MULTI-CRITERIA RISK-BASED PROJECT SELECTION USING IPA FRAMEWORKS (INFRASTRUCTURE AND PROJECTS AUTHORITY – THE UK)

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ABSTRACT

The main objective of this article is to propose a method by which projects can be evaluated in terms of their level of risk and execution strategies. For this evaluation, the study proposes using frameworks developed by the British government and linear programming techniques. Such frameworks are proposed for the analysis and validation of large infrastructure projects. However, their applicability can be tested in smaller-scale projects and eventually in projects linked to areas with similar control and conduction characteristics. The method applied in a single project or on a set of projects starts with defining the parameters considering their complexity. Then, the capacity of an organization to execute it is also assessed. After cross-checking complexity versus capacity, the outcome will indicate the best execution strategy or even if the project presents risks that make it infeasible. The IPA (Infrastructure and Projects Authority) Frameworks are applied to assess the input parameters. The complexity is assessed using the DECA framework (Delivery Environment Complexity Analytic). The capacity analysis will follow the PDR-Tools framework (Project Development Routemap tools). The combination addresses a decision-making process through a linear programming model using the logic of the standard problem known as the "Transportation Problem". As a side result, the proposed model will support the execution strategies related to the projects defined as feasible. These strategies are based on the "Align for Success" framework, splitting the strategies into execution modules. In order to test the overall method, this article also brings the results obtained by a simulation. Although the simulation indicates the method works, other perspectives for future development are necessary due to the limited universe of analysis. Nonetheless, the core of development has shown itself relatively promising to what is proposed.

1. INTRODUCTION

Despite the variety of existing frameworks for evaluating, designing, and executing projects, the major decisions and the fulfillment of tasks, and the accomplishment of the deliverables are still in the hands of the project managers. Likewise, there is a considerable range of execution strategies. Therefore, the main objective of this document is to apply commonly adopted project control frameworks and then submit them to a mathematical model that indicates the risk level of a given project at same that facilitates the decisions regarding the best execution strategies. For the present study, the methodology named "Project Initiation Routemap" developed by the British government through the IPA (Infrastructure and Projects Authority) of that country will serve as a standard input base for projects subject to be controlled by government agencies. This set of guidelines and frameworks proposes that the execution, or in a better description, the execution plan should be developed based on the assessment of the project's complexity and the organization's capabilities to execute it. These joined documents form a route map that advocates that the better evaluated the "Complexity" versus "Capacity" relationship, the less costly it will be to execute - in terms of workforce appropriation and costs. According to the British body NAO (National Audit Office), even with the various project management strategies, they continue to find out execution problems mainly related to issues not addressed in the initial stages [1].

None of the researched previous studies presented detailed information about evaluating projects combining the level of risk and execution strategies. Some of these researched papers are listed herein in section 2. This study responds to the following important research question:

Research Question 1: What method would allow projects to be evaluated in terms of their level of risk and execution strategies.

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The innovation of this paper is related to the model for evaluating projects combining the level of risk and execution strategies. The model supports the execution strategies related to the projects defined as feasible. These strategies are based on the "Align for Success" framework, splitting the strategies into execution modules. The paper is structured as follows: Section 2 describes the methodology and previous studies and concepts on PIR (Project Initiation Routemap), DECA (Delivery Environment Complexity Analytic), PDR-tools (Project Development Routemap), "Align for Success" – Execution Strategies, and the mathematical support. Section 3 presents the discussion, and section 4 the conclusion. In the end, the list of references used in this paper is provided.

2. DESCRIPTION

2.1 Methodology

The model development detailed steps are presented in section 3. In a nutshell, the roadmap is a cycle. After analyzing the complexity of an undertaking and the capacity to carry it out, one becomes aware of the gaps to be addressed. After that, the execution plan will absorb the improvements and adjustments to be proposed for the next cycle. According to the IPA, the cyclical dynamics of the "Project Initiation Routemap" works as follows:

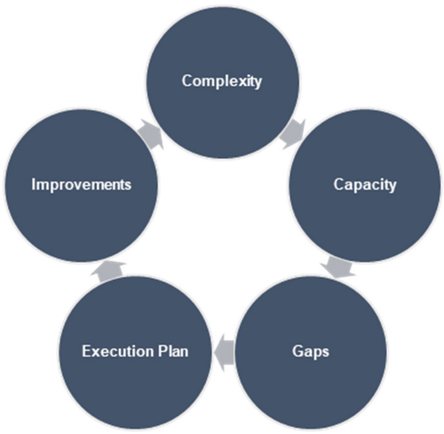

Fig.1 - "Project Initiation Routemap" PIR cycle

The "PIR" cycle has five stages. Two come from the analysis phase (Complexity and Capacity), and the other three are part of the execution strategy (Gaps, Execution Plan, and Improvements). From the second "round" of the cycle, the Execution Plan(s) can absorb the correction of gaps and improvement proposals observed after the first interaction, and so on. The mathematical model of this study proposes which adjustments would be integrated from the "choices" made during the analytical phases. These analytical phases will be treated separately, and the execution phases will be conducted in a single block from the outputs. The "Complexity Analysis" phase will follow the DECA (Delivery Environment Complexity Analytics). DECA is a guide that analyses the complexity of an enterprise considering twelve factors that can define its success or failure. It is a tool developed by the NAO that delivers a high-level view of the challenges according to the agency itself. It also covers the complexity and the risks linked to a project, program, policy, or area of work [2]. For the "Capacity Analysis" phase, a series of checklists are used, which will objectively level the capacities for the four main actors that directly influence the direction of a project through their capabilities. Similar to the complexity factors, these four elements are also classified into three levels according to the results obtained as checklist outputs. It is important to emphasize that this study will not discuss the criteria contained in the checklists, focusing only on their results for classifying available capabilities. The group of these checklists is part of the "PDR-Tools" package, also developed by IPA through the PDR (Project Development Routemap), which, according to the development agency itself, is "a structured and tested methodology to prepare projects for success" [3]. Finally, the execution strategy itself is also segmented into seven modules. In this case, the IPA suggests the individual analysis of each module while carrying out a preliminary diagnosis to identify any issues to be solved even before the execution plan is put into practice. In the end, this approach provides simultaneous analysis of the gaps, execution, and improvements that make up the so-called "Align for Success", a term coined by the government agency itself [4].

The frameworks used in this study are part of a major British government program to improve the delivery of large projects. Composing this package of projects, actions, and initiatives, a route map or a "path to be followed" was developed by the IPA so that the initiation of projects occurs more assertively, which will provide a better-quality delivery, respecting stipulated budgets and deadlines. This leading guide indicates that a path to success must necessarily confront the complexity of a project versus the ability to execute it. It is shown in the diagram below developed by the IPA [5]:

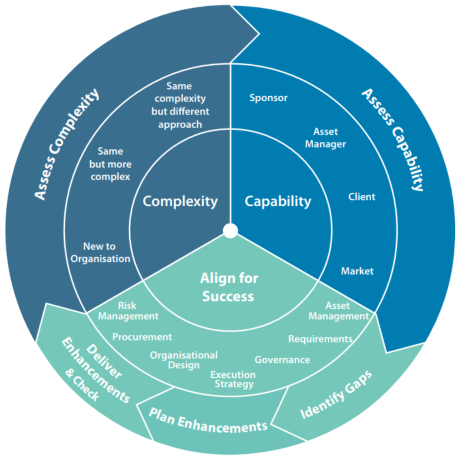

Fig. 1 - "The Project Initiation Routemap"

2.2 PIR (Project Initiation Routemap)

As the IPA defines, the PIR's primary motivation is to achieve more efficient results and deal with the high cost of infrastructure delivery. In the UK public and private sector, customers need to ensure their capacity is aligned with the challenges they face and optimize their approach to engaging their supply chains supply [6]. So broadly speaking, PIR provides support to address most of the common capability gaps that a project's key stakeholders need to bridge, such as governance processes or poor alignment between benefits and requirements. IPA further states that route map tools can be used as self-assessment, peer review, or external assessment [6].

2.3 DECA (Delivery Environment Complexity Analytic)

The NAO developed the DECA (Delivery Environment Complexity Analytics) to provide a high-level view of the challenges, complexities, and risks associated with delivering projects, programs, policies, or the work area. This support framework works together or, more precisely, within the PIR, having as its primary function to describe the project's complexity under consideration [2]. This analysis is performed by dividing the macroscope into twelve factors that have a particular treatment procedure looking for to answer the following questions: 1) Strategic Importance - How significant is the client/project to deliver the sponsoring body's key strategic objectives and/or legal obligations? 2) Stakeholders - Who are the stakeholders, and how much interest/influence/support do they have for the planned objectives? 3) Requirements and Benefits: Are the sponsoring body and delivery team clear about their requirements and what benefits achieving the objectives will bring? 4) Stability: Is there likely to be a change in scope in the future? Is the delivery plan reliable? 5) Financial Impact: How significant is the investment in the client/project to the sponsor/delivery body? 6) Execution Complexity: Are the approaches/technologies planned for use in achieving objectives new to the delivery body and/or untested? 7) Interfaces and Relationships: How many separate bodies/teams are involved in delivery? 8) Disciplines Involved: Are specialist skills necessary to achieve objectives, and are this available in-house? 9) Dependencies: Is anyone else's work dependent on the success of the project/client, and is it dependent on others? 10) Extent of change: Will current working patterns need to change to deliver the expected outcomes and benefits? 11) Capability Background: What experience does the delivery body have in delivering similar objectives or work of a similar complexity? 12) Interconnections: What work has been done to understand the connections between factors affecting the client/project?

As the purpose of this study is not to go deep into each factor, an optimized model is proposed where the items will be individually classified (or valued) from "1" to "9" - as to their complexity level. Thus, the factor that receives the weight "1" is the least complex, and the one that receives the weight "9" is the most complex one.

2.4 PDR-tools (Project Development Routemap)

As part of the package of actions to improve the quality of large-scale project deliveries, IPA has also created a framework for analyzing the capacity of actors that influence the planning, execution, and delivery of these projects. The execution/absorption capacities of each actor - Sponsor, Asset Manager, Customer, and the Market - are evaluated through checklists organized into three categories, which help in a more accurate reading of the characteristics of each one [3]. Like the complexity factors, each member of this section will be leveled in terms of capability to the project using a three-level ruler. Thus, level "1" has limited capacity, level "2" has the medium capacity, and the most capable is assigned level "3".

2.5 "Align for Success" – Execution Strategies

Also, within the same package of actions, the responsible agency allocates special treatment to the project execution phase. Bearing in mind that the complexity and capacity assessments have already been carried out, IPA proposes a specific framework to conduct the activities [4]. This method is called "Align for Success," which mainly has the following purposes: 1 - Gain a greater understanding of complexity capability results; 2 - - Identify and analyze options to better align capacity-complexity; 3 - Develop the plan to achieve the desired results successfully; 4 - Ensure improvement plans during implementation. These purposes are conducted through seven dimensions or areas of execution: Requirements, Governance, Execution Strategy, Organizational Development and Design, Acquisition, Risk and Asset Management [5]. After reading the complexity and capacity, the basic idea is that it is possible to choose the best way to conduct a project by dividing the execution tasks through these modules [6]. By the original framework, each module has its strategy, and in this study, such strategies will be simplified with "Alpha," "Beta" and "Gamma" tags. Furthermore, as mentioned in the introduction to this document, each strategy can assume a particular characteristic in an actual situation, which may be aligned with risk, cost, type of resource, or any other strategic direction required by the business. In short, the combination of possible frameworks and execution outputs can be listed in table form as follows:

Tab. 1 – Possible values to be assumed by the components of the model

Item	**Complexity** (1 to 9)	**Capacity** (1 to 3)	**Execution Module**	**Execution Strategy**
1	Strategic Importance	Sponsor	Requirements	Alfa
2	Stakeholders	Asset Manager	Governance	Beta
3	Requirements and Benefits	Customer	Execution Strategy	Gamma
4	Stability	Market	Organizational Development & Design	
5	Financial Impact		Acquisition	
6	Execution Complexity		Risk	
7	Interfaces		Asset Management	
8	Disciplines			
8	Dependencies			
10	Extent of Change			
11	Organizational Capability			
12	Interconnectedness			

2.6 The Mathematical Support

The mathematical model itself will analyze the results arising from the relationship between Complexity and Capacity. The results obtained will be compared to a ruler, guiding the execution and indicating if a project is unfeasible due to its high risk. The Operational Research (OR) knowledge area through Linear Programming (LP) optimization tool was the chosen basis to support the input process parameters' decisions. The first formal application of the OR techniques was registered during World War II when a combination of scientific-military force produced studies on the war materials optimized utilization [7]. After the war, advanced successful ideas were adopted in the civilian sector as well. Since the development of the simplex algorithm, LP has been used to solve optimization problems in industries as diverse as banking, education, forestry, petroleum, and trucking [8]. The standard problem known as "Transportation Problem" or "Transportation Theory" given to the study of optimal transportation and allocation of resources [9] is the specific model template applied herein. Although this definition, at first sight, is not related to the present study, such a model proves to be flexible for practically any type of situation. The transportation problem is associated with its most immediate application. However, it applies to any model with a similar structure, even if it does not involve transport, giving it remarkable versatility [10]. Thus, in general terms, the relationship between the frameworks and the mathematical model – it means, the methodology - runs as follows:

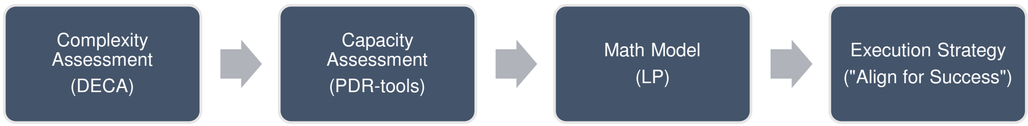

Fig. 2 – Model Processing Flow

3. DISCUSSION

3.1 Model Development

The model proposes that through the input parameters (or factors) arising from the complexity and capacity analyses, the best execution strategy can be chosen for each of the seven modules of the "Align for Success" framework. In this case, each of the seven modules will have three pre-defined execution strategies, according to the nature of the project. The present study will not detail each of these strategies precisely because of the immense variation that they could present in real cases. As a demonstration, each possible execution strategy will receive a kind of tag which, for simulation purposes, are named "Alpha", "Beta" and "Gamma". As mentioned, these may be associated with the approach to execution, such as from the most conservative to the least conservative or even as per the level of importance. "Figure 4" below elucidates the dynamics to be proposed by the modeling:

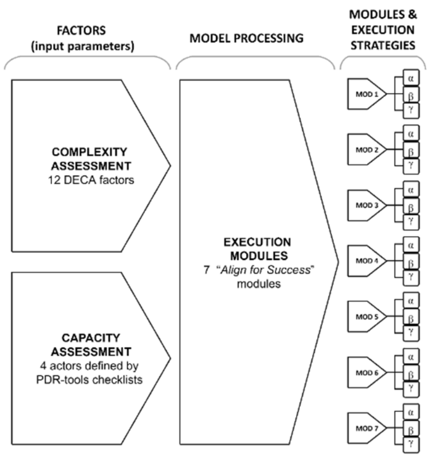

Fig. 3 – Model processing sequence

The model will analyze the problem by first receiving two sets of inputs, referring to Capacity (*Fi*) and Complexity (*Dj*). Then, the valuation (*xi* and *xj*), or assignment of weights, will be performed as described in the previous section when the frameworks are detailed. This process will form a 4x12 matrix which receives four rows referring to the capacity parameters and twelve columns for assigning the complexity parameters. The row-column crossing (*xij*) results from subtracting the complexity minus the capacity, that is, $xj - xi$. The sum of each row (ΣFi) and each column (ΣDj) will be restricted by the results arising from the complexity and capacity analyses (for both *bn*). The representation below describes the idea:

Tab. 2 – Capacity x Complexity Matrix

		COMPLEXITY FACTORS (*Dj*)													
	x_{ij}	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}		
CAPACITY FACTORS (*Fi*)	F_1	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}	x_{110}	x_{111}	x_{112}	ΣF_1	b_1
	F_2	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	x_{27}	x_{28}	x_{29}	x_{210}	x_{211}	x_{212}	ΣF_2	b_2
	F_3	x_{31}	x_{32}	x_{33}	x_{34}	x_{35}	x_{36}	x_{37}	x_{38}	x_{39}	x_{310}	x_{311}	x_{312}	ΣF_3	b_3
	F_4	x_{41}	x_{42}	x_{43}	x_{44}	x_{45}	x_{46}	x_{47}	x_{48}	x_{49}	x_{410}	x_{411}	x_{412}	ΣF_4	b_4
		ΣD_1	ΣD_2	ΣD_3	ΣD_4	ΣD_5	ΣD_6	ΣD_7	ΣD_8	ΣD_9	ΣD_{10}	ΣD_{11}	ΣD_{12}	ΣT	
		b_5	b_6	b_7	b_8	b_9	b_{10}	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}	b_{16}		

The resultant that is, ΣT is precisely the main decision variable that will define the modular execution strategies while indicating whether a project is feasible. This first intrinsic filter automatically brings a summarized list of options – or a short-list. Methods that use weights for multicriteria decisions efficiently select candidates to form a short-list before the macro decision [11].

3.2 Choosing the better Execution Strategies

From the result possibilities for ΣT, the path is given to choose the Alpha, Beta, and Gamma execution strategies (highlighting this nomenclature is fictitious and the real assignment of what it represents depends on the execution strategy of each case, not being the object of this study). However, suppose the result is above a certain value; this will indicate that the project is unfeasible for presenting a complexity incapable of being absorbed by the system's capabilities – it means the project is too risky. If each complexity factor can receive the maximum value of "9" and each capacity factor can receive the maximum value of "3"; it infers that the best scenario is when ΣT is equal to or below the resulting value of this matrix below. That is $\Sigma T = 288$:

Tab. 3 – Best possible ΣT

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	**ΣF**
F_1	6	6	6	6	6	6	6	6	6	6	6	6	**72**
F_2	6	6	6	6	6	6	6	6	6	6	6	6	**72**
F_3	6	6	6	6	6	6	6	6	6	6	6	6	**72**
F_4	6	6	6	6	6	6	6	6	6	6	6	6	**72**
ΣD	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**288**

Likewise, in cases where the maximum complexity "9" and the minimum capacity "1" is assigned, it would make a project unfeasible. That is, the value of $\Sigma T = 384$:

Tab. 4 – Worst possible ΣT

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	ΣF
F_1	8	8	8	8	8	8	8	8	8	8	8	8	**96**
F_2	8	8	8	8	8	8	8	8	8	8	8	8	**96**
F_3	8	8	8	8	8	8	8	8	8	8	8	8	**96**
F_4	8	8	8	8	8	8	8	8	8	8	8	8	**96**
ΣD	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**384**

From these inferences, it can be concluded that a project is feasible if $\Sigma T \leq 384$ and that the proximity of this number can describe whether a project is risky. This conclusion makes it easy to designate a decision ruler by associating it with Alpha, Beta, and Gamma levels. These parameters will be better described in the model representation section.

3.3 Hypotheses

In addition to the classification (or disqualification) hypotheses of a project, the model can propose the following hypotheses: 1) Projects with similar levels of complexity tend to generate similar execution strategies. For example, if a highly complex project generates an Alpha execution strategy, similar projects tend to reach the same conclusion; 2) The valuation of output variables, that is, those assigned to each execution module, tend to have a normal distribution, tending to form a Gaussian. Both hypotheses will be confirmed or refuted as the model is executed (or at least described). The first hypothesis could be evaluated with theoretical analysis, but the second could require the simulation of several random entries using Monte Carlo simulations.

3.4 The Model Principals

In short, the model will describe how to define execution strategies based on input data composed of complexity and capacity parameters via the support of decision-making processes. The complexity parameters will be defined from twelve criteria which will be valued with three possible levels. The capacity, similarly, will be assigned from four parameters equally leveled in three possible values (weights). The relationship between these two groups of parameters will define the project's execution strategy to be adopted. This solution is divided into seven modules. Each module will be assigned a specific strategy related or not directly to the others; those will receive a tag with possible Alpha, Beta, or Gamma values. This relationship will be represented by a variable that will receive an absolute value (from 288 to 384). The more optimized, or in fact, the more minimized this value is, the closer it is to the best project execution solution.

3.5 Variables

The variables are defined by crossing the lines and columns of the matrix formed by the values obtained from the capacity versus complexity relationship, represented by the indicial notation *xij*. Each execution module may also be assigned a variable. However, at this point, this study will be limited to considering a single ΣT decision variable, which will guide the execution plan for each of the seven modules individually.

3.6 Parameters & Input Data

The input data will be precisely the data referring to the complexity and capacity analyses. There will be twelve factors for the first category and four for the second, following the DECA and PDR-Tools frameworks. The two groups will be confronted through matrix distribution, as shown in "Table 2".

3.7 The Model Representation

As mentioned above, the model will be represented using linear programming, which leads us to the following representation in the form of a linear *Z* function, which should be optimized, following the minimization direction [12]:

$$Min\ Z = x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + x_{18} + x_{19} + x_{110} + x_{111} + x_{112} + x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} + x_{28} + x_{29} + x_{210} + x_{211} + x_{212} + x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} + x_{38} + x_{39} + x_{310} + x_{311} + x_{312} + x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} + x_{48} + x_{49} + x_{410} + x_{411} + x_{412}$$

Subject to

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + x_{18} + x_{19} + x_{110} + x_{111} + x_{112} = b_1$$
$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} + x_{28} + x_{29} + x_{210} + x_{211} + x_{212} = b_2$$
$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} + x_{38} + x_{39} + x_{310} + x_{311} + x_{312} = b_3$$
$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} + x_{48} + x_{49} + x_{410} + x_{411} + x_{412} = b_4$$
$$x_{11} + x_{21} + x_{31} + x_{41} = b_5$$
$$x_{12} + x_{22} + x_{32} + x_{42} = b_6$$
$$x_{13} + x_{23} + x_{33} + x_{43} = b_7$$
$$x_{14} + x_{24} + x_{34} + x_{44} = b_8$$
$$x_{15} + x_{25} + x_{35} + x_{45} = b_9$$
$$x_{16} + x_{26} + x_{36} + x_{46} = b_{10}$$
$$x_{17} + x_{27} + x_{37} + x_{47} = b_{11}$$
$$x_{18} + x_{28} + x_{38} + x_{48} = b_{12}$$
$$x_{19} + x_{29} + x_{39} + x_{49} = b_{13}$$
$$x_{110} + x_{210} + x_{310} + x_{410} = b_{14}$$
$$x_{111} + x_{211} + x_{311} + x_{411} = b_{15}$$
$$x_{112} + x_{212} + x_{312} + x_{412} = b_{16}$$
$$x_{ij} \geq 0,\ to\ i = 1, 2, 3, 4\ \ and\ \ j = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 \quad (1)$$

In order to facilitate the understanding and optimize the representation of the model, the index notation was adopted. Assuming that the available capacity in *m* "actors", where *F* is the availability for each *actor i=1, ..., m*. On the other hand, the capacity is confronted in n complexity "factors", where *D* is the complexity "demand" *j=1,..., n*. Furthermore, consider that the sum of the capacity must be equal to the sum of the complexity (i.e., *ΣT*):

$$\sum_{i=1}^{m} F_i = \sum_{j=1}^{n} D_j \quad (2)$$

Considering that the resulting value of the subtraction *Dj - Fi* is the assigned weight of executing something with an available capacity *i* of a given complexity *j* and that the decision variables resulting from this operation are the variables *xij*, the optimized formulation of the model is as follows:

Min

$$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

Subject to

$$\sum_{i=1}^{n} x_{ij} = F_i \qquad i = 1,2, \dots , m$$

$$\sum_{i=1}^{m} x_{ij} = D_j \qquad j = 1,2, \dots , n$$

$$x_{ij} \geq 0, \; to \; i = 1, 2, \dots , m \; \; and \; \; j = 1, 2, \dots , n \tag{3}$$

It remains for the treatment of the model's output, that is, from the output *ΣT* to analyze whether the project is viable and, if so, in which range of execution strategy it would be classified in order to trigger the execution actions for each module. As inferred above, it was observed that the better resulting values would be below 288. At the same time, a value that would make the project unfeasible would be above 384. Therefore, this whole range between 288 and 384 can also form levels of a classification ruler. As mentioned throughout this work, the true meaning of Alpha, Beta, and Gamma strategies are indicative of not exactly representing a specific strategic path. However, by way of illustration, it is defined here that the Alpha strategy is the one that represents the lowest risk. Likewise, Beta is the medium risk, and Gamma represents the high risk. Above that, the project is classified as unfeasible. The illustration below helps to represent this logic:

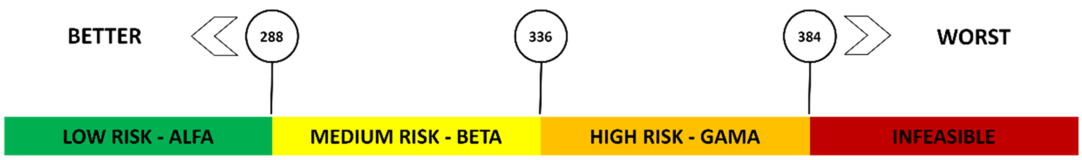

Fig. 4 – Classification ruler based on the values of the variable *ΣT*

3.8 Discussion on the Model

In order to verify the capabilities and the limitation of the proposed model, a simulation was generated. It verifies the proposed logic with the support of the Solver tool, an add-on of the *Excel* software. Input data were obtained by random simulation of values, ranging from 1 to 3 for capacity factors (light orange) and from 1 to 9 for complexity factors (light blue). The variable *xij* is then obtained by subtraction (*Dj-Fi*), and the final configuration of the input data is shown below:

Tab. 5 – Input data (simulated)

	Strategic Importance			Stakeholders			Requirements and Benefits			Stability			Financial Impact			Execution Complexity		
Sponsor	9	2	7	7	2	5	9	2	7	9	2	7	8	2	6	9	2	7
Asset Manager	8	3	5	8	3	5	8	3	5	8	3	5	8	3	5	8	3	5
Customer	7	2	5	7	2	5	8	2	6	6	2	4	7	2	5	8	2	6
Market	8	3	5	8	3	5	8	3	5	8	3	5	8	3	5	8	3	5

	Interfaces			Disciplines			Dependencies			Extent of Change			Organizational Capability			Interconnectedness		
Sponsor	8	2	6	8	2	6	5	2	3	8	2	6	9	2	7	5	2	3
Asset Manager	8	3	5	7	3	4	6	3	3	6	3	3	7	3	4	8	3	5
Customer	8	2	6	7	2	5	9	2	7	5	2	3	6	2	4	2	2	0
Market	8	3	5	8	3	5	8	3	5	8	3	5	8	3	5	8	3	5

In order to facilitate the choice of cells for execution via Solver and also to incorporate the language used in the model description, the table was optimized - inheriting only the results of variables *xij* - as follows:

Tab. 6 - Input data (optimized)

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	ΣF
F_1	7	5	7	7	6	7	6	6	3	6	7	3	**70**
F_2	5	5	5	5	5	5	5	4	3	3	4	5	**54**
F_3	5	5	6	4	5	6	6	5	7	3	4	0	**56**
F_4	5	5	5	5	5	5	5	5	5	5	5	5	**60**
ΣD	**22**	**20**	**23**	**21**	**21**	**23**	**22**	**20**	**18**	**17**	**20**	**13**	ΣT

With the data already prepared, Solver is executed to find the best distribution, obeying the restrictions imposed by the model. Shown below is the software screen with the input data and parameters to be computed:

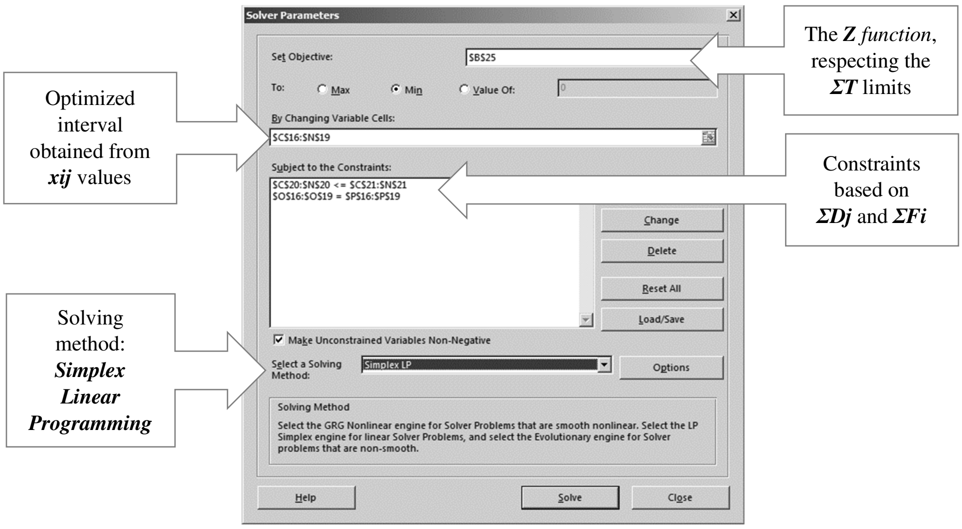

Fig. 5 – Excel (Solver) input screen

After the data input, the model is executed, obtaining the following results:

Tab. 7 – Output values after the Solver processing

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}	ΣF
F_1	0	20	0	0	10	0	22	0	18	0	0	0	**70**
F_2	0	0	0	0	0	19	0	20	0	0	15	0	**54**
F_3	0	0	0	21	0	0	0	0	0	17	5	13	**56**
F_4	22	0	23	0	11	4	0	0	0	0	0	0	**60**
ΣD	**22**	**20**	**23**	**21**	**21**	**23**	**22**	**20**	**18**	**17**	**20**	**13**	**240**

3.9 General Results Discussion

With the optimized data in hands, it is needed to raise some observations: 1) The model proved to be easy to execute, indicating that in a real case, the greatest energy would be spent precisely in obtaining the data - that is - in the actual valuation of the input parameters (factors) simulated in this execution; 2) The distribution of values between rows and columns indicates the best distribution of variables following the constraints and in pursuit of optimization. The assigned values would then indicate the points where the "Stakeholders" should focus the most. For example, when *F4D1* receives a value greater than *F1D1*, *F2D1,* and *F3D1*, this indicates that greater attention should be paid to the capabilities of "Market" (*F4*) regarding the complexity of "Strategic Importance" (*D1*). Likewise, this logic would be applied to the other factors, which can be represented by the table below using the conditional formatting features of the Excel software:

Tab. 8 – Critical items to be observed/treated (red "X")

	Strategic Importance	Stakeholders	Requirements and Benefits	Stability	Financial Impact	Execution Complexity	Interfaces	Disciplines	Dependencies	Extent of Change	Organizational Capability	Interconnectedness
Sponsor	✔ *0*	✖ *20*	✔ *0*	✔ *0*	✖ *10*	✔ *0*	✖ *22*	✔ *0*	✖ *18*	✔ *0*	✔ *0*	✔ *0*
Asset Manager	✔ *0*	✔ *0*	✔ *0*	✔ *0*	✔ *0*	✖ *19*	✔ *0*	✖ *20*	✔ *0*	✔ *0*	✖ *15*	✔ *0*
Customer	✔ *0*	✔ *0*	✔ *0*	✖ *21*	✔ *0*	✔ *0*	✔ *0*	✔ *0*	✔ *0*	✖ *17*	! *5*	✖ *13*
Market	✖ *22*	✔ *0*	✖ *23*	✔ *0*	✖ *11*	✔ *4*	✔ *0*	✔ *0*	✔ *0*	✔ *0*	✔ *0*	✔ *0*

3) In this simulation, the *ΣT* value reached is 240 (green circle), indicating an "Alpha" execution strategy. So, in this specific case, this project would be classified as low risk, as it is already below 288:

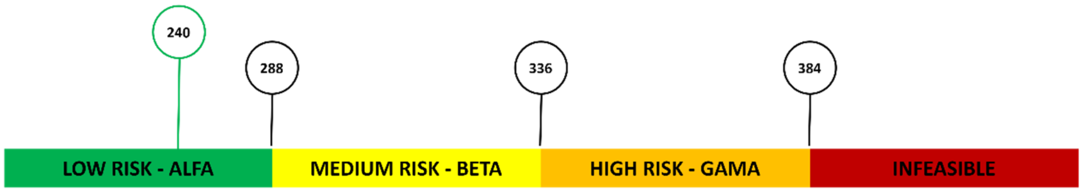

Fig. 7 – Classification ruler with *ΣT = 240*, indicating the Alpha execution strategy

3.10 Observed Limitations

Along with the general observations on the results obtained, limitations were observed that might indicate needs for refinement of the model, as follows: 1) At the end, the macro decision variable *ΣT* returns a value that indicates a single execution strategy for all modules. Thus, an Alpha strategy can be used for "Governance", but it may not be efficient for "Asset Management", for example; 2) The linear function *Z* result is not considered a determining factor for choosing the best execution strategy during the model execution. Eventually, it would be healthy to include this result as a decision-making factor, following the assumptions of the minimization equation itself.

4. CONCLUSION

The target of the study was to propose a method to evaluate projects in terms of their level of risk and execution strategies. The proposed model supports the execution strategies related to the projects defined as feasible. These strategies are based on the "Align for Success" framework, splitting the strategies into execution modules. In order to test the overall method, this article also shows the results obtained by a simulation.

In response to the research question, *"What method would allow projects to be evaluated in terms of their level of risk and execution strategies."* After presenting the frameworks and how they are applied by the British bodies responsible for conducting large projects, a model was generated, which was tested using randomly generated data. This model, supported by the "Transport Problem" pattern, returned the complexity and capacity analyses outputs, was executed using the Excel Solver tool. The results observed demonstrate the model's potential for the type of analysis proposed, even if there is a lack of future development, as described in the observed limitations session. Furthermore, such results showed that the chosen frameworks are suitable for evaluating practically any project since any execution of this nature will present beginning-middle-end characteristics and a scope that must be executed from available resources. The model itself presented a logic tested by inserting random data but within the previously stipulated input parameterizations. The results indicated execution strategies within the identifications predefined by the Alpha, Beta, and Gamma tags. In other words, the model fulfilled the main objective that, from input data, it addressed and supported decision-making actions. However, as mentioned during the model discussion session, while it was possible to observe the solution's potential, a horizon of new opportunities for improvement was also opened. Such opportunities can be developed in future actions by a massive generation of more random values for different cases to identify possible patterns of more effective execution based on the generated history. There is also an imminent need to include mechanisms in the model that differentiate the strategies between the seven execution modules. Even with the gaps mentioned above, the study's preposition reached the objective of providing a model that applies innovative design risk analysis methods.

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