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Sustainable Decision-Making for Construction Projects

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Abstract

The construction sector is always in need of development. The processes and strategies employed in decision-making also require enhancement. Conventional methods are different from the demands of a rapidly evolving sector. Problems frequently originate from the contractual agreements and provisions agreed upon and accepted by the parties needing to comprehend their viability fully. Both during the endeavor and toward its conclusion, these cause several issues. New methodologies, such as Agile, are emerging to address these challenges, hoping that breaking the project down into smaller components would lower the likelihood of unfavorable results. It works best when the project can be completed in smaller steps, which may only sometimes be possible in construction or other industries. The Agile technique, in which the team works collaboratively to navigate the phases of project development, can be compared to the Project Design-Build delivery method. In actuality, though, even these methods annoy the stakeholders because project terms and conditions frequently alter and give rise to conflicts. Every project is, in actuality, a distinct deliverable that, if improperly managed, is highly brittle. This work proposes a novel modeling tool called Fragile, which extends the Agile approach to assist in delivering the project in the most effective manner possible from the outset, particularly for conditions that may change in the future.

Introduction

Project management is far more challenging in real life than when studying its challenges philosophically. Project management can be simple to navigate and maintain structure if it adheres to PMBOK. However, because the project involves so many different elements—goals and scope, owners and other stakeholders, engineers and architects, contractors and subcontractors, suppliers and vendors, specifications and drawings, contracts and agreements, and much more—the real issues that crop up during the project can be challenging to manage.

The most crucial aspect of the management process is remembering the project's goal, as determined by the parties involved and in whatever capacity. Generally speaking, everyone concerned wants to get the most out of their resources and labor. The owner's goal may be to finish the project as quickly as possible, within budget, and with the highest possible quality; conversely, the goal of a negatively involved party in the same project might be to disrupt it, limit its scope, or address conceptual issues that the owner and other involved parties have defined. Using this strategy, all parties involved can hone their negotiating skills to move the project forward with the least amount of opposition and come to terms and conditions that are widely agreed upon, and that can be included in the contracts. Because of all these complexities, it becomes necessary to analyze projects step by step, which is best explained by breaking them down into smaller, more manageable chunks wherever possible. In IT projects, this project division is considerably more straightforward. The Agile Manifesto, first created to support incremental techniques, can aid this situation. However, breaking the project into smaller deliverables that the owner or other stakeholders can properly examine and understand can be difficult in other sectors. One project type where it may only sometimes be feasible to deliver the project in stages and ensure its seamless conclusion using Agile approaches is construction work.

Methodology

It is necessary to outline the fundamentals of the Agile methodology, assess its applicability, and then suggest a novel way that may be used for projects that would be difficult to manage using Agile to explain the intricacies of the approach fully. Some may suggest that this approach works well when combined with the Agile methodology, serving to supplement it rather than entirely replace it as needed. When applied to software industry projects, the Agile Manifesto is organized around 12 principles, as reported by Beck et al. (2001):

a. The top goal is to satisfy the customer by providing helpful software on time and consistently.

b. Embrace requirements that change, especially toward the end of development. Agile methods leverage change to benefit the client's edge over competitors.

c. Whenever possible, deliver functional software within a few weeks or a few months; however, faster turnaround times are preferred.

d. Throughout the project, developers and business personnel must collaborate every day.

e. Center projects around driven people. Give them the required space and assistance, and believe in their ability to do the work.

f. Face-to-face communication is the most effective and efficient way to share information with a development team.

g. Having functional software is the leading indicator of development.

h. Agile processes support sustainable development. It should be possible for the sponsors, developers, and users to keep up a steady pace indefinitely.

i. Agility is improved by constant attention to technical perfection and superb design.

j. It is imperative to practice simplicity or the skill of maximizing the quantity of work not done.

k. Self-organizing teams produce the finest requirements, architectures, and designs.

l. The group tunes and modifies its behavior in response to periodic reflections on how to increase effectiveness (Beck et al., 2001).

While the Agile Manifesto has been shown to have potential applications in the construction industry, there are still many unanswered problems regarding its broad and practical applicability in other construction project types where incremental and segmental approaches might not be practical. Straçusser, G. (2015) discussed this. Specifically, Straçusser, G. (2015) examined the use of Agile in research, development, and demonstration (RD&D) and talked about a nuclear power plant construction project. It would be reasonable to divide a project this size and complex—which employed 169 companies from 28 states to support RD&D construction, manufacturing, and operations activities—into increments and segments to deliver it to the owner gradually and obtain approval for the next step. During construction, the workforce increased to more than 1,100 workers. However, the results of the management process and the success rate of finishing the project on schedule and within budget might be even higher if there was a chance to examine the potential outcomes of brainstorming before and even during the construction stage to keep it consistent with the Agile Manifesto while keeping in mind that not only the owner needs to be happy and satisfied, but also other involved parties should be happy. Careful management is necessary for any project to succeed because they are all delicate. Risks are inherent in project management and can be carefully assessed. In light of this, the "Fragile" approach that has been suggested uses the well-known—and perhaps underappreciated—power of game-theoretic mathematical modeling to develop tools for application in such analysis, which in turn allows for evaluating potential project outcomes. The application of game-theoretic mathematical modeling has been. It continues to be widespread in various areas, including energy, oil and gas, sustainable infrastructure construction, market behavior analysis, and many more. It can undoubtedly be successfully embraced by the project management community and move the goal of successful project completion one or more steps closer to reality.

The luxury of establishing the interactions between relevant parties in any project is made possible by the flexibility of possibilities in game theory. According to game theory, the participants in the project, or game, are referred to as players. These participants decide on the project. These include suppliers and vendors, engineers and architects, contractors and subcontractors, owners and other stakeholders, and, most crucially, from the standpoint of project or program management, project or program managers. The number of players, simultaneous or sequential decisions—also referred to as moves in the game—random moves, the presence or absence of perfect or complete information, the presence or absence of communication between parties, and cooperative or non-cooperative actions are some of the flexibilities offered by a game-theoretic setup that can be used to define relationships.

Examining a few sample settings with a few participants helps illustrate the suggested strategy in this paper's decision-making process. Assume that the Agile Manifesto debate involves a sizable project. Large projects are frequently provided in different bundles rather than given to a single organization. Large undertakings also bring about numerous changes as they are being realized. From the owner's or stakeholders' standpoint, it can be viewed as bidding and negotiating to select which Contractor to work with moving forward. Selecting which subcontractor to move on with will be difficult for the Contractor to pick if they consider that viewpoint. Selecting the right supplier to work with will be difficult depending on the item being considered from the standpoint of the stakeholder, Contractor, or subcontractor. Finding a point at which all stakeholders will concur on a particular choice can be difficult when considering options or choices for the project from their point of view. These and other situations can all be set up as a game with a few players, where they make decisions simultaneously or

sequentially, with perfect or imperfect information, taking gain and loss into account, and more.

Details – Part 1

The suggested method can be reduced to a fictitious example using the information provided. How should contractors manage their strategies to receive additional orders from the owner and increase their capital if, based on the technology employed, they can offer unit output for the owner and stakeholders? The owner wants to choose the least expensive route. Depending on various factors, other investors and stakeholders in this project may choose an alternative course of action rather than the least expensive one. What plan of action can the contractors follow to ensure that they secure the extra work for the project and maintain the commitment and satisfaction of the stakeholders? Assume three (A, B, and C) distinct technologies can be employed to produce the same result and better examine this scenario. Each has a varied price that each Contractor can provide to the owner and other interested parties. Every Contractor sets their rates for each unit. Options A, B, and C can be delivered for $20.00, $40.00, and $50.00 per unit, respectively. The owner directly demands 40,000.00 units each month for the cheapest price trade, and if two contractors submit identically low bids, the work is divided between them. Given the project's modifications, stakeholders must determine an extra 60,000 work units. One possible tactic contractor could use is to attempt to undercut one another by placing the lowest possible bid. However, taking into account the payoff matrix may make it less prudent. The payoff matrix can be computed, making organizing the situation uncomplicated.

Contractor I will receive 40,000.00 units from the owner if Contractor II charges $40.00 per unit, and there is a 50% chance that this will draw 30,000.00 units from other stakeholders. This will mean that 70,000.00 units will be completed with $20.00 by returning a total of $1,400,000.00. The Contractor II will receive the remaining 30,000 units (or 50% of the 60,000.00 units) for $40.00 per unit, or $1,200,000.00. All option payoffs are shown in thousands of dollars in Table 1. The results of the above sample calculation are shown in Table 1's first column and second row.

Table 1: Payoff Matrix of Contractor I and II accordingly.

	A - $20	B - $40	C - $50
A - $20	$1000, $1000	$1400, $1200	$1400, $1500
B - $40	$1200, $1400	$2000, $2000	$2800, $1500
C - $50	$1500, $1400	$1500, $2800	$2500, $2500

It is clear from this payoff matrix that choosing the $20 option is the least advantageous course of action for any of the contractors, as all other options are seen as preferable by both parties and provide no reason for any of them to call that price. As a result, it can be removed from the matrix to make the payout simpler and the game shorter (Table 2).

Table 2: Contractor I, II Reduced Payoff Matrix.

	B - $40	C - $50
B - $40	$2000, $2000	$2800, $1500
C - $50	$1500, $2800	$2500, $2500

From this, it can be seen that none of the participants favor the $40/$50 option, and they have an incentive to choose otherwise because they know there is a better way for them to make $2,000,000 if they both call for $40. Although there is a better alternative if both ask for $50 per unit, there is a significant danger that the other Contractor will play at $40 per unit and win $2,800,000.00 because this is a simultaneous game. As a result, both would want to stick with the $40 option to earn $2,000,000.00 apiece. It will be rare for contractors, owners, or their representatives to fail to perform these computations to comprehend the actual situation. Using this approach, the project manager may better serve the client at every project step by negotiating more effectively and being aware of the calculated space for a better, less expensive option.

Similarly, a non-cooperative setup can result in a Nash equilibrium in the game. In other cases, the game will be a Stackelberg game where some players have more power than others, acting as leaders and others as followers in the market (Avetisyan et al., 2013, 2014, 2015, 2017, 2018). While the scenario in the example above is undoubtedly oversimplified, it is also typical of initiatives that result in poor conclusions. Note that not all of the extensive analysis conducted for this project is shown here.

Details – Part 2

It is necessary to discuss the significance of the small-scale project prioritizing process to grasp better what else is involved in the suggested approach, which also tackles some of the shortcomings of Agile principles. Correctly evaluating and classifying items for sprints and stages is one of the most crucial things to perform to go forward with the Agile approach. This is not feasible without offering a suitable method for prioritization—the Analytical Hierarchy Process, for instance. The process flow that prioritizes completing the highest priority things first may be inefficient, even with proper trim segment priority configuration. This is the process and actions that can be taken to guarantee that projects will be profitable. The idea would be simple to grasp if one were to think of a traditional issue setup from the field of operations research. Look at a manufacturing challenge involving two items, where the producer can profit $300 per unit from the first product and $200 per unit from the second.

Each product uses resources, and these resources have limits. Two units of resource one are used in product one, and one unit is used in product two. Each of the two goods uses one unit of resource two. In order to maximize profit, the manufacturer must choose which product to make and in what quantity, given the current constraints on resources and the market. Up to 100 units of resource one and 80 units of resource two are available. Product two has no market cap, and a maximum of 40 units of product one may be manufactured. If the manufacturer were to manage this process using the Agile methodology, they would start with the product with the most significant profit margin and work down to the second one. In this case, "cherry picking" is not the wisest course of action. The highest profit that may be anticipated is $16,000.00 if the resources are used to make product one at the rate of 40 units, earning a profit of $12,000.00.

Product two should then be produced at a rate of 20 units,

depending on the remaining resources, earning a profit of $40,000. Since high-priority topics will receive all the attention and resources, this method is comparable to the Agile Manifesto. However, a quick calculation shows that the predicted profit, assuming we produce 20 units of product one and 60 pieces of product two, can be $18,000.00. The $2,000.00 profit differential results from working in parallel and effectively distributing resources rather than starting with the item with the highest priority. This is merely the result of computation; resource availability or use is unaffected. The difference can be inconceivable when considering massive projects that cost millions of dollars. The scheduling savings or any other element of the decision-making process can be analyzed similarly.

Fragile Approach

The following ideas can enhance management and decision-making and perhaps enhance project management and the successful completion of projects when some previously described concepts for the proposed methodology have been established. The established process is graphically represented in Figure 1. However, it is subject to space constraints and intellectual property concerns. The project is broken down into stages, and each stage uses a conceptual analysis of the current State, much like dynamic programming. The project's status is then assessed at each stage from various angles, including earned value management, game-theoretic models, scheduling impacts, resource allocation, and other relevant risks or limits. Tools are created to help with any analysis at every stage. The user, who could be the project/program manager, Contractor, owner, owner's representative, or anybody else who wants to make well-informed decisions for the project, defines the stage. Given the many variables involved, it is doubtful and nearly impossible for the project to be completed optimally and efficiently if any of the Fragile processes in Figure 1 are absent or improperly examined.

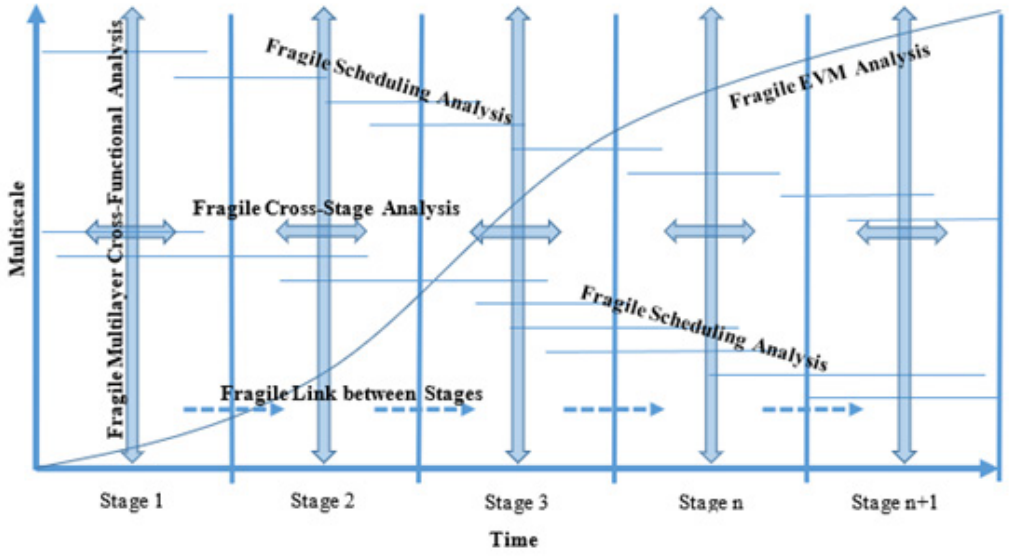

Figure 1: Graphical representation of Fragile Approach.

Conclusion

While Agile can be difficult to implement outside the software and IT industries, Fragile is simple to use in projects and programs across various industries. Every project and program are highly delicate, and they only succeed if they are effectively managed or if problems are identified as soon as feasible. The idea behind the "fragile" method is to carefully assess projects at every level and take appropriate action to manage them ideally rather than merely feasibly. It helps minimize needless risks and creates more advantageous contract conditions. The Fragile Approach can answer whether there is a better method to accomplish tasks while maintaining the highest level of happiness for all parties involved.

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