Technology Selection and Risk Assessment through Equipment Development in Oil & Gas Industry: A Literature Review

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1. PROBLEM DESCRIPTION

Over the years, companies have been investing in Research and Development (R&D) because they recognize it as key factor for economic and competitive growth [1]. However, Matkovskaya *et al.* [2] mention that most oil companies show low innovative activities. Hence, the elaboration of active innovation policies, through greater investments in R&D and the effectiveness of the results implemented, becomes essential to move toward an intensive scenario.

Due to budget and legislative constraints, companies often need to choose one or more projects from a group of options listed in a portfolio. Thus, analyzing relevant criteria to evaluate and aggregate them efficiently, especially when in data scarcity, requires attention in the decision-making process. Usually, there is insufficient historical project data, uncertain performance data, and little knowledge about the technologies, particularly in the early stages of project development [3]. Historically, several uncertainty factors, such as commercial/market risks and technical failure risks, are the main cause of the low success rates [1].

When formulating strategies based on technology portfolio analysis methods, technology attractiveness assessment is one of the key dimensions of the attractiveness-capability matrix. There are multiple methods for assessing the technology attractiveness, depending on the purpose and the type of the application, as well as the research background (industry level, enterprise level, private and public R&D company departments, specific industries, etc.) [3].

Regarding new equipment selection, the customer necessities satisfaction requires the firms to become extra sensitive and perform deep analyses. The choice of outsized equipment may disturb the company's income. On the contrary, the choice of under-sizing equipment cannot fulfill customers' requested quality levels and capability needs. Equipment selection is essential for the planning of a versatile production system [4]. Thus, this study aims to develop a systematic literature review to investigate the methodologies currently used for selecting and/or ranking projects, especially regarding what has been developed in terms of new equipment selection.

2. RESEARCH METHOD

Different procedures are adopted for conducting systematic reviews of the literature [5]. In general, they are based on three main steps: (1) planning the review; (2) collecting and selecting articles; and (3) reporting. In the review planning stage, preliminary studies supported the search for the main topics and keywords. These were defined and combined as follows: (i) "Project Selection" and "Oil and Gas"; (ii) "Project Portfolio" and "Oil and Gas"; (iii) "Research and Development" and "Oil and Gas"; (iv) "R&D" and "Oil and Gas"; (v) "New technologies" and "Project selection"; (vi) "Project risk" and "Project selection". The first four correspond to articles strictly related to the O&G industry. The last two combinations refer to project selection methodologies applied to other industries, but with a focus on new technologies and project risk analysis. In addition, eight articles [1], [6]–[12], which are not in the keywords, were added according to prior readings. After this selection, the Web of Knowledge database was chosen as the research source. It aggregates several different databases into a single search tool [13].

In the collection and selection stage, few criteria were used to filter articles, which include: English language, articles, review, and early access. In addition, the search interval was the last ten years, from 2011 to April 2021. So far, 169 articles related to the theme were found. Then, first filtering was performed.

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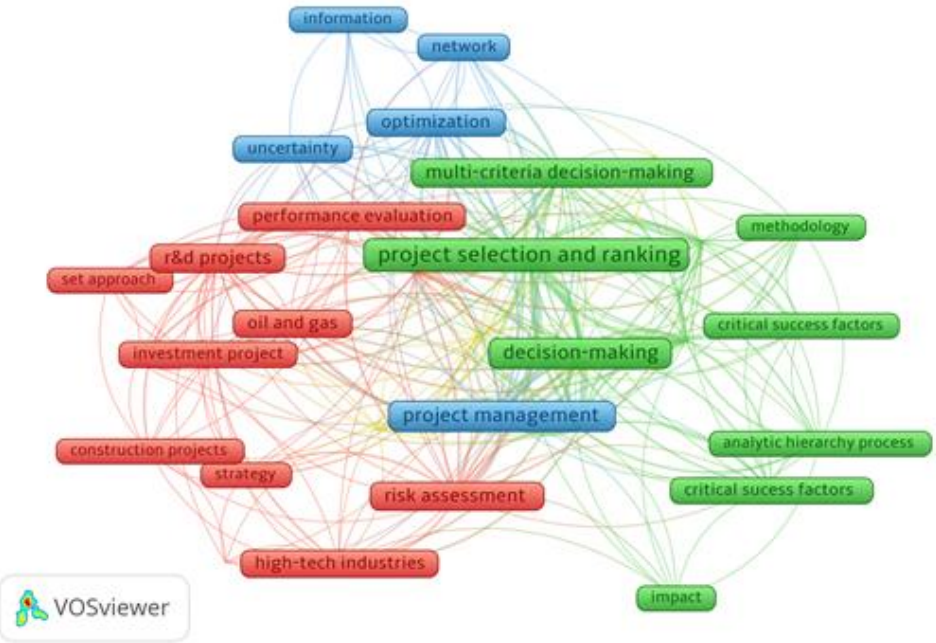
Abstracts were read to guide the selection of articles within the scope and context of the research. In this step, 39 articles remained in total. Finally, we analyzed the articles completely and concluded that 23 of these are strictly related to the research. Notable that this is a small number of papers for a ten-year interval.

We used two free software programs to perform the descriptive analysis of the articles: (1) Nails Project® and (2) VosViewer®. With the first one, for example, we can follow the evolution of publications over the years [14]. With the latter, in turn, we can create network maps that relate the keywords and the main terms used in the article portfolio [15]. In this way, an overview of the main aspects of the papers is obtained. Finally, the last stage consists of writing a final article. It must contain the final report of the research, gaps, and other important points regarding the theme.

3. RESULTS AND DISCUSSIONS

We have identified the principal terms used in the 23 articles (Figure 1). We can highlight, for example, "project selection and ranking" at the core of the samples. Also, some standings are associated with decision-making processes, such as "decision-making" and "multi-criteria decision-making". The term "oil and gas" is connected to "investment project", "R&D projects", "risk assessment", "performance evaluation", and "innovation". These results suggest a growing interest related to those subjects' intersections.

Figure 1 – Main terms of the articles filtered in VosViewer®



The literature review provides a general overview of the methodologies focused on project selection. We can already identify multi-criteria decision-making (MCDM) and multi-criteria decision analysis (MCDA) methods. For example, the Analytic Hierarchy Process – AHP [8], [17], Fuzzy-TOPSIS [11] and the Multi-attribute Utility Theory – MAUT [18]. Also, the use of Grey-MADM [3], and the PROMETHEE V [19]. Dahooie *et al.* [20] performs analysis by combining two techniques: the Step-Wise Weight Assessment Ratio Analysis (SWARA) method and a novel interval-valued fuzzy extension of the Additive Ratio Assessment (ARAS) method. Another study also merges two tools: SWARA-WASPAS [21]. Applying the MCDM method in technology attractiveness assessment allows the evaluation process of technology options based on several attributes to be systematically completed [3].

Another interesting technique was used twice in our sample, namely the Structural Equation Modelling (SEM) [22], [23]. This method is useful for testing the relationship between the factors and estimating the measurement errors in the formulated hypotheses [22]. Sharma and Chanda [1] developed a Bayesian belief network model for prediction of R&D project success. We also mention the use of heuristics and robust optimization [24]. Machine learning methods are also cited in project selection, for example, using artificial neural networks [25]. Wang *et al.* [26] developed a capability-based risk assessment (CapRA) calculator for project selection decisions. Nevertheless, merging different types of methods can be interesting to increase the

analysis. This is the case of Mavrotas *et al.*[6] that combine multiple criteria analysis, mathematical programming, and Monte Carlo simulation to tackle uncertainty in R&D project portfolio selection.

In this study, we also point out the areas and projects covered in the literature. We can notice project selection methodologies applications in the O&G industry focused on drilling and petroleum exploration [3], [5], [8], new technologies [3], nanotechnologies [21], and for prioritization of project portfolios in oil and gas platforms to increase its useful life [18], [19]. Beyond this sector, there are studies in selecting new technologies in the automotive area [24], in the integrated circuit industry [17], among others. However, from 2011 in the WoK base, there is a gap in specific methodologies applied to selecting or ranking new equipment projects in the O&G industry.

4. RESEARCH IMPACT AND CONCLUSIONS

The research objective consists of performing a systematic literature review to investigate the methodologies currently used for selecting and/or ranking projects, especially developments for new equipment selection. Although equipment choice plays a very important role within the style of a good producing system, the literature on this subject is limited. The findings generate four main contributions to academia and companies, as follows:

1) Methods mapping and classification: address studies highlighting and classifying the methods by their domain. For example, which exists in terms of MCDM and MCDA, heuristic and other optimization methods, and machine learning approaches. And which of them include uncertainty in their approaches;
2) Areas and applications mapping: provides an opportunity for the management level to identify what is being applied in their domain;
3) Critical criteria survey: suggests the important aspects to be taken into consideration when evaluating projects;
4) Research agenda: consider the research gaps found from the literature overview, which allows a list of promising options for new studies. It is noteworthy that the previous contributions are inter-related, broadening the potential research from them.

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