EX-POST PROJECT COMPARISONS: FROM TRIPLE CONSTRAINT MEASUREMENTS TO AGGREGATED ORGANIZATIONAL IMPACT

IBRIAN CĂRĂMIDARU *

ABSTRACT: *While many of the social and economic outputs in the contemporary world are delivered by means of interconnected or disparate projects, comparing and aggregating completed projects is still a difficult task for organizations, financing institutions and governmental agencies. Moving beyond the typical appraisal of projects in terms of investment placement or financial impact, the current paper explores the adequacy of comparing the organizational effort for completed projects through similarity measurements of metrics for the triple constraint compliance (duration, cost, scope). Building on this statistically oriented proposal, the organizational impact of networked project is to be compared through the lenses of two divergent scenarios – one of project failures and one of connected projects, whereas two successive projects are connected by arrays of shared deliverables. Project comparisons in terms of organizational impact are using a stakeholder approach to the organizational setting, hence asking for metrics suitable for each stakeholder category – from valuing the lessons learned by team members to customer satisfaction or mission compliance metrics.*

KEY WORDS: *project management, project comparison, project coupling*.

JEL CLASSIFICATIONS: *O22, L22*.

1. INTRODUCTION

Our social and economic world is undoubtedly characterized by the pervasiveness of projects and project-based or project-oriented organizations. During the past decades many organizations shifted their outlook form centralized, hierarchical, stable settings to decentralized, participative and ephemeral contexts where the outputs are delivered thorough interconnected projects, rather than the mass production industrial lines. According to some authors (Jensen, et al., 2016), the

* *Assist. Prof., Ph.D., University of Petroșani, Romania, ibriancaramidaru@upet.ro*

transition to the ephemeral setting of projects is not something specific to organizations, but it becomes, more and more, a feature of contemporary society or of contemporary human condition.

Under such auspices, assessing project success, comparing similar projects and aggregating their results turn into stringent social needs for various stakeholders. The purpose of this paper is to investigate the adequacy of various similarity measurements for completed projects (ex-post similarity). Such an endeavor might be regarded as a subset of project assessment and comparison. Project comparisons are done ex-ante (for decisions of intaking projects into portfolios), during the project execution (for monitoring and control processes and procedures) or ex-post. Ex-post appraisal and comparison is usually performed for project implementation assessment, and this could be necessitated for reasons that differ according to the peculiar interests of stakeholder in need of ex-post information.

The need for ex-post similarity measurements is at least given by the following factors: a coherent definition of project success; a predictable project implementation complying with the constraints of scope, duration and budget; settling efficient project teams; channeling organizational efforts to successful projects; the prospect of aggregating project metrics for projects with a high degree of similarity. Since most of current applications of artificial intelligence are founded on processing similarity measures, progressing on similarity operators adequate for projects can lead to fruitful applications which may begin with team members relocation suggestions and end-up with establishing a probability of success for similar projects developed under similar circumstances.

The structure of this paper builds up on a section on scientific background and method, followed by a section on triple constraint measurements as metrics for internal project similarity, one on the difficulties of defining similarity for failed and collinear projects and the final section explores what project similarity entails from the venue of various stakeholders. The last paragraphs offer some conclusions and final remarks.

2. BACKGROUND AND METHOD

The scientific literary background for project similarity is rather thin. While the literature on similarity search is relatively vast, the research on project comparison and similarity is still in need of growth. The industrial domains which are mainly characterized by project delivery – the construction and software industries - are somewhat well represented in the studies on project comparisons. Significant studies on software project similarities, such as (Oliveira Suarez Barreto & Rocha, 2010), focus on a set of project characteristics for construing an aggregated similarity measurement: while others (Abbas, et al., 2021) focus on project requirements, project reliability (Kywat, et al., 2021), and the possibility to generalize by similarity (Ghaisas, et al., 2013). The ability to generalize some past project mechanisms through the judicious analysis of similarity is at the core of case-based reasoning. Construction projects can be assessed in terms of similarity by comparing their work-breakdown structure, as in (Trokanfar & Rezadader Azar, 2020), or on their pay item composition (Qiao, et al., 2019). Our approach would follow the regular similarity operators take on establishing similarity between objects. This approach is briefly described in the next paragraphs (Deepak & Deshpande, 2015; Zezula, et al., 2006).

Establishing adequate similarity measurements asks for an ontology of projects that depicts projects in terms of a finite set of attributes and their relevant domain of variation. These attributes are to be assigned measurement scales according to their nature/content and their values per projects constitute the elements of a database which informs project comparison operators. An identity of all values of the attributes for a pair of project indicates project identity, whereas a certain variation of values raises questions pertaining to measuring the similarity of projects in terms of the chosen schema of attributes defining their ontological status. Of course, the similarity is actually an inverse function of attribute value distance (which might be intuitively given, *prima facie*, by the absolute value of the difference between two corresponding attributes).

Once projects are defined as sets of attributes, the differences between attribute values are to be aggregated in a similarity function that usually has the form of a weighted sum of the differences. When comparing a large pool of projects, comparisons are starting form a given project for which a query is performed comparing each project with the starting one. In order to come up with a list of the most similar project to the one for which the query is performed, a result function that picks only the projects exhibiting some values of the similarity function, this result function might establish a value threshold, select closest neighbors or apply similar operators filtering the array of similarity function values.

Hence, the first question that has to be tackled is – which project attributes are relevant for project comparison? A first requirement would be that the attributes are generic enough to be appliable to each and every project in a given organizational setting. The second requirement has to do with obtaining, storing and retrieving relevant information on attribute values, a requirement that covers aspects such as: a set of procedures ensuring that the values of the attributes are consistently determined across all the project in the organization and are documented through project reviews.

Complying with these two basic requirements are the standard attributes related to the project constraints of time, budgets and deliverables/scope. These types of attributes have to do mainly with the internal organizational processes for project delivery leading to what will be termed hereafter *inward similarity*. As shall be further shown inward triple-constraint similarity does not suffice as a measure of project success, especially in terms of project failures and linked or coupled projects, since success is to be assessed differently by different stakeholders leading to variegated types of *outward similarity* from the perspective of various stakeholders.

3. TRIPLE CONSTRAINT COMPARISONS – INWARD SIMILARITY

A precondition for ex-post project comparisons consists in establishing informational homogeneity at the organizational level through procedures ensuring that project reviews capture the same attributes using the same metrics and estimation methods across the entire project network. For example, the duration of the project should include the same methods for estimating and aggregating the duration of activities, especially overlapping ones, and the same methods for assessing time buffers. The cost of resources and the budgeting of activities should also be homogenous in terms of currencies, rates of exchange, fixed cost allocation etc. One of the main reasons for choosing triple constraint attributes as means of determining project similarity is that establishing baseline compliance is already operating in organizations which regularly implement projects, tracking the budget, dead-lines and deliverables does not ask for additional technologies and staff training solely for the purpose of project comparisons.

Once informational homogeneity is ensured, the project reviews should provide adequate information for project comparisons based on triple constraint measurements. The duration and cost values registered by projects allow for direct comparison using standard similarity distances, such as Euclidian distance and cosine similarity. Figure 1 below, suggests these distance measurements: the arrow from project A to project B represents the Euclidian distance, while the dotted vectors stating from the origin and aiming at the two project dots constitute the basis for estimating the cosine similarity based on their divergence angle.

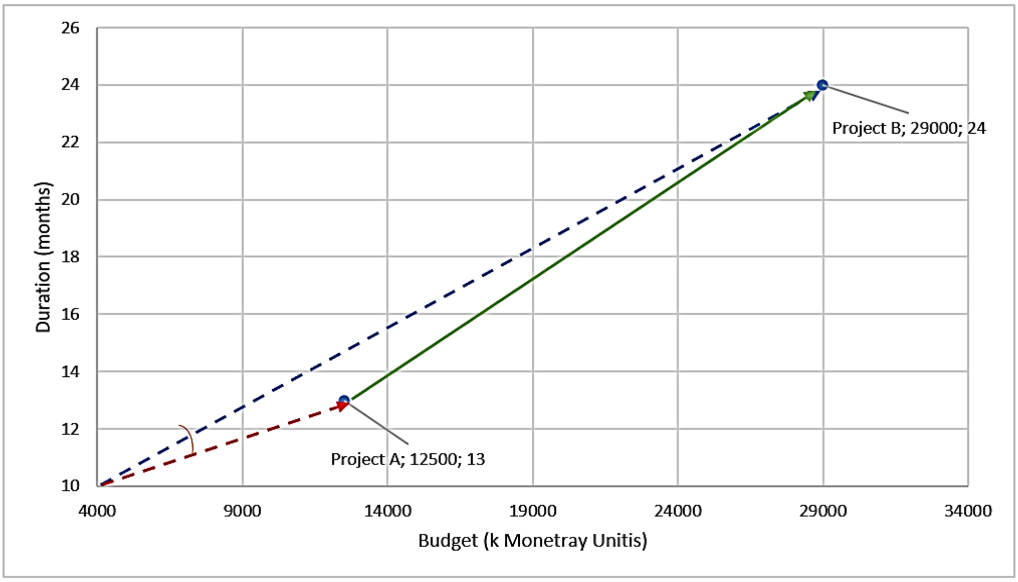


Figure 1. Project distance for attributes of duration and budget

Adding a third dimension depicting project scope attributes would lead to the same similarity measurements but applied to vectors positions in a three-dimensional space (where the Euclidian distance becomes a Minkowski distance for three attribute). As suggested in Figure 2 below.

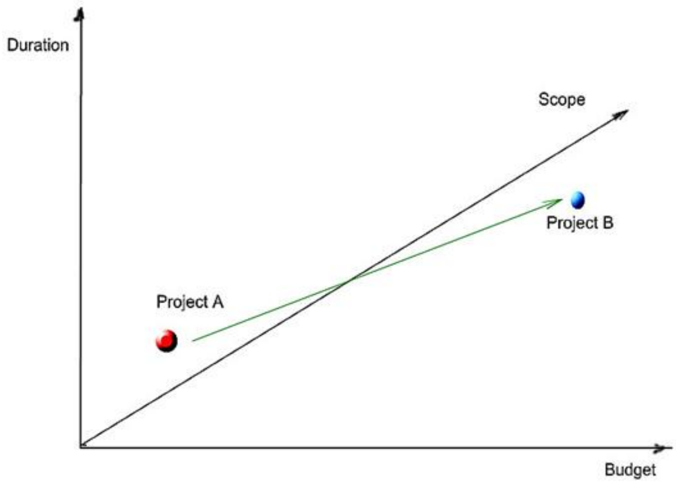


Figure 2. Project distance for attributes of duration, budget and scope

While applying an extra attribute seems rather intuitive, finding an aggregated single value for the project scope is not without difficulties. A first approximation of a single value for the project scope consists in establishing the market value of the deliverables, which can only be achieved if there is an active market for such goods and services or if the contracted beneficiaries already agreed to the final amount that is going to be paid in return for the deliverables.

But if one is dealing with projects that have deliverables which are going to be used inside the organization or for noncommercial purposes such a market approach is unusable. Even when the aforementioned commercial requirements for scope appraisal are met, the market value of the deliverables, while being significant for organizational impact of project success, it still does not give a glimpse into the magnitude of the organizational effort invested in the project implementation.

Another proxy for the effort of attaining the project scope might be given by the number of team members, provided that the skills of the workers are similar and that their cost is deduced form the budget attribute in order to avoid doubling their impact o a similarity operator.

While deliverables are best detailed at the working package level through work breakdown structures (WBS), these documents are relying heavily on verbal descriptions making it almost impossible to use similarity operators, one way to compare projects based on their WBS is proposed in (Trokanfar & Rezadader Azar, 2020) consists in using sematic similarity measurement by natural language processors. Past projects presenting similar goals can be compared in this respect using Project Comparison Technique (Wasielewski, 2010). This approach is adequate for project comparisons in cases where the comparable projects are using project methodologies leaning on predictive project cycles. While certain authors (Trokanfar & Rezadader Azar, 2020) compare projects which are to be implemented through different project cycles (predictive or iterative), the current pursuit deems such comparisons ex-post as inadequate, because in iterative project cycles the project deliverables are more or less contingent on ongoing interaction with third parties (customers, resellers etc.), so even if two projects with iterative cycles present very similar deliverables this has to do more with the context of project delivery rather than with the internal process of output delivery, giving less relevant information on the organizational efforts being comparable among the corresponding projects.

There are certain limits of comparing projects in terms of deliverables, since the deliverables are the “what” of the projects, rather the “how” of the means for project implementation. Supposing two projects have an identical set of deliverables, a great deal of internal dissimilarity is given by a significant variation in budget and deadlines. A diminished budget and/or a shortened final deadline drastically impact the work intensity of various working packages, the abilities required and, hence, the team constituency. But even if two projects are identical or slightly dissimilar in all the triple constraint measurements, but present a different list of successive activities which are based on discretionary or preferential dependencies, this will lead two rather dissimilar working efforts. To complicate things even further, two identical projects in terms of project constraints are accomplished by very dissimilar means if the project management opts for using methods such as critical chain management, fast tracking and teams shared across projects. This latter mentioned threats to adequate project comparisons using triple constraint attributes is pointing to the relative dependencies amongst the classical project constraints themselves.

4. DIVERGENT CASES – PROJECT FAILURE AND PROJECT COLLINEARITY AND COUPLING

While the current paper does not deal with triple constraint compliance/efficiency metrics, the question that is still relevant is: Are projects that fail to comply with some/all requirements of their triple constraint still apt for similarity appraisal?

From a mathematical point of view, it does not make a peculiar difference whether an element of the triplet vector describing the project is off for one of the attributes. For example, if a completed project presented a belated delivery or exceeded some budgetary prescriptions, the correlative positions of the vector will exhibit a higher value than a similar project that complied with its baselines. But this can still constitute a practical failure, when the beneficiary of the project outputs cannot wait on project completion or the organization cannot finance the additional unplanned costs. While mathematically a scope noncompliance is still acceptable (supposing that the market value of the accomplished scope is less than predicted), in practice this usually results in complete project failure to satisfy the needs of a third-party beneficiary. In this case it seems more robust to assign the zero value to the third position of the project vector.

Even this last scenario allows for project comparison through switching the focus from tangible deliverables to the knowledge and skills gained by perennial project team members and to the lessons learned about the factors that lead to project failure. Gaining valuable lessons learned from failed projects is a rigorous application of the dictum ”sometimes you lose, sometimes you learn”.

Leseure and Brookes (2004) make a useful distinction between generic project knowledge (or kernel knowledge) and specific project knowledge (ephemeral knowledge). Kernel knowledge includes: proprietary product, craftsman's know-how, technician's skills and general business skills. Distinguishing generic and project related knowledge is also in view of the distinction made in (Han & Park, 2009) amidst task-support and process knowledge, the former being mostly tacit. Frezee and Kulkarni (2007) identify categories of knowledge capabilities described as knowledge assets: expertise, knowledge documents, lessons learned, policies and procedures and data. The most biographical capability is expertise, the time required for its development makes it a highly valuable asset.

Knowledge transfer between projects leads to rather difficult statistical issue: a requirement in both metric and nonmetric approaches to similarity search is that the similarities between two objects, in our case between two projects, are not to be influenced by a third object. Now then if projects are influenced by transferable knowledge a comparison between them is unfeasible. One such specific case is project coupling.

Project coupling represents a mean to organize relations between projects. Abdel-Hamid (1993) defines the project coupling problem as one of an inter-project coupling mechanism which permits sharing people along two projects. Abdel-Hamid's approach (1993) comes from system dynamics models, relying on mechanistic leveling of workforce rather than the dynamics of knowledge within successive project.

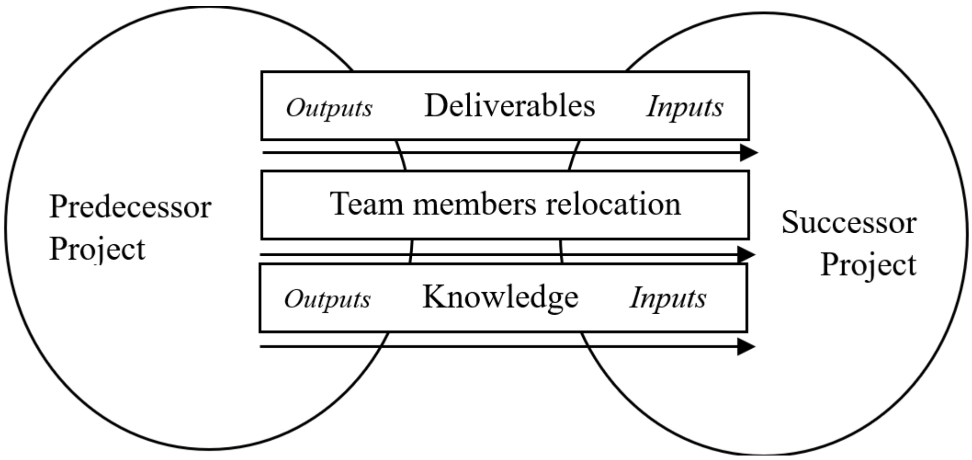


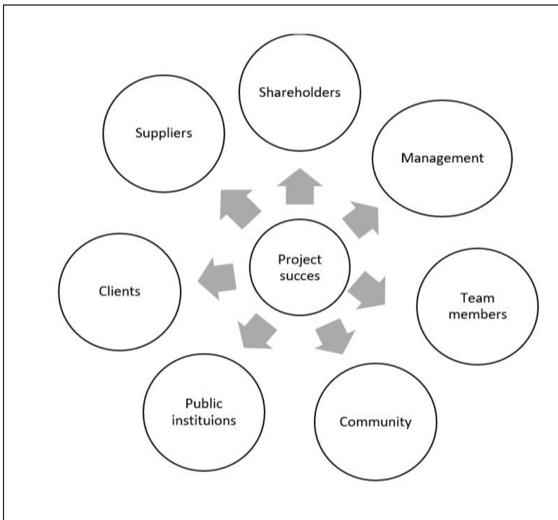
Figure 3. Factors of project collinearity

In practice, project-based organizations exhibit more linkage issues between their projects than just knowledge transfer. New projects almost always benefit from trained people and past deliverables from antecedent projects. This project intertwining transforms the deliverables of a predecessor projects into the inputs of a successor project - a relationship depicted in Figure 3 above. This aspect not only makes ex-post comparison difficult, but most of project attributes become statistically collinear.

5. SUCCES MEASUREMENT SIMILARITIES – OUTWARD SIMILARITY

As it has been noticed establishing project success based on project baselines of time, scope and budget is rather elusive, and the question is what does project success mean for different parties affected by or affecting the projects? Historically the most used indicators for project selection and appraisal were linked to investment theory, indicators such as Return on Investment or Net Present Value, the values of such indicators are relevant if projects are merely portrayed as investment placements. This instance is actually the case for shareholders and some management members, but they represent only a certain category of organizational constituency or stakeholders.

As it has been the case at the strategic, organizational level, where the measurement revolution (Eccles, 1991) witnessed a transition from the primacy of financial indicators to the adequacy of marketing, quality and social/environmental indicators, the project world is also in need of enlarging the array of measures in order to capture what success means for the manifold categories of project stakeholders.



Stakeholder category	***Succes measurements***
Shareholders	▪ Return on investment ▪ Net Present Value
Management	▪ Strategic alignment ▪ Efficiency of resource allocation
Team members	▪ Skills gained ▪ Member perpetuity ▪ Promotion opportunities
Clients	▪ Quality of the outputs ▪ Ongoing collaboration
Suppliers	▪ Delivery on schedule ▪ Predictable requirements
Public institutions	▪ Compliance with industry regulation ▪ Transparent reports
Community	▪ Environmental impact ▪ Social accountability

Figure 4. Succes measurement according to stakeholder categories

Depending on where one might place the organizational borders, labeling these indicators as *outward* is done rather loosely, especially if one incorporates the project team members and the organizational management among the stakeholders. But what is meant here by *outward* has to do with the mechanics of project delivery, rather than the organizational setting.

Figure 4 above offers a synthetic picture exemplifying what the relevant stakeholders might be for a certain project and what success metrics they would aim at. One could regard this proposal of measuring success through the lenses of various stakeholders as an extension of the strategic question posed by Kaplan and Norton (1993) – how would the project appear to the stakeholders if it represents a success. Two aspects have to be delineated: what type of organizational burden does collecting information on outward metrics place on the project effort, and, secondly, how could these indicators be used as attributes for further similarity assessments.

When it comes to the organizational role in collecting information on outward project success, stakeholder management is already in place as part of project drafting and implementation, the project management needs to ensure that instruments such as stakeholder mapping and requirements traceability matrixes also contain rubrics and data on what constitutes project success for each stakeholder category. This approach is also to be harmonized procedurally if a project management office is a structural component at the organizational level.

Secondly, in order to use the indicators for similarity operators, the following steps are to be followed: 1) establish a list of stakeholders that are common for all the projects analyzed; 2) establish the indicators most relevant for each stakeholder category; 3) Assign a suitable scale to quantify the domain of variation for each indicator. Once a vector containing the values of each indicator is obtainable for each project, standard distances for metric or non-metric spaces can be applied (such as Minkowski distance for a n-dimensional space), or filtering the vector positions relevant to certain comparisons can be also applied, and this will be followed by a similarity function and a result function, as described in section 2 above.

One of the limits of the outward measures is that some of the success indicators might overlap in meaning and influence each other in biunivocal manner. In order to avoid this, if possible, either each indicator shall be spelled out in terms of components which are independent of other organizational results, or when this is not possible some specific indicators are to be excluded form the project attributes vector.

6. CONCLUSIONS

This paper aimed at identifying suitable ways for comparing completed projects and assessing their similarity starting from the main insights of similarity search operators. In order to achieve these, the research analyzed the adequacy of the triple constraint measurements of scope, duration and budget as projects attributes usable for project similarity measurements. At this level, while metrics for cost and time are usually available, converting the scope dimension of the project intro a metric attributed has shown to be problematic. The failure to comply with one of the constraints and the interdependence of projects were analyzed as divergent cases where comparison can be mediated in terms of knowledge deliverables.

But since project success cannot be adequately depicted through the lenses of internal organizational effort for project completion, a more robust project comparison has to take into account the measurements for success attributed by the main categories of project shareholders. In the relevant section the success indicators were exemplified and a blueprint for the organizational requirements and mathematical significance of multi-dimensional vectors were given.

One of the limits of this current pursuit has to do with the need to test the suggestions made in term of similarity search on a project data base, and doing this shall provide to opportunity to explore artificial intelligence applications of project similarity search.

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