and precedence networks. They can also apply to any model of a project as a graph. In the case of PERT networks, the CNC is equal to the quotient of activities squared divided by events.
- The cyclomatic number defined by Temperley (1981) is given in Eq. (1). S is the cyclomatic number, A is the number of arcs, N is the number of nodes.

$$S = A - N + 1 \tag{1}$$

- Arguing that complexity measures such as CNC are imperfect since they take redundant arcs into account and therefore show that the system is more complex than it actually is, Nassar and Hegab (2006) define the following measure:

$$\begin{aligned} Cn &= 100 \times (Log(a/(n-1))/Log[(n^2-1)/4(n-1)])\% \text{ if } n \text{ is odd} \\ Cn &= 100 \times (Log(a/(n-1))/Log[n^2/4(n-1)])\% \text{ if } n \text{ is even} \end{aligned} \tag{2}$$

The third group gathers more holistic measures such as systems thinking oriented measures or informational measures. For instance, we can think of:

- The traditional static entropic measurement of complexity by the Shannon information (Shannon, 1951)

$$Sha = -\Sigma log_2(p(n_i)) \tag{3}$$

- Even though not calculated in the book, complexity indexes may be deduced from the areas of spider charts used by Haas (2009), who described project complexity using a complex systems thinking approach to identify several aspects of complexity (such as team composition and performance, cost/duration or political sensitivity/multiple stakeholders). This approach is particularly adapted to the issue of project selection.

2.3. Limits of existing project complexity measures

Existing measures have shown their limits for several reasons. First, some limits have been highlighted about the reliability of such measures. Second, these measures are often non intuitive for the final users and thus give results which are difficult to communicate on. Finally, these measures mainly refer to a model of the project system.

For the first group of computational complexity measure, the main drawback is that they do not focus on the complexity of the project system in itself. Indeed, with such measures, it can only be assessed given the bias of a specific issue like scheduling.

For the second group of graph-based complexity measures, some of them lack of reliability since counterexamples can be found. For instance, some graphs and networks were sharing the same CNC but were very different considering their easiness to be managed. One of the main reasons for this lack of reliability is that these measures refer to a single aspect of (project) complexity, essentially in terms of interdependencies. Moreover, measures such as the CNC, the cyclomatic number or the one proposed by Nassar and Hegab refer in essence to an existing network or graph. Such graphs are specific models of the project system, which restrict the view and understanding of project complexity. For instance, a project can be modelled thanks to different WBS (Work Breakdown Structure), PERT networks or Gantt charts, depending on the detail level, willingness of the project manager, etc. Applying such measures to these kinds of elementary models of the project systems cannot properly account for a measure of project complexity since they are in essence relative to the model. This is less the case with approaches based on systems thinking such as the one proposed by Haas.

However, for the last group of holistic complexity measures, such measures are sometimes difficult to calculate for non-skilled users, which make it all the more complex to perform and analyse them. Moreover, in the case of the Shannon number, the mathematical formulation does not permit a reference to real project complexity factors. Both the identification of important complexity sources and possible actions for complexity handling/reduction are not facilitated.

As a whole, in order to overcome the limits of existing measures, this paper aims at defining a systems thinking oriented index, which is as far as possible:

- Reliable, meaning the user can be confident with the measure.
- Intuitive and user-friendly, meaning it should be easily computed and implemented, and that users must understand why it assesses project complexity.