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THE SELECTION OF OIL & GAS PROJECTS CONTRACT STRATEGIES WITH THE ANP: A CASE STUDY

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ABSTRACT

The key objective of this study is to present a model that uses the analytic network process (ANP) to select contract strategies for oil and gas projects and discuss its benefits at the organizational level. The literature review explores the concepts of contract strategies and multicriteria decision-making methods, particularly the ANP. This study conducted an analysis of a working group formed to recommend the most adequate contract strategy for a particularly complex project, explaining its drivers, criteria, and evaluation. Next, an ex post facto analysis was performed, applying the model proposed to the same problem. The results showed that the ANP improved the transparency of the selection process. A sensitivity analysis was conducted, considering the independence of the clusters (group of related elements), which did not change the ranking of the alternatives, leading to a robust solution to the problem. The case study showed that the candidate strategies had multiple, interrelated consequences and generated technical and commercial impacts. This article's main contributions are the proposition of a model for selecting project contract strategies that provides more transparency to the decision making process.

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Keywords: contract strategy; oil & gas projects; multicriteria decision making; analytic network process; ANP

1. INTRODUCTION

In project management, acquisition management covers the processes required for buying or obtaining products, services, or results that do not depend on the project team. This area of knowledge also includes contract management and change control processes, which are essential for developing and managing contracts or purchase orders (PROJECT MANAGEMENT INSTITUTE, 2013).

The contract strategy is an initial step of the contracting process that aims to define the optimum level of risk allocation, delivery, and incentives to the contractor, as well as the degree of integration between the engineering and the construction phases (OFFICE OF GOVERNMENT COMMERCE, 2003).

Briefly, the contract strategy must reflect the organizational policies required to execute and achieve the project's objectives. Moreover, other aspects should be defined, such as responsibilities of parties, payment and contractual conditions, companies' selection, organizational structure for design and construction, and the tendering procedure (PERRY, 1985; WRIGHT, 2002; DHANUSHKODI, 2012).

This article aims at presenting a model to define the contract strategy for oil and gas (O&G) projects by using the analytic network process (ANP) (SAATY, 2008; SAATY, 2009). Since this process usually involves multiple and conflicting criteria, the use of a multicriteria decision making (MCDM) method is adequate. Thus, based on a case study, this article shows the benefits of using the ANP.

An ex post facto analysis of a working group's (WG's) results was performed in this research. This group was created to recommend the best contract strategy for a complex O&G project, so the managers could make an informed decision. Thus, the contract strategies described in this article are appropriate for huge industrial and construction projects, such as those in the O&G industry.

Since the contract strategy has the power to influence the project schedule and cost (BOWER, 2003), it is crucial that it represents the most suitable commitment among the different evaluated criteria, contributing to the project's success and the achievement of its goals. When an MCDM, such as the ANP, is used, the reasons for

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recommending an alternative become clearer, leading to a more transparent decision and thus adding value to the organization.

The literature review discusses the concepts of contract strategies and the MCDM, particularly the ANP. The articles about a contract strategy describe what it is, its main aspects, and when each is applicable. Nonetheless, no research demonstrating how organizations choose their contract strategies has been found. Therefore, this study's relevance lies not only in the proposed model but also in the discussion on the analysis conducted by the WG, which represents how an O&G company chooses each of its projects' contract strategy. Some state-of-the-art articles on the ANP are mentioned, indicating some of its applications. This discussion highlights the originality of the study since no research that relates projects' contract strategies to MCDM methods has been found.

2. CONTRACT STRATEGIES

Contracts are formal agreements between two or more parties in which conditions for performing a certain job are established (DHANUSHKODI, 2012). Some of the contract objectives are defining the work to be done, determining the amount to be paid and the payment method, as well as establishing the responsibilities of the parties (DHANUSHKODI, 2012).

In turn, the contract strategy determines the level of integration across the different stages of a project (from design to operation). The aim is to attain the project's goals in terms of delivery, incentives, risk allocation, and so on (OFFICE OF GOVERNMENT COMMERCE, 2003).

According to Perry (1985), the four decisions associated with choosing the contract strategy are the project's characteristics, the organizational structure for design and construction, the type of contract, and the tendering procedure. These four aspects are usually correlated, resulting in interactive decision processes. The project characteristics (scope, quality, cost, etc.) are inputs to the contract strategy and should be defined prior its selection.

As for the organizational structure, an appropriate selection of the work size and scope should be made, as well as the allocation of duties to the client and the contractor. The main organizational structures used in projects are turnkey,

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separation between design and implementation, build-own-operate-transfer (BOOT), and management agreements (WRIGHT, 2002; DHANUSHKODI, 2012).

In turnkey contracts, one contractor is responsible for all the stages of the project, from design to completion. Usually, they are lump-sum contracts, that is, the price is known and fixed from the beginning. This structure is widely used in process industries, such as the chemical industry, the O&G sector, and so on. A slight variation of the turnkey type is the engineering, procurement, and construction (EPC) structure. The difference between EPC and turnkey is that the first has distinct stages (engineering, procurement, and construction), and each may have a specific payment method (PERRY, 1985; WRIGHT, 2002).

However, the client may opt to divide the stages of design and implementation by assigning them to two different companies or even create the design with its own resources. A third possibility is the BOOT contract, which is more commonly used in public-private partnerships or concessions. In this case, the contractor builds and operates the asset, owning its property while the concession contract lasts; subsequently, the property returns to the client (WRIGHT, 2002).

There are also management agreements in which a client hires a company to manage the project. However, the project's execution is usually subdivided into smaller contracts. Typically, the party responsible for the management plays a collaborative role with the client. These contracts are normally implemented when the client lacks the resources to manage the project or when flexibility is necessary. This model allows an easier negotiation of scope alterations and some overlapping between the stages of design and construction (PERRY, 1985; WRIGHT, 2002).

Another aspect of contract strategies is the type of contract, which varies according to the payment method. Contracts can be divided into two main categories, based on price and based on cost. Contracts based on price can set the lump sum or the unit price. In lump sums, contractors stipulate fixed prices to perform the services. In unit price contracts, a price per measuring unit is established for each item of service.

In contrast, contracts based on cost can consist of reimbursable cost or the target cost. Regarding the first type, the client reimburses the contractor for the cost of goods and services, plus a profit margin. As for the second type, the deviations

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from the previously defined and established target cost are shared between the client and the contractor. Each type of contract has its advantages and disadvantages. The choice of the most suitable type depends on the nature of the parties involved, the available resources for the contract management, as well as incentive alignment, responsibility delegation, and risk allocation (PERRY, 1985; WRIGHT, 2002).

On one hand, contracts based on price require strong discipline from the contractor. The contractor must be efficient in handing over the deliverables because it bears the financial risk. Anyway, the fixed price serves as an incentive for cost reduction since any saved amount represents an increase in the contractor's profit margin.

On the other hand, cost-reimbursable contracts do not entail any financial risk for the contractor, requiring less discipline in expenditure control. Regarding target cost contracts, the financial risk is shared between the parties. In this model, the client also reimburses the contractor for the costs incurred by the latter; both agree on the possible value of the service cost (target cost). This value is defined as the target on which a contractual mechanism of cost sharing is established. In other words, the difference between the target cost and the final cost (whether positive or negative) is shared between the parties according to the proportion agreed on the contract.

Finally, as for the tendering procedure, a few definitions must be established: the parties who will be responsible for design and construction, the need for prequalified suppliers, and the appropriate contractual conditions. There are several procedures for selecting proposals. The first pertains to the competitive process (bidding). The second involves a two-stage process, where the initial proposal is based on the conceptual (basic) project according to the plan, and the final proposal is based on the cost and the price indicated in the initial proposal. The third entails direct negotiation, usually involving up to three companies. The fourth is contracting for several similar projects, based on the initial proposal. The fifth involves serial contracting, in which a proposal for a contract package is presented. The sixth refers to overall contracting, in which the contracted object and the contract term are defined, but the amount of work is not noted (WRIGHT, 2002).

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Given its importance, some strategic decisions about the contracting process must be carefully evaluated, for instance, involving bid document preparation, bid proposal preparation, and proposal analysis.

The client must evaluate the potential suppliers' commitment before beginning the bidding process to increase the probability of participating companies. The client should also assess competitiveness, whether the risk allocation on the contract is appropriate to the size and the characteristics of potential bidders, the deadline for the proposals' elaboration, as well as potential clarifications throughout the process.

Regarding the proposal analysis, it should be determined whether there is a need for prequalified suppliers and the evaluation criteria. Several criteria are used to choose the contractor, including expertise, technical or managing ability, use of the supplier's specific resources, capacity to manage certain risks, development of a future supplier base, or hiring a well-known supplier, whose competence has been attested.

The supplier selection may occur before the bidding process—the invitation is restricted to a group of companies—or an open competition may be implemented, where companies should demonstrate that they meet the qualification requirements throughout the tendering procedure (WRIGHT, 2002).

As for proposal analysis and classification, it is necessary to elaborate on a detailed estimation to compare the proposals. In the documentation sent to the bidders, it is also common to specify the criteria for determining the winner although it is not mandatory. These criteria may vary from the best price to the evaluation of qualitative factors (PERRY, 1985).

3. MULTICRITERIA DECISION MAKING AND THE ANALYTIC NETWORK PROCESS METHOD

Decisions are part of everyone's daily life. At times, alternatives and their consequences are clear and intuitive, making the decision easy and fast. However, it is usual to face situations in which the problem itself is not straightforward, let alone the alternatives' consequences. In these cases, it is necessary to undertake an in-depth analysis of the results that a client wishes to achieve (objectives) and what is or is not acceptable (preferences and restrictions) so that viable alternatives are established and compared. This thorough and structured analysis is the basis for

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MCDM, which involves multiple and conflicting objectives (BELTON; STEWART, 2002).

According to Belton and Stewart (2002), MCDM can be divided into three distinct stages: problem identification and structuring, model construction, and development of action plans. The first stage consists of gathering the parties interested in the problem—decision makers, technicians, and facilitators—to promote a mutual understanding of it, the decisions to be made, and the criteria and the assessments used for deliberation. Subsequently, a model is elaborated—representing the decision makers' preferences in terms of objectives, criteria, and tradeoffs—which allows the comparison of different alternatives, instilling transparency in the process. Finally, action plans are developed and associated with the chosen alternative, destined to solve the initial problem.

Typically, problems addressed by multicriteria analysis can be classified into six categories: choice, classification, ordination, description, design, and portfolio (BELTON; STEWART, 2002).

In the analytic hierarchy process (AHP), a particular case of ANP, relative measures of tangible and intangible criteria are calculated through the construction of the criteria hierarchy where the alternatives are placed at the lowest level. An element of the hierarchy can only influence elements at the next higher level.

After the hierarchy elaboration, pairwise comparisons are made among the different elements of the same level. The pairwise comparison uses Saaty's (1980) fundamental scale as a reference, presented in Table 1. The resulting evaluations of these comparisons are arranged in a reciprocal and positive square matrix.

Table 1: Fundamental scale of AHP evaluations

Importance Strength	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, and 8	Intermediary values
Reciprocal values above	If the comparison between criterion *i* and criterion *j* is one of the values above, then the comparison between criterion *j* and criterion *i* will be reciprocal.

Source: SAATY, (1980)

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From this matrix, it is possible to obtain an eigenvalue of priorities that represents each criterion's relative priority. According to Saaty (1980), the eigenvector of priorities *w* must be calculated, becoming reciprocal to the sum of the elements of each column and dividing it by the sum of the reciprocals of each column. Next, the consistency ratio (CR) is calculated, according to Equations (1), (2), and (3).

$$\lambda_{max} = \frac{1}{n}\sum_{1}^{n}\frac{[Aw]_i}{w_i} \quad (1)$$

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad (2)$$

$$CR = \frac{CI}{RI} \quad (3)$$

In Equations (1), (2), and (3), *n* denotes the number of criteria, *A* refers to the matrix of comparisons by pairs, λ_{max} signifies the highest eigenvalue of matrix *A*, *CI* represents the consistency index, and *RI* pertains to the random index.

Inconsistency is admitted to a certain extent since the AHP is not based on the transitivity principle. For this reason, the determination of the CR is fundamental. Saaty (1980) presents the values of the *RI* to some values of *n*, calculated by the National Laboratory of Oak Ridge. Ideally, the CR should be zero, but an inconsistency of up to 10% may be tolerated. In case the percentage is over 10%, the pairwise comparisons should be reviewed (SAATY, 1980).

Finally, after the hierarchy construction, the acquisition of relative weights through the pairwise comparison and the verification of model consistency, the overall value of each alternative can be calculated by the sum of grades in each criterion multiplied by the relative weight in each criterion (SAATY, 1980).

The ANP is a generalization of the AHP, in which the problems of the decision are represented through networks composed of elements in clusters that are interconnected internally or externally. There may be an interaction or a dependency among those elements. This method uses pairwise comparisons and a fundamental scale, such as the AHP (SAATY, 1980; SAATY, 2009).

In the real world, almost everything is interdependent to a higher or a lower degree. This means that the ANP structure is more associated with reality. Nonetheless, the difficulties with feedback—inherently cyclical—exceed the

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problem's structuring, which makes the calculation of priorities in the ANP more complex, requiring much effort to justify the results' validity (SAATY, 2009).

The ANP uses the concept of the supermatrix to synthesize the impact of the elements on each other. Consider a network with *N* clusters (*CN*), in which each cluster *i* contains n_i elements (e_i). Figure 1 represents the supermatrix (*W*) resulting from the model, which synthesizes the relative influence of one element from the left on one element from the top, in terms of a certain control criterion. Each element of the supermatrix is a submatrix (W_{ij}), whose columns represent the relative influences of the elements in cluster C_i on each element in cluster C_j, in terms of a certain control criterion.

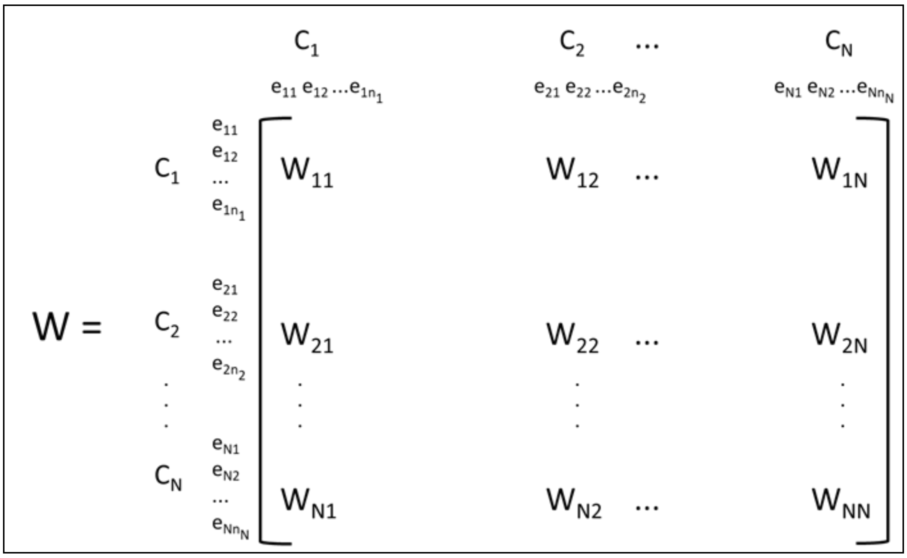

Figure 1: Graphic representation of the supermatrix generated in the ANP
Source: SAATY (2008).

The pairwise comparisons of the clusters' elements result in an unbalanced supermatrix. The clusters' matrix is then obtained from pairwise comparisons among the clusters. Next, the balanced supermatrix is obtained by multiplying each element (C_{ij}) of the clusters' matrix by the corresponding elements from the unbalanced matrix (W_{ij}). This operation ensures that the balanced supermatrix is stochastic, that is, the sum of the elements of each column is one (SAATY, 2008).

Subsequently, the limit supermatrix is calculated by raising the balanced supermatrix to the umpteenth power to obtain convergence in the values. The previous balancing stage guarantees the limit supermatrix convergence. The last stage involves a sensitivity analysis to verify the results of the variations in the assessments.

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To identify the state-of-the-art articles on the ANP and some relevant applications in organizations, two databases were searched: Ebsco and Science Direct. The key phrase used was “analytic network process,” which generated over 250 articles (combining both databases). The results were filtered by relevance, and nine were chosen among the first fifty results after scanning the abstracts and identifying relevant application to the organizations.

The articles’ topics ranged from the stakeholders’ influence on project management to the assessment of wastewater treatment alternatives, including logistics site selection and international contractor rating, among others. As mentioned, no research relating contract strategy to MCDM was found. (For further information on the applications, refer to HSU et al., 2012; ERGU et al., 2014; ÖLÇER; AKYOL, 2014; BOATENG et al., 2015; NEUMÜLLER et al., 2015; SENANTE et al., 2015; OCAMPO; SEVA, 2016; PEKER et al., 2016; BELTRAN et al., 2017.)

4. METHODOLOGY

This study employed both a qualitative and an analytical approach. The research method used was the case study, which was carried out through document analysis and focused on the participants’ perspectives on a certain problem, not on the researchers’ or the literature’s interpretation (STAKE, 1995; CRESWELL, 2010).

The ANP was chosen for several reasons. These included the network approach, which allowed the modeling of problems where many elements influenced one another and entailed interactions among the decision makers for the model structuring, enabling adaptations to the problems. Lastly, Saaty’s (1980) fundamental scale was also useful because the existing verbal correspondence was adequate to assess the elements involved in the contract strategy definition.

This section shows the proposed network to define the project’s contract strategy using the ANP. This model is the outcome of the literature review and the authors’ experience in this subject. It is used in the case study presented in the following section, with the aid of the Super Decisions software (CREATIVE DECISIONS FOUNDATION, unknown date).

The created model has six clusters: objective, project characteristics, organizational structure, contract types, tendering procedure, and alternatives. The

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control criterion in this network is the organization responsible for contracting. Specifically, all the comparisons among different elements and clusters are about the influence of one over the other in the organization. Figure 2 presents the clusters and the elements of the proposed network.

In cluster 2, “Project characteristics,” the elements’ cost, time, and performance represent the project’s approved budget, the deadline for starting the operations, and the scope and quality demands, respectively.

In cluster 3, “Organizational structure,” the ease in identifying the responsible party represents the time and the necessary resources to identify the company responsible for failures or flaws. Flexibility is associated with the contractual tolerance to changes, which indicates client favorability when negotiating scope alterations. Control refers to the client’s need or desire to control the design or the execution activities.

The use of internal resources is related to the availability and the extension of allocating internal resources for the project activities. The number of interfaces is about dividing the project scope into contract packages. Competitiveness is associated with the number of companies that are able to execute the contract’s scope.

Cluster 4, “Contract types,” comprises six elements. The contractor’s discipline pertains to the level of commitment expected from this company in terms of fulfilling the contract. Risk transfer refers to the client’s tendency to pass on the project’s main risks to the contractor, either due to the inability to manage these risks or to strategic decisions. Established price represents the client’s inclination to sign a contract, knowing its price.

Experience in contract management denotes the level of experience of the team responsible for managing the contract, which may be relevant for contracts with a high competition among bidders. Experience in project management measures the client’s level of knowledge on this matter, especially the experience in managing activities executed by third parties. Incentives are associated with the intention of inserting elements in the contract that represent motivations for the contractor to finish the project or meet a certain deadline.

Cluster 5, "Tendering procedure," has only two elements: the contractor's prequalification and the evaluation procedure. The first refers to the need to limit the participation in the tendering procedure to the companies selected based on specific requirements. The second represents the way that these proposals will be classified (best price, best technique, the combination of these two criteria, or others) and defines how this analysis will be conducted.

Lastly, cluster 6, "Alternatives," presents the possible options for the contract strategy. The traditional possibilities for organizational structures in different contract strategies are included in this cluster (turnkey, EPC, two-stage contracting, management, BOOT, design, build and operate [DBO], and design, build, finance, and operate [DBFO]), instead of the alternatives themselves. Nevertheless, the specific alternatives are presented in the case study.

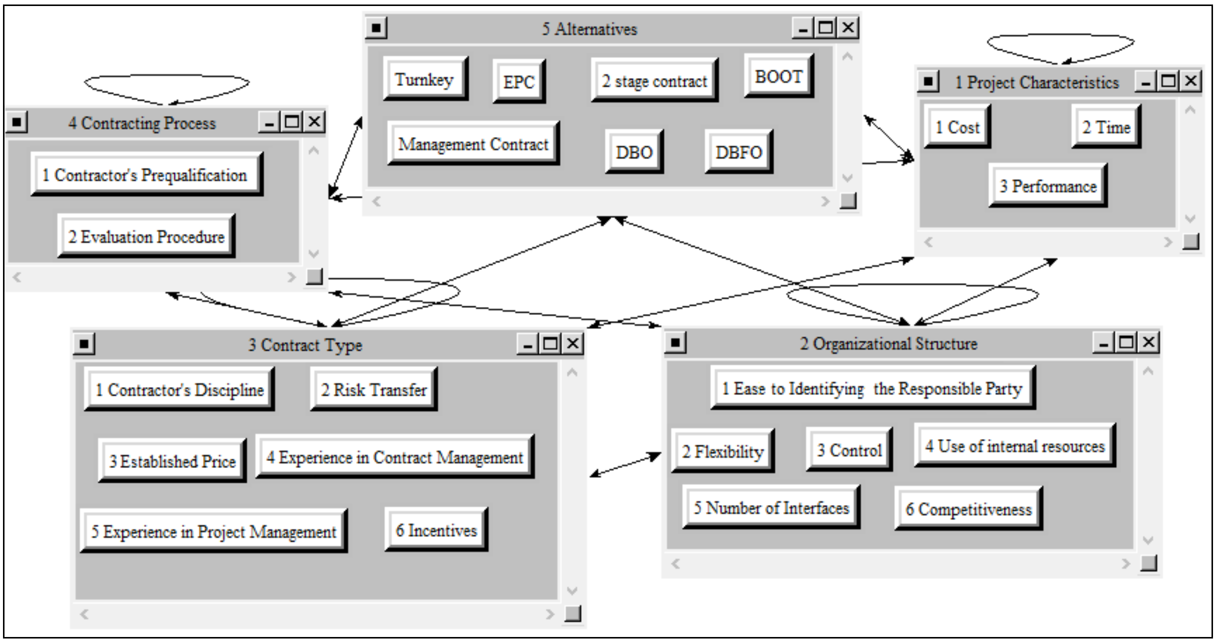

Figure 2: Representation of the network proposed using the Super Decisions software

5. CASE STUDY AND DISCUSSION OF RESULTS

The case study involves the analysis of the process of choosing the contract strategy for a project by a Brazilian O&G company. It is important to highlight the times faced by the O&G companies upon seeing the price of oil plummet from more than US$100 a barrel in 2014 to US$70 a barrel in 2018, with registered prices lower than US$30 a barrel some time in 2016 (U.S. ENERGY INFORMATION ADMINISTRATION, 2018).

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This dramatic slump in the oil price required the companies' revision of their projects' portfolios (among other actions), suiting these to the new reality and preparing for a long period of low oil prices.

The definition of the contract strategy was developed in this environment of investment revision. For this purpose, a WG was created to recommend the best contract strategy for a project to the decision makers. According to the document that formally created the group, its responsibility was to "analyze the supply record, future demands and suppliers, as well as develop actions and levers for value generation, considering maximum adherence to the business plan, minimum consumption obligation, local content, procurement alternatives, risk evaluation and other actions/levers for value generation." The document also highlighted the urgency of reducing the investment in the current business plan and the need to study alternatives that considered partnerships and better tax solutions, reinforcing cost as a fundamental variable in the contract strategy.

A previous WG had been created—with some members also belonging to the second WG—and its work had already been concluded and evaluated two alternatives, A and B, for the contract strategy of the given project. In alternative A, the asset belonged to the client, whereas in the other alternative, the asset belonged to the contractor. Alternative B was a leasing. However, alternative A was discarded in this second WG for involving a considerable disbursement over a short period, which was not included in the company's business plan at that time. Alternative B was also eliminated for impacting the company's leverage.

Therefore, after evaluating the project and the restrictions, this second team dedicated itself to describing and analyzing two other alternatives, C and D. They represented a provision of a service contract and a rent contract, respectively.

On one hand, alternative C was considered the base case and represented the status quo. The company used to work with it, so there was an advantage in contract management compared with alternative D, the rent contract. Nonetheless, alternative C incurred a much higher cost than alternative D did. Alternative C's cost was also higher compared with those of alternatives A and B. However, disbursements would occur some years ahead and did not affect the company's debt, which was why alternative C was not discarded.

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On the other hand, alternative D was new to the company. Therefore, the decision makers requested an in-depth risk evaluation of this strategy when the support of experts from the legal, tax, and risk departments was needed.

On another front, the second WG contacted potential suppliers to map the market's interest in the project and its preferences. It would thus be possible to compare the two alternatives in terms of contract attractiveness/competitiveness.

Furthermore, the difference between the contract models (service provision and rent) imposed operational differences. The reason was that the service provision model entailed the definition of service-level agreements (SLAs) with the establishment of the main conditions for the service provided. Nevertheless, since it was a long-term contract (more than 10 years), there was considerable uncertainty about what this operating model would become at the end of the contract. Many disruptive applications could arise and would not be covered in the original SLA. Thus, alternative C involved less operational flexibility compared with alternative D. In the latter, the client was responsible for controlling the asset, without the need for SLAs.

The project schedule was another aspect evaluated by the group. In this case, the rent implied a deadline extension (one month more than that of the service provision) since it would be necessary to elaborate new and specific contractual documentation.

After observing the above-mentioned aspects, the following criteria were established to evaluate the most suitable contract strategy: legal risks, updated expenditure, attractiveness, number of contracts, operational flexibility, and project completion.

A color-code table (Table 2) was used to illustrate the comparison between the alternatives, indicating each one's favorability. The colors green, red, and yellow indicated high, low, and medium favorability, respectively. Some information in Table 2 was slightly altered to maintain confidentiality. Based on these pieces of information, the WG recommended alternative D, mainly because of the significant difference in cost. The alternatives had no disparities in the other criteria.

The evaluation on the WG's methodology and conclusions indicated that although there were six evaluated criteria, the cost had the most considerable

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influence. Furthermore, the fact that the two alternatives showed similar results when evaluated in the other criteria reduced these criteria's importance relative to the cost. Despite the group's coherent conclusion, the tool it used did not point directly to the recommended alternative.

Table 2: Representation of the color-code table elaborated by the WG

Criteria	Service provision	Rent
Legal risks	No risk	Fine equivalent to 6.5% of the cost
Cost	151%	100%
Attractiveness	9 interested companies	6 interested companies
Contracts	1 bidding (2 contracts)	3 biddings (5 contracts, 2 of which must be open for a new bidding every 5 years)
Operational flexibility	Need for contractual negotiation in case of SLA deviation	Easy to upgrade and increase capacity, besides synergy with existing assets
Project completion	28 months	29 months

Next, the same problem was assessed with the model proposed in this article. It showed that the transparency stemming from the use of a system that would aid decision making could help the group reach its conclusions, as well as promote third-party visualization and understanding of the decision process. To verify the criteria's applicability, the authors identified (from the available documents) the basis for associating the criteria with each cluster, as well as the identified alternatives (C and D). Table 3 describes the main characteristics of the four mentioned alternatives, in conjunction with the pertinent alternatives used in the case study.

Figure 3 illustrates the model applied in the case study. The authors relied on their own experience to make pairwise comparisons between the criteria and the alternatives. Relying on the authors' expertise limited the analysis since it could not be implied that the WG would produce the same comparisons. In any case, this approach is still valid when showing the benefits of its use.

Table 3: Description of alternatives in the case study

Alternatives	Description
A: Own the asset	Standard turnkey contract. This alternative was rejected because it needed investments that were not included in the company's business plan.
B: Leasing	In this model, the contractor is the asset's owner and responsible for its construction and maintenance. It is similar to the build, own, and operate (BOO) model, but the client controls the operation. This alternative was eliminated for affecting the company's leverage.
C: Service provision contract	This model resembles the design, build, finance, and operate (DBFO) type. A multi-user model, it has well-defined and strict service-level agreements (SLAs).

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D: Rent contract	In this model, the contractor is the asset's owner and responsible for its construction and maintenance, similar to leasing. However, only a part of the constructed asset is rented to the client, who is responsible for operating this rented portion.

The influence between the elements and the pairwise comparisons are valid only when done by experts with recognized experience and competence in the subject. Ideally, the decision-making agents should have experience and technical knowledge about the subject matter. The more experienced the group is, the better and more trustworthy the results will be.

After defining the dependence between the elements, a pairwise comparison between the elements and the clusters was made. It was necessary to make 286 pairwise comparisons due to the number of network elements and their dependence. All consistency indexes of the submatrices were all below 10%, according to Saaty's (2008) recommendation. The unbalanced, balanced, and limit supermatrices are listed in Tables 4, 5, and 6, respectively.

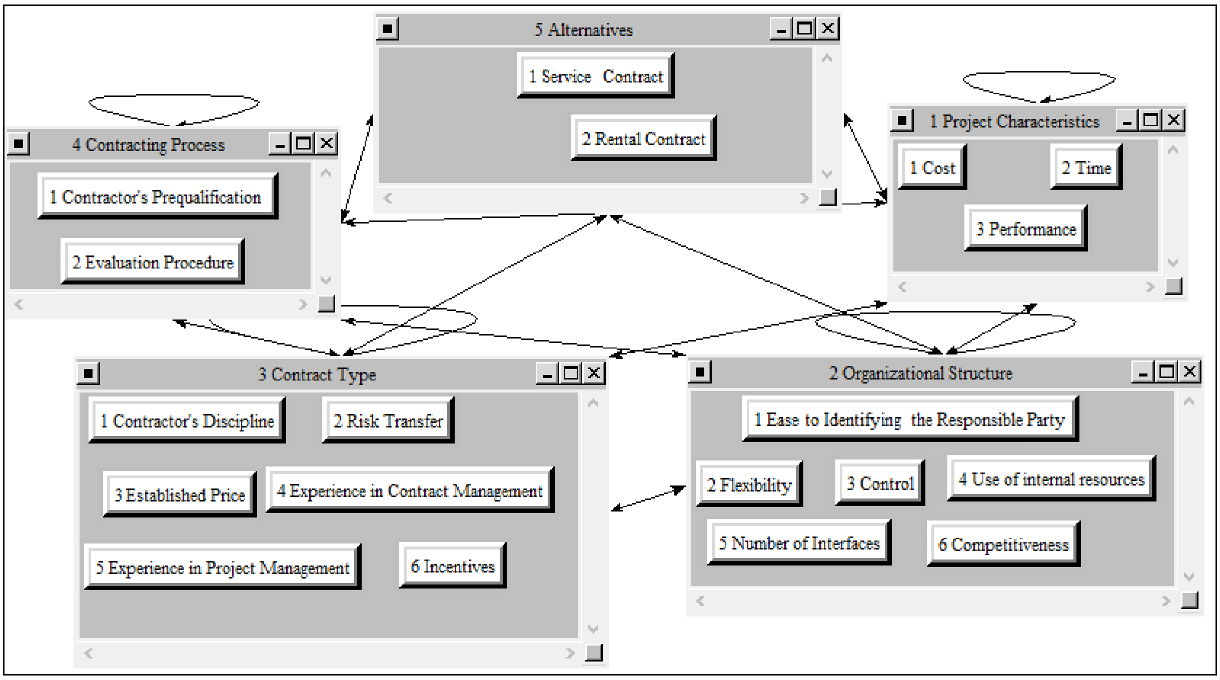

Figure 3: Representation of the contract strategy selection model using the Super Decisions software with the ANP applied in the case study

In Table 4, the last two columns of the unbalanced supermatrix (alternatives under evaluation) show that for service provision, the most relevant criteria of the clusters "project characteristics," "organizational structure," "contract types," and "contracting process" are time (74.47%), competitiveness (38.79%), established price (28.86%), and criterion of evaluation (66.67%), respectively. For the rent alternative,

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the most relevant criteria are cost (71.47%), flexibility (34.81%), established price (29.37%), and contractor's prequalification (75%).

Of the six criteria used by the WG, five are listed in the preceding paragraph: time, competitiveness, costs, risks, and flexibility. This finding indicates that the criteria chosen by the group are the most relevant for these alternatives.

In its last rows, the unbalanced supermatrix also reveals the comparisons between the two alternatives in each criterion. For example, these data show a preference of over 75% for rent in terms of the cost, performance, flexibility, and control criteria. Likewise, service provision has a preference of over 75% in the following criteria: ease in identifying the responsible party, use of internal resources, number of interfaces, competitiveness, and experience in contract management. This first evaluation demonstrates a certain balance between the alternatives since service provision is preferable in seven criteria, rent is preferable in six, and there is no difference among the other four criteria.

The last two columns of the balanced supermatrix (Table 5) indicate that for service provision, the most relevant criteria are time (46.98%), performance (9.40%), and cost (6.71%). As for rent, the most relevant criteria are cost (45.09%), performance (13.78%), and established price (5.61%).

Lastly, in Table 6 the limit supermatrix columns (where it is possible to prioritize the alternatives) show that the criteria with higher relative weights are cost (15.32%), performance (11.30%), time (7.14%), control (6.53%), number of interfaces (5.76%), incentives (5.64%), risk transfer (5.14%), ease in identifying the responsible party (4.76%), flexibility (4.09%), established price (3.55%), competitiveness (3.42%), experience in contract management (2.97%), contractor's prequalification (2.89%), contractor's discipline (2.79%), experience in project management (2.10%), use of internal resources (2.00%), and evaluation criterion (1.28%).

The sum of the six criteria used by the WG—cost, number of interfaces, ease in identifying the responsible party, performance, control, flexibility, time, and competitiveness—represents 58% of the total preference. This figure demonstrates the relevance of the criteria used by the WG. However, the remaining percentage (42%) cannot be overlooked. Therefore, the results demonstrate that the other criteria also contribute to the selection of the contract strategy.

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The limit supermatrix's last two rows present the final prioritization of the alternatives: service provision (0.056323) and rent (0.077008). When the values are normalized, the final prioritization vector can be obtained. Its values are 57.7569% preference for rent and 42.2431% preference for service provision, illustrated in Figure 4. Thus, the simulation indicates that the preferred alternative is rent contract, supporting the WG's recommendation. The simple fact that the ANP produces this clear recommendation to the decision makers already indicates an improvement in the organization's decision-making process since the color-code table used by the WG does not directly express its recommended alternative.

Name	Graphic	Ideals	Normals	Raw
1 Service Contract		0.731395	0.422431	0.056323
2 Rental Contract		1.000000	0.577569	0.077008

Figure 4: Prioritization of alternatives obtained with the Super Decisions software

Subsequently, a sensitivity analysis was carried out, removing the influence among clusters but keeping the previously defined internal dependencies. In this way, the model would be close to a hierarchy, similar to the AHP. Therefore, it would be possible to evaluate the results of both the ANP and the AHP applied to the case study.

Figure 5 presents the sensitivity analysis results. Although the results shown in Figure 4 are not altered, there is a considerable change in the prioritization of the alternatives. In the base case, the preference for rent is approximately 58%, whereas in the hierarchy setting (sensitivity analysis), this preference is approximately 64%.

Name	Graphic	Ideals	Normals	Raw
1 Service Contract		0.561493	0.359587	0.066567
2 Rental Contract		1.000000	0.640413	0.118553

Figure 5. Prioritization of alternatives obtained with the sensitivity analysis

Based on the exposed information, it is possible to state that the model for selecting contract strategies is valid for this case study since it supports the WG's conclusions. Besides, the use of the ANP facilitates the visualization of the WG's recommendation, as well as which criteria have exerted more influence on the WG's selection decision. Moreover, when comparing the criteria used by the WG with those from the model, the latter set is more complete. The proposed model thus enables

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the analysis of different cases, where the alternatives may differ from those in this case study.

Furthermore, the WG recommended the rent contract mainly “due to the significant difference of cost, since there were no great disparities in the criteria between alternatives.” The results of the simulation also support this fact. Additionally, the WG’s report mentions that for the rent contract, the “operational flexibility of this model reveals itself as a great advantage in this setting,” which is also reflected in the simulation. These facts indicate that the simulation supports the WG’s main conclusions.

It is also important to highlight that the prioritization of the alternatives may initially indicate a weak preference for the rent contract instead of the service provision since the values shown in Figure 4 are close. However, the alternatives are equivalent in four criteria (contractor’s discipline, risk transfer, incentives, and evaluation procedure), and there is a weak preference for the other four (time, established price, experience in project management, and contractor’s prequalification).

Certainly, it balances the results of both alternatives. Moreover, it indicates that the simplification proposed by the WG has no influence on the decision in this specific case study since the alternatives are similar in eight criteria, which represents approximately 30% of the total preference, according to the limit supermatrix.

Moreover, the sensitivity analysis allows the verification of the impact extension in the results, in case hierarchical modeling is adopted. Although it does not alter the recommendation, this change results in different priorities between the alternatives, which could influence the decision analysis.

The implementation of a multicriteria method, such as the ANP, allows in-depth conclusions, explicitly indicating which criteria have more influence on the selection decision, as can be extracted from the supermatrices. Thus, this selection becomes clearer and stronger. The proposed model also minimizes the possibility of excluding relevant criteria compared with the simplified model used by the WG.

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Table 4. Unweighted supermatrix obtained from the ANP

		1 Project Characteristics			2 Organizational Structure						3 Contract Type						4 Contracting Process		5 Alternatives	
		1 Cost	2 Time	3 Performance	1 Ease in Identifying the Responsible Party	2 Flexibility	3 Control	4 Use of internal resources	5 Number of Interfaces	6 Competitiveness	1 Contractor's Discipline	2 Risk Transfer	3 Established Price	4 Experience in Contract Management	5 Experience in Project Management	6 Incentives	1 Contractor's Prequalification	2 Evaluation Procedure	1 Service Contract	2 Rent Contract
1 Project Characteristics	1 Cost	0.000000	0.666667	0.800000	0.296961	0.614411	0.474230	0.666667	0.571429	0.666667	0.250000	0.833333	0.658644	0.454545	0.600000	0.571429	0.250000	0.600000	0.106383	0.714710
	2 Time	0.250000	0.000000	0.200000	0.163424	0.117221	0.149373	0.000000	0.142857	0.111111	0.250000	0.000000	0.156182	0.090909	0.200000	0.142857	0.250000	0.000000	0.744681	0.066796
	3 Performance	0.750000	0.333333	0.000000	0.539615	0.268369	0.376397	0.333333	0.285714	0.222222	0.500000	0.166667	0.185174	0.454545	0.200000	0.285714	0.500000	0.400000	0.148936	0.218494
2 Organizational Structure	1 Ease in Identifying the Responsible Party	0.104729	0.000000	0.000000	0.000000	0.000000	0.310814	0.000000	0.833333	0.000000	0.000000	0.666667	0.000000	0.250000	0.166667	0.000000	0.000000	0.000000	0.192847	0.066850
	2 Flexibility	0.000000	0.493386	0.249310	0.250000	0.000000	0.195800	0.000000	0.000000	0.000000	0.000000	0.000000	0.750000	0.750000	0.000000	0.593634	0.000000	0.000000	0.094690	0.348093
	3 Control	0.000000	0.195800	0.593634	0.000000	1000000	0.000000	1000000	0.000000	0.000000	0.666667	0.333333	0.250000	0.000000	0.500000	0.157056	0.833333	0.500000	0.065443	0.185809
	4 Use of internal resources	0.000000	0.000000	0.000000	0.000000	0.000000	0.493386	0.000000	0.000000	0.000000	0.333333	0.000000	0.000000	0.000000	0.166667	0.000000	0.000000	0.000000	0.080677	0.058485
	5 Number of Interfaces	0.258285	0.310814	0.157056	0.750000	0.000000	0.000000	0.000000	0.000000	1000000	0.000000	0.000000	0.000000	0.000000	0.166667	0.000000	0.000000	0.000000	0.178438	0.067159
	6 Competitiveness	0.636986	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.166667	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.249311	0.166667	0.500000	0.387904	0.273604
3 Contract Type	1 Contractor's Discipline	0.000000	0.154939	0.310814	0.000000	0.053372	0.257991	0.250000	0.000000	0.166667	0.000000	0.067925	0.077472	0.142857	0.750000	0.142857	0.000000	0.000000	0.051773	0.046424
	2 Risk Transfer	0.569541	0.120843	0.195800	0.000000	0.132035	0.076290	0.000000	0.085631	0.000000	0.114032	0.000000	0.318148	0.428571	0.250000	0.428571	0.000000	0.106290	0.271897	0.242948
	3 Established Price	0.000000	0.347436	0.000000	0.000000	0.079243	0.000000	0.000000	0.000000	0.000000	0.114032	0.389862	0.000000	0.000000	0.000000	0.428571	0.000000	0.186796	0.288569	0.293671
	4 Experience in Contract Management	0.097390	0.000000	0.000000	0.750000	0.207498	0.172458	0.000000	0.617504	0.000000	0.357326	0.152352	0.155270	0.000000	0.000000	0.000000	0.250000	0.500340	0.064660	0.054195
	5 Experience in Project Management	0.000000	0.000000	0.000000	0.250000	0.161541	0.410490	0.750000	0.296865	0.000000	0.227673	0.000000	0.000000	0.000000	0.000000	0.000000	0.750000	0.047015	0.081643	0.102242
	6 Incentives	0.333069	0.376782	0.493386	0.000000	0.366312	0.082771	0.000000	0.000000	0.833333	0.186937	0.389862	0.449110	0.428571	0.000000	0.000000	0.000000	0.159558	0.241458	0.260520
4 Contracting Process	1 Contractor's Prequalification	0.000000	1000000	0.750000	0.000000	0.000000	1000000	0.000000	1000000	0.750000	1000000	0.000000	0.000000	0.800000	0.833333	0.000000	0.000000	1000000	0.333333	0.750000
	2 Evaluation Procedure	1000000	0.000000	0.250000	0.000000	0.000000	0.000000	0.000000	0.000000	0.250000	0.000000	0.000000	0.000000	0.200000	0.166667	0.000000	0.000000	0.000000	0.666667	0.250000

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Table 5. Weighted supermatrix obtained from the ANP

		1 Project Characteristics			2 Organizational Structure						3 Contract Type						4 Contracting Process		5 Alternatives	
		1 Cost	2 Time	3 Performance	1 Ease in Identifying the Responsible Party	2 Flexibility	3 Control	4 Use of internal resources	5 Number of Interfaces	6 Competitivenes s	1 Contractor's Discipline	2 Risk Transfer	3 Established Price	4 Experience in Contract Management	5 Experience in Project Management	6 Incentives	1 Contractor's Prequalification	2 Evaluation Procedure	1 Service Contract	2 Rent Contract
1 Project Characteristics	1 Cost	0.000000	0.310381	0.372458	0.040260	0.083298	0.061049	0.090382	0.073561	0.085822	0.050324	0.175249	0.138512	0.091498	0.120777	0.120171	0.110719	0.122849	0.067118	0.450916
	2 Time	0.116393	0.000000	0.093114	0.022156	0.015892	0.019229	0.000000	0.018390	0.014304	0.050324	0.000000	0.032845	0.018300	0.040259	0.030043	0.110719	0.000000	0.469825	0.042142
	3 Performance	0.349179	0.155191	0.000000	0.073157	0.036384	0.048454	0.045191	0.036781	0.028607	0.100647	0.035050	0.038942	0.091498	0.040259	0.060085	0.221439	0.081899	0.093965	0.137850
2 Organizational Structure	1 Ease in Identifying the Responsible Party	0.021828	0.000000	0.000000	0.000000	0.000000	0.167150	0.000000	0.448152	0.000000	0.000000	0.079521	0.000000	0.028543	0.019029	0.000000	0.000000	0.000000	0.026184	0.009077
	2 Flexibility	0.000000	0.102833	0.051962	0.141590	0.000000	0.105298	0.000000	0.000000	0.000000	0.000000	0.000000	0.089461	0.085630	0.000000	0.070809	0.000000	0.000000	0.012857	0.047263
	3 Control	0.000000	0.040809	0.123727	0.000000	0.566360	0.000000	0.566360	0.000000	0.000000	0.076116	0.039760	0.029820	0.000000	0.057087	0.018734	0.123022	0.034125	0.008886	0.025229
	4 Use of internal resources	0.000000	0.000000	0.000000	0.000000	0.000000	0.265334	0.000000	0.000000	0.000000	0.038058	0.000000	0.000000	0.000000	0.019029	0.000000	0.000000	0.000000	0.010954	0.007941
	5 Number of Interfaces	0.053832	0.064781	0.032734	0.424770	0.000000	0.000000	0.000000	0.000000	0.537782	0.000000	0.000000	0.000000	0.000000	0.019029	0.000000	0.000000	0.000000	0.024228	0.009119
	6 Competitiveness	0.132762	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.089630	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.029738	0.024604	0.034125	0.052668	0.037149
3 Contract Type	1 Contractor's Discipline	0.000000	0.018181	0.036472	0.000000	0.007364	0.033799	0.034492	0.000000	0.021835	0.000000	0.035176	0.040120	0.070814	0.371773	0.073981	0.000000	0.000000	0.009884	0.008863
	2 Risk Transfer	0.066833	0.014180	0.022976	0.000000	0.018217	0.009995	0.000000	0.011218	0.000000	0.056525	0.000000	0.164759	0.212441	0.123924	0.221944	0.000000	0.011430	0.051908	0.046381
	3 Established Price	0.000000	0.040770	0.000000	0.000000	0.010933	0.000000	0.000000	0.000000	0.000000	0.056525	0.201898	0.000000	0.000000	0.000000	0.221944	0.000000	0.020088	0.055091	0.056065
	4 Experience in Contract Management	0.011428	0.000000	0.000000	0.103477	0.028629	0.022593	0.000000	0.080898	0.000000	0.177125	0.078898	0.080410	0.000000	0.000000	0.000000	0.058152	0.053805	0.012344	0.010346
	5 Experience in Project Management	0.000000	0.000000	0.000000	0.034492	0.022288	0.053777	0.103477	0.038892	0.000000	0.112857	0.000000	0.000000	0.000000	0.000000	0.000000	0.174455	0.005056	0.015587	0.019519
	6 Incentives	0.039084	0.044213	0.057896	0.000000	0.050540	0.010844	0.000000	0.000000	0.109173	0.092664	0.201898	0.232580	0.212441	0.000000	0.000000	0.000000	0.017158	0.046097	0.049736
4 Contracting Process	1 Contractor's Prequalification	0.000000	0.052836	0.039627	0.000000	0.000000	0.050460	0.000000	0.050460	0.037845	0.042816	0.000000	0.000000	0.034253	0.035680	0.000000	0.000000	0.537687	0.014135	0.031804
	2 Evaluation Procedure	0.052836	0.000000	0.013209	0.000000	0.000000	0.000000	0.000000	0.000000	0.012615	0.000000	0.000000	0.000000	0.008563	0.007136	0.000000	0.000000	0.000000	0.028270	0.010601
5 Alternatives	1 Service Contract	0.019478	0.093495	0.025971	0.133414	0.026683	0.038004	0.133414	0.126682	0.114014	0.073010	0.076275	0.061020	0.109514	0.097346	0.076275	0.058963	0.040889	0.000000	0.000000
	2 Rent Contract	0.136346	0.062330	0.129854	0.026683	0.133414	0.114014	0.026683	0.025336	0.038005	0.073010	0.076275	0.091530	0.036505	0.048673	0.076275	0.117926	0.040889	0.000000	0.000000

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Table 6. Limit supermatrix obtained from the ANP

0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163	0.153163
0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411	0.071411
0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987	0.112987
0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586	0.047586
0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902	0.040902
0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308	0.065308
0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019	0.020019
0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614	0.057614
0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149	0.034149
0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917	0.027917
0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378	0.051378
0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496	0.035496
0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694	0.029694
0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007	0.021007
0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359	0.056359
0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850	0.028850
0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829	0.012829
0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323	0.056323
0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008	0.077008

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Finally, it is important to note that the generalization of the model for selecting contract strategies for projects in any context does not belong to this article's scope. It is suggested that further studies implement the model in different cases, with varying alternatives to test its validity. Moreover, research can be carried out by adapting the proposed model to investigate the effects of including or excluding specific criteria.

6. CONCLUSIONS

As previously stated, the selection of a contract strategy for a project is fundamental to its success. Therefore, it is a decisive factor for its completion in a timely and cost-effective manner with high-quality outcomes. Thus, the development of methods that improve this process is relevant for organizations.

The theoretical background has emphasized the influence of the contract strategy on project management and risk management. Furthermore, it has defined the main organizational structures in current contracts, which directly affect how the stages of design and project implementation will turn out. Two types of contracts have been identified, based on price (e.g., lump sum) or on cost (e.g., cost-reimbursable contracts), which differ according to the payment method. Lastly, the main stages of the process that should be defined have been revealed, including the importance of the bidder's prequalification and the definition of a clear evaluation criterion.

Moreover, the basis of the ANP has been presented. It allows the representation of dependencies and feedback across different criteria and alternatives, which are divided into clusters. Some of the cited state-of-the-art articles show a few relevant applications of this method for organizations.

The presented methodology involves the proposed model for selecting contract strategies for projects, using the ANP and its implementation in a case study. The model's criteria are in accordance with the aspects discussed in the theoretical background and presented in the literature review. As for the case study, it aims to verify if the implementation of the model would support the decision made and if there would be benefits of its use.

The criteria used by the WG responsible for analyzing the problem in the case study and the proposed criteria are correlated. The results of the simulation have led

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to the same recommendation, with the advantage of facilitating its visualization. The proposed model is also more complete than the one used by the WG, but it does not affect the results because both alternatives are equivalent in the additional criteria. Therefore, the results show that the model is valid for this case study and beneficial for the decision process in terms of improving transparency.

For future studies, it is suggested that case studies with different alternatives be analyzed to test the validity of the model. The model could also be modified to investigate the effects of including or excluding some criteria.

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