

Cost-Benefit AHPSort for performance analysis of offshore providers

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ABSTRACT:

The performance of a company is largely affected by that of its providers as they are a direct factor that determines product prices, flexibility and quality. It is therefore important to measure their performance. Several aspects need to be measured but traditional multi-criteria decision methods (MCDM) do not benchmark but only rank providers. Multi-criteria decision sorting methods are well indicated to benchmark activities into classes. In this paper, we present a modification of the AHPSort sorting method, where cost and benefit criteria are kept separate for a better and easier comparison. A case study in the aerospace industry will illustrate the efficacy of the new Cost-Benefit AHPSort method. The results will help managers to make specific decisions concerning their current offshore providers. They will also give valuable feedback for providers in order to improve their performance. Additionally, the findings enable a definition of benchmarking that will support future evaluations.

Keywords: Offshore outsourcing decisions; Benefit, Cost; AHPSort, Provider evaluation.

1. Introduction

Outsourcing has become a key strategic component to compete in terms of costs, flexibility and responsiveness (Gunasekaran and Irani 2010). As several criteria need to be considered for selecting an outsourcing partner, multi-criteria decision methods (MCDM) have been largely used to support the provider selection process, such as the Analytic Hierarchy Process (AHP) (Ishizaka 2008), the Analytic Network Process (ANP) (Asadabadi 2017), fuzzy AHP (Ishizaka 2014), fuzzy ELECTRE (Sevкли 2010), TOPSIS (Kasirian and Yusuff 2013), a coupling of fuzzy AHP and fuzzy TOPSIS (Kaur, Singh, and Majumdar 2018), etc. A review of decision-making methods used for provider selection can be found in (Chai, Liu, and Ngai 2013). However, the provider selection is only the first step of the outsourcing process and the relationship needs to be managed (Ishizaka and Blakiston 2012). In

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order to do so, it is important to measure the provider's performance. Performance needs to be benchmarked against targets measured through several criteria (Ihrig, Ishizaka, and Mohnen 2017). The traditional MCDM methods rank alternatives but do not benchmark them (Alessio and Nemery 2013). Therefore, multi-criteria sorting methods have been developed: AHPSort (Ishizaka, Pearman, and Nemery 2012), FlowSort (Nemery and Lamboray 2008), Electre-Tri (Mousseau, Slowinski, and Zielniewicz 2000), ELECTRE-Sort (Ishizaka and Nemery 2014), MACBETHSort (Ishizaka and Gordon 2017) and GAIASort (Nemery et al. 2012). Their aim is to classify alternatives in predefined ordered classes. AHPSort has been adapted from AHP and retains all its advantages. It enables evaluating only two elements at a time, which provides more precise information (Millet 1997). The problem is structured in a hierarchy, which makes the problem easier to visualise, solve and explain. The decision quality is also enhanced, due to the consistency check and sensitivity analysis embedded in the AHPSort–AHP method. AHPSort has been further improved to be applied to major problems (Miccoli and Ishizaka 2017) and group decisions (López and Ishizaka 2017a). Although AHPSort has been useful, a unique hierarchy is confusing when criteria to maximise and to minimise are mixed. Therefore, in this paper, we propose a Cost-Benefit AHPSort, where cost and benefit criteria are separated into two distinct hierarchies. The classification will then be done in a grid and feedback to providers will be given. This will help them to gain a better understanding of their performance and therefore to make more accurate targeted actions. The new method is illustrated in a real case study of provider performance analysis for an aerospace manufacturing company, where two consecutive evaluations of offshore providers at a one-year interval are carried out.

The rest of the paper contains a literature review of performance analyses of outsourcing processes in Section 2. Section 3 describes the Cost-benefit AHPSort. Section 4 presents the case study and Section 5 concludes the paper.

2. Literature review of performance analyses of outsourcing processes

Offshore outsourcing strategy has become widely adopted by both manufacturing and service firms over the last decades. This refers to the transference of a concrete process or value chain activities from a client firm to one or more independent providers operating in a foreign country.

According to Mihalache and Mihalache (2015), the main aim of offshore outsourcing processes is to optimise the client firm value chain by performing specific tasks in locations that present specific advantages in terms of competencies, labour availability or cost structures. Nevertheless, when the client firm outsource a significant part of its processes to offshore providers, it can create additional risks and unrecognised threats often arise (Herath and Kishore 2009; Nakatsu and Iacovou 2009). In this manner, Steven, Dong, and Corsi (2014) highlight that geographic and cultural distances between both sides might lead to information asymmetry which will negatively impact on quality recalls. As results of offshore outsourcing risks, the Boeing 787 incorporated faulty lithium-ion batteries causing fires and thus a grounded fleet (Denning 2013). Hence, the business profitability and market position

of the client firm could be severely damaged. It is no wonder that today some companies are even considering the possibility of bringing their offshore outsourcing activities back home (Barbieri et al. 2018; Di Mauro et al. 2018; Brandon-Jones et al. 2017). In this way, it has been empirically analysed whether offshoring and reshoring strategies have provided better or worse cost performance, cost accounting capabilities and operational performance (Stentoft et al. 2018). In order to achieve success in outsourcing, client firms must invest in effective performance measurement (Whitaker, Kumar, and Krishnan 2018).

Undesired outcomes in offshore outsourcing would be avoided through a continuous feedback and a proper performance evaluation of providers, which encourage the stability in offshore outsourcing relationships (Manning, Lewin, and Schuerch 2011). A successful offshoring relationship lies in a good co-specialisation, effective coordination efforts and collaboration between both the client firm and the offshore provider (Mukherjee, Gaur, and Datta 2013). A client outcome control has shown an improvement of or has even substituted the effect of vendor outcome control (Zheng et al. 2018). In order to attain this, the development of measurable specifications is required (Ellram, Tate, and Billington 2008; Rottman and Lacity 2006). In spite of this, few research efforts have been carried out to support the performance analysis of providers once the process has already been outsourced.

Khan et al. (2003) presented a benefit and risk framework of offshore outsourcing process that does not incorporate specific performance measures. Wu (2010) carried out a stochastic DEA model to estimate the efficiency of offshore outsourcing providers and rank them. Sivapornpunlerd and Setamanit (2014) applied AHP in a case study to evaluate the providers' performance of an offshore enterprise in Thailand. Sivapornpunlerd and Setamanit (2014) developed an AHP-based provider performance evaluation system. The same technique has been used for measuring the green supply chain performance (Dey and Cheffi 2013). AHP has also been combined with fuzzy logic and fuzzy TOPSIS to measure the performance of advanced manufacturing systems (Mohammadzadeh et al. 2011). Bentes et al. (2012) integrated AHP and Balance Scorecard (BSC) to measure the organisational performance of a telecom company. For their part, Modak, Pathak, and Ghosh (2017) combined FAHP and BSC to assess organisational performance in outsourcing decisions. In this vein, Yadav et al. (2018) have recently proposed a hybrid BWM-ELECTRE method to evaluate effective offshore outsourcing adoption in client firms. In spite of the development of strategies which facilitate low cost and high value contracts in offshore outsourcing having been reported as a critical challenge (Weerakkody and Irani 2010), no method has been identified to evaluate the performance of an offshore provider considering costs and benefits in multicriteria sorting methods.

The performance of offshore providers is complicated to determine because of the fact that multiple criteria must be considered, and these are often based on a subjective metrics. Moreover, some criteria would need to be maximised (benefit criteria) and some to be minimised (cost criteria). These issues together with scant information available in outsourced processes largely exceed the managers' cognitive ability to intuitively assess offshore provider performance. Accordingly, this article proposes a new Cost-Benefit sorting method to evaluate offshore outsourcing providers. This is

presented in Section 3 and applied in a real case study described in Section 4.

3. The proposed method

Generally, decisions are based on benefits (positive) versus costs (negative). Nonetheless, benefits and costs are often difficult to express in monetary terms, especially when intangible benefits and costs are to be evaluated. Therefore, AHP has been used for benefit/cost analysis (Azis 1990; Ishizaka and Labib 2011). Two hierarchies are constructed, one for costs and one for benefits. The priorities derived are expressed on a derived ratio scale. The main criticism of benefit/cost analysis with AHP is that different hierarchies produce priorities in different relative derived ratio scales, and these are generally not commensurate. It is therefore not possible to calculate a meaningful cost/benefit ratio (Wijnmalen 2007). The cost-benefit AHPSort method reuses the idea of having two separate hierarchies but for a sorting problem. Yet, it eliminates the problem of two different relative ratio scales as each alternative is compared only with the benchmarks. As the benchmarks are the same for all alternatives, the relative magnitude is the same for all alternatives. Furthermore, a ratio is not calculated but results are analysed in a two-dimensional grid.

This section describes the Cost-Benefit AHPSort method, which is based on nine steps and three main phases: problem definition, evaluations and assignment to classes.

A) Problem definition

- 1) Before being solved, a problem needs to be clearly defined, otherwise we may not solve the correct problem. For this task, the goal of the problem needs to be defined along with the benefit criteria c_b , $b = 1, \dots, m$, cost criteria c_c , $c = 1, \dots, o$ and alternatives a_k $k = 1, \dots, l$ of the problem. This is the first important difference from the previous methods listed in Section 2. The criteria to be minimised (cost criteria) and the criteria to be maximised (benefit criteria) are listed in two different groups.
- 2) As it is a sorting problem, the number n of classes C_i , $i=1, \dots, n$ with its label (e.g., excellent, good, average, bad) needs to be defined. . The classes are ordered from the best to the worst.
- 3) The classes labelled in 2) need to be defined. This can be automatically, e.g., with a K-neighbour algorithm as in (Lolli, Ishizaka, and Gamberini 2014), or through decision makers, if they have some information; for example, based on their experience. The most precise way to define classes by a decision maker is to provide the minimum requirement to belong to a class. This is done by defining local limiting profiles lp_{ib} and lp_{ic} for each class. This indicates the minimum performance needed in each benefit and cost criterion to belong to a class C_i . We need $(m+o) \cdot n-1$ limiting profiles to define each class. It is to be noted that central profiles, as in the AHPSort standard, can also be used.

B) Evaluations

- 4) The evaluation of criteria is done in a pairwise comparison matrix. It has been proven that pairwise comparisons are more precise than direct rating (Millet 1997; Por and Budescu 2017). The benefit criteria c_b and the cost criteria c_c are evaluated separately; therefore, two comparisons matrices are needed. There are different ways to derive the criteria weights w_b and w_c from the comparisons matrices (Ishizaka and Lusti 2006). The most popular is the eigenvalue method of the AHP (Saaty 1977).

$$\mathbf{A} \cdot \mathbf{p} = \lambda \cdot \mathbf{p} \quad (2)$$

where A is the comparison matrix

p is the priorities/weight vector

λ is the maximal eigenvalue

- 5) In this step, the alternatives will be prioritised in terms of how beneficial they are. They are benchmarked against the limiting profiles lp_{bi} defined in step 1). One alternative a_k is compared pairwise with each limiting profile lp_{bi} and for each benefit criterion. These evaluations are entered into the benefit comparison matrix, one for each criterion. From this matrix, we derive the local benefit priority p_{bk} for the alternative a_k with the eigenvalue method (2). We also derive the local benefit priority p_{bi} for the limiting profiles lp_{bi} , with the same method (2). A comparison of the local benefit priority of the limiting profiles lp_{bi} , and of the alternative a_k will be used for the classification in step 7.
- 6) In this step, the alternatives will be prioritised in terms of how costly they are. This means that a higher score reflects a higher cost. As in 5), they are benchmarked, but this time against the limiting profiles lp_{ci} defined in step 1). One alternative a_k is compared pairwise with each limiting profile lp_{ci} and for each cost criterion. These evaluations are entered into the cost comparison matrix, one for each criterion. From this matrix, we derive the local cost priority p_{ck} for the alternative a_k with the eigenvalue method (2). We also derive the local cost priority p_{ci} for the limiting profiles lp_{ci} , with the same method (2). A comparison of the local cost priority of the limiting profiles lp_{ci} , and of the alternative a_k will be used for the classification in step 7.

C) Assignment to classes

- 7) In the two previous steps, we have calculated the local priorities. In this step, we wish to know the global priority, i.e., as regards all the criteria. For this purpose, the weighted local priorities are aggregated, which provides a global cost priority p_{ck} (3) and a global benefit priority p_{bk} for the alternative k (4), a global cost priority lp_{ci} for the limiting profile (5) and a global benefit priority lp_{bi} for the limiting profile (6).

$$p_{ck} = \sum_{c=1}^o p_{ck} \cdot w_c \quad (3)$$

$$p_{bk} = \sum_{b=1}^m p_{bk} \cdot w_b \quad (4)$$

$$lp_{ci} = \sum_{c=1}^o p_{ci} \cdot w_c \quad (5)$$

$$lp_{bi} = \sum_{b=1}^m p_{bi} \cdot w_b \quad (6)$$

The comparison of p_{ck} with lp_{ci} is used to assign the alternative a_k to a class C_{ci} according to its cost criteria. This step does not exist in ranking techniques, where only the score of the global priority matters. The comparison of p_{bk} with lp_{bi} is used to assign the alternative a_k to a class C_{bi} according to its benefit criteria. The next paragraph describes the assignment procedure for the benefit criteria. The assignment for the cost criteria follows exactly the same procedure.

If limiting profiles have been defined, the alternative a_k is assigned to the class C_{ci} that has the lp_i just below the global priority p_k (Figure 1).

$$\begin{aligned} p_{bk} \geq lp_{b1} & \Rightarrow a_k \in C_{c1} \\ lp_{b2} \leq p_{bk} < lp_{b1} & \Rightarrow a_k \in C_{c2} \\ \dots & \\ p_{bk} < lp_{bn-1} & \Rightarrow a_k \in C_{cn} \end{aligned} \quad (7)$$

Insert Figure 1
Figure 1. Sorting with limiting profiles

- 8) The final classification is given by the assignment on the cost and benefit criteria. If both assignments are identical $C_{ci}=C_{bi}$, then a_k is assigned unanimously to C_i . If $C_{ci} \neq C_{bi}$, then a_k can belong to several classes: the class is an interval covering the class from C_i to C_j . The results can be visualised in a 2-dimensional decision-grid, where the dimensions are the cost and benefit global priorities. This decision grid facilitates the visual management of the decision.
- 9) As this process is aimed to classify only one alternative at a time, the process 5) to 8) needs to be repeated for each alternative to be classified.

4. Evaluation of offshore outsourcing providers: a case study.

AHPSort has been adopted for supporting an offshore outsourcing decision making in a European aerospace manufacturing industry. This industry revenues reached USD 674.4 billion in 2016, where the European sector revenue growth (8.2%) is higher than the US sector (1.4%) (Lineberger and Hussain 2017). European aerospace manufacturing SC is structured around tiers. At the top of the pyramid, Original Equipment Manufacturer (OEM) aims at assembling final aircrafts to order and at the same time building large aero structures. First-tier providers build to order components and subcomponents. Second-tier providers manufacture instruments, parts and devices and/or provide multiple engineering services.

According to (Chirulescu 2017), managing an increasingly complex global SC is one of the most important challenges that European aerospace manufacturing currently faces. Over the last decades, the volume of offshored outsourcing activities has augmented increasingly more due mainly to cost pressure and the need to shorten development time, thereby allowing the client firm to focus on its core competencies and specific skills. In fact, a report reflected a strong tendency to outsource offshore in the European aerospace manufacturing sector by detecting mismatches between the growth of the production and value-added (Ecorys 2009). In addition, the engineering service outsourcing market demand in aerospace manufacturing sector was estimated at around USD 4.71 billion in 2012 (GVR 2014), forecasting a very high growth in the period 2012-2020.

Offshore outsourcing is not exempt from significant challenges in the aerospace manufacturing sector. The performance of providers is critical for the client firm (WCIR 2013). Hence, a European aerospace manufacturing firm was finally chosen to illustrate the Cost-Benefit AHPSort method. The company studied operates in the first-level of its SC providing a great variety of aerospace components to the two most important aircraft manufacturers worldwide. It has diverse plants in Europe, at the same time as it has outsourced some of its processes to specialised providers outside abroad.

To collect the data required in the case study, we conducted two semi-structured interviews with the operations manager, who is also the decision maker. The problem was described in detail during the first interview, which included the goal, classes, and the cost and benefit criteria definition. Subsequently, the operations manager compared the cost and benefit criteria in terms of importance within their respective hierarchies. At the beginning of the second interview, the operations manager revised the hierarchies and defined the limiting profiles for each criterion. In addition, the decision maker individually assessed the providers with pairwise comparisons for each criterion. The widely accepted nine-point scale suggested by Saaty (1977) was used in all the evaluations. The results were sent to offshore providers to guide them in developing improvement actions. After completing a transitional period, the operations manager carried out a third interview to again assess the providers' performance. The operations manager was also contacted via telephone and answered questions that had been overlooked during the interviews.

4.1 Problem definition

One of the client firm's offshored outsourcing processes was the edge finishing of metallic pieces and equipment. Currently, they have four providers:

- Provider 1 carries out the manual edge finishing of metallic pieces and equipment in Asia.
- Provider 2 also carries out the manual edge finishing of metallic pieces and equipment in Europe.
- Provider 3 carries out the automatic edge finishing of metallic pieces and equipment in Europe.
- Provider 4 carries out the manual edge finishing of metallic pieces and equipment in South America.

These providers shape metallic pieces and assemble simple mechanisms. They will be subsequently assembled into more complex components by the client firm. The aim of this research was to measure the performance of the existing providers. In doing so, the decision maker defined two hierarchies. These are described below.

4.1.1 Cost criteria

One of the hierarchies of the problem is made up of cost criteria, which the client company seeks to minimise. From a cost-benefit analysis point of view, cost criteria are those that require direct or indirect spending from the client firm. The following cost criteria were identified:

- Logistic cost, which includes the charges derived from the transport of the finished metallic pieces and equipment by any mode between the client company and the provider, warehousing, transport packaging, inventory carrying, administration and other indirect cost (Engblom et al. 2012). The geographical distance itself between the client firm and the offshore providers gives rise to a high logistic cost, although this is also conditioned by many factors such as the mode of transport, insurance, the transport infrastructure of each offshore location and so on. This cost is even encouraging some client firms to relocate and backshore activities that had been offshored (Di Mauro et al. 2018). Because of offshore providers being geographically located in distant countries, the operation managers aimed at minimising logistic cost.
- Inventory cost arises from holding metallic pieces and equipment in stock once the shipment is received by the client firm. According to (Lee and Billington 1992), its assessment should include the costs of capital, warehousing, storage, obsolescence and the cost of reworking the existing inventory to meet engineering changes. This criterion is strongly and directly related to the purchase order rigidity, fixed lot size, container-size minimum order, order frequency and lead-time. Indeed, the longer lead-times (as usual in offshore outsourcing) implies higher inventory levels to meet customers' expectations and thus raise their associated costs (Kumar and Wilson 2009). This matter is even pointed out as a driver in reshoring and insourcing decisions (Fratocchi et al. 2016; Brandon-Jones et al. 2017). In fact, it has become a challenge to maintain inventory to a minimum when

complex pieces and equipment have been outsourced to distant regions, as in this case study.

- Impact on the assembly/adherence time; that is, the effect of the time delivery of outsourced metallic pieces and equipment on the assembly/adherence time. This operation performs the assembly of individual parts, subassemblies and substances into uppermost components or final product assemblies of a given quantity and complexity in a given period of time (Choi, Chan, and Yuen 2002). Offshore outsourcing has been shown to lead to operational risks derived from the complexity of operations, cultural differences, communication constraints and the geographic distance between the client firm and the outsourced providers (Herath and Kishore 2009), and to lengthen the development cycle time. This fact has been also aggravated by the recent adoption of slow-steaming ocean freight in the shipping industry (Tate et al. 2014), which slows down the velocity of transoceanic shipments. In this way, major delays registered in the client firm's receptions from an offshore provider in turn resulted in delays in delivery to the customer. In order to minimise this issue, this criterion was also added into the cost hierarchy.
- Non-quality cost, also unknown as cost of poor quality, comprises those charges that would not be incurred in the case of the whole products and processes being perfect (Isaksson 2005). Problems of quality in outsourced products or services has been viewed as a disadvantage of offshore outsourcing (Dolgui and Proth 2013) and therefore a driver for reshoring (Fratocchi et al. 2016; Barbieri et al. 2018; Hartman et al. 2017). A quality criterion is normally considered in the selection of offshore outsourcing providers (Wadhwa and Ravindran 2007; Kaur, Singh, and Majumdar 2018; Kahraman, Beskese, and Kaya 2010), but this is not enough to avoid some quality problems. When a faulty piece or equipment is received, the client firm checks it and generates a discrepancies report. The provider then must send a further piece that fulfils the initial requirements agreed upon as soon as possible to the client firm, causing delays in assembly operations and production. All charges derived from receiving faulty metallic pieces or equipment represents a non-quality cost that the client firm seeks to minimise.
- Hourly rate paid by the client firm for receiving the outsourced metallic pieces and equipment in good conditions from an offshore provider. This must be carefully estimated by addressing direct and indirect costs (Smite, Britto, and van Solingen 2017; Marion, Thevenot, and Simpson 2007), as well as hidden costs derived from interaction distance, and cultural differences or inflexibility (Stringfellow, Teagarden, and Nie 2008; Lowson 2002). Regarding getting huge cost savings from its offshore outsourcing strategy, the operation manager emphasised the need to minimise this.

4.1.2 Benefit criteria

The second hierarchy brings together the benefit criteria that the client firm pursues to maximise.

These criteria aim to attain quantitative or qualitative benefits for the client company. Five criteria were defined:

- Work environment improvements in the client firm, since the process generating hazardous wastes at the workplace is outsourced. Offshore providers must also guarantee the safety and health condition of their employees to continue performing the outsourced process. There is a growing concern to manage companies and their operational linkages in a more sustainable way. This matter implies guiding operations towards a compliance with specific environmental, economic and social objectives that represent the triple bottom line (Walker et al. 2014), offshore outsourcing operations playing a vital role to attain them (Resta et al. 2017; Martínez-Jurado and Moyano-Fuentes 2014). One of the social objectives is the improvement of safety and health conditions at the workplace (Giannakis and Papadopoulos 2016), which the operations manager pursues to maximise
- Specialisation improvements or co-specialisation results in greater value-added of the final product delivered to the final client. As the outsourced process is the core business of the overseas providers, this allows the client firm to focus primarily on its core business processes and thus to rethink its business model (Lahiri and Kedia 2011). This is in line with the fact that co-specialisation fosters new generated knowledge (Mukherjee, Gaur, and Datta 2013) and improves client firms' innovation capabilities (Nieto and Rodríguez 2011). If the greater value-added were finally obtained and this was perceived by the final clients, this would lead to increasing the total revenue in the client firm. Hence, the operation manager aims at maximising specialised improvements.
- Increases in cash flow are achieved by driving down unit costs (Stentoft et al. 2018). In the same vein, client firms may reach a higher financial flexibility through the sale of disused assets as a result of outsourcing a process (Dolgui and Proth 2013). The client firm has achieved the enhancing of its cash flow level thanks to lower process costs and material handling costs recorded because the edge finishing of metallic pieces and the equipment process was outsourced abroad. The operation manager wants to maximise this increase in cash-flow as much as possible.
- Reduction of lead-time of the client firm, which is equal to the time that the client firm would need if it had to perform the outsourced process. This term encompasses queue time, process time, the provider's lead-time, move time, wait time and setup time (Tersine 1993). However, Stentoft et al. (2018) revealed firms that have moved manufacturing abroad achieved a lower performance level on lead time than those firms which have maintained their manufacturing at home. Hence, additional efforts will be required to maximise the reduction of lead time. This reduction depends on the completion method applied by providers, although it would be even higher if the lot size or inventory in safety stocks were smaller, or emerging manufacturing technologies were implemented (Dietrich and Cudney 2011; Lin, Chen, and Hsiao 2011; Yang and Pan 2004), among other actions. Since the

client firm follows a Just-in-Time purchasing system, shortening its lead-time is considered a primary criterion.

- Better cooperation in the global Supply Chain (SC) thanks to the introduction of new specialised agents operating in different continents. The expansion and strength of relational ties beyond the client firm's frontiers generated by offshore outsourcing may bring improvements in exportation performance and international competitiveness (Di Gregorio, Musteen, and Thomas 2009; Bertrand 2011). In addition, certain resilience capabilities in the SC would be even reinforced (López and Ishizaka, 2017). For these reasons, the client company seeks to maximise this criterion.

4.1.3 Limiting profile between classes

Three classes, low, medium and high performance, were defined. The ultimate goal was to classify each offshore provider. Therefore, the decision maker also defined the limiting profiles of each class. These are shown in Table 1. For example, the limiting profile low-medium on logistic cost indicates that when this amount is greater than 15% of the total value of the outsourced metallic pieces and equipment, the provider moves from class low cost to class medium cost.

Table 1. Limiting profiles of the criteria

Insert Table 1

4.2 Evaluation of offshore outsourcing providers

According to the methodology applied in this study, the decision maker had to provide several evaluations. The procedures and findings are detailed in the following subsections.

4.2.1 Weight of the criteria

In the first interview, the decision maker separately determined the importance of the benefit criteria and the cost criteria. In doing so, he carried out paired comparisons of cost criteria and benefit criteria in the nine-point scale proposed in (Saaty 1977). We subsequently introduced the extracted judgment matrices in Expert Choice for calculating the priorities with the eigenvalue method (2).

The priorities of cost criteria are depicted in Table 2. Non-quality cost reached the highest global weight of 0.555. Its importance was from 2 to 18.5 times greater than the other criteria. Inventory cost was ranked in second place with a global weight of 0.275. These two costs criteria add up to 83% of the total global weight and therefore offshore providers should have minimised to a greater extent those two cost criteria to provide a good performance to the client firm. Otherwise, offshore providers probably need to improve or even might need to be replaced.

Table 2. Global weights of cost criteria

Insert Table 2

Table 3 shows the priorities of the benefit criteria. The reduction of the lead-time achieved the highest global weight of 0.459. Its importance was from 1.4 to 17 times greater than the other criteria. Cash flow and specialisation were considered as the second and third most important benefit criteria, with a global weight of 0.328 and 0.151 respectively. The importance of these three benefit criteria amounted to 93.8% of the total global weight. The offshore providers should have thus maximised them to a larger extent to provide a good performance. If one of the providers got a negative evaluation in those benefit criteria, it would probably need to be replaced.

Table 3. Global weights of benefit criteria

Insert Table 3

4.2.2 First evaluation

The decision maker compared pairwise each offshore provider with the limiting profile in each criterion during the second interview. The appendix shows an extract of the questionnaire answered. We computed the priorities of each provider and their limiting profiles with Expert Choice. As this software is not primarily designed for sorting decisions, it requires a file for each provider (López and Ishizaka 2017a; Ishizaka, Pearman, and Nemery 2012). Given that we had two hierarchies, we created eight files. The results according to the cost and benefit criteria are listed in Tables 4 and 5, respectively. These tables are used for the assignment of the providers. From the cost criteria point of view, provider 3 achieved a lower value ($p_{c3} = 0.090$) compared to the limiting profile low-medium score ($lp_{c3,1} = 0.289$). Hence, it was assigned into class 'Low cost'. This means that provider 3 generates low cost to the client firm when that offshore firm produces outsourced metallic pieces and equipment. On the contrary, provider 4 reached a higher score ($p_{c4} = 0.728$) compared to the limiting profile medium-high value ($lp_{c4,2} = 0.185$) for the cost criteria. The client company thus regarded it as a provider that generates high costs. Both provider 1 and 2 were classified in intermediate positions, and these were therefore assigned to the class 'Medium cost'.

Table 4. Global priorities for providers and limiting profiles according to cost criteria

Insert Table 4

Concerning the benefit criteria, provider 3 obtained a higher value ($p_{b3} = 0.751$) compared to the limiting profile medium-high score ($lp_{b3,2} = 0.164$) for these criteria and was therefore assigned to class 'High benefit'. Accordingly, this alternative provides the client firm with high benefits when this offshore company makes outsourced metallic pieces and equipment. Providers 1 ($p_{b1} = 0.076$) and 4 ($p_{b4} = 0.069$) were assigned to the class 'Low benefit' since they achieved lower scores compared to their respective limiting profile low-medium values ($lp_{b1,1} = 0.321$) and ($p_{b4,1} = 0.324$)

for the benefit criteria. Nevertheless, provider 2 reached a value between the limiting profile low-medium value and limiting profile medium-high value. This alternative thus provides a medium benefit to the client firm.

Table 5. Global priorities for providers and limiting profiles according to benefit criteria in the first evaluation

Insert Table 5

Results in cost criteria and benefit criteria were not considered in isolation since this might lead to wrong decisions. Hence, we developed a cost-benefit analysis to individually evaluate each offshore outsourcing provider of the client firm. This analysis resulted from the joint understanding of the global priorities for the providers and the limiting profiles according to the cost and benefit criteria listed in Tables 4 and 5, respectively. Table 6 presents the local priorities for providers and the limiting profiles in each one of the criteria. These results will help the client firm to develop a more accurate diagnosis of the four providers' performance in the past, as well as making a concrete decision concerning each provider.

In order to facilitate an understanding of the final decision, Figure 2 represents the case of provider 1. Looking at this figure, it can be observed that this provider led to a medium cost to the client firm. As Table 6 shows, this is due to provider 1 generating high logistic and inventory costs, as well as a high assembly/adherence time for the client firm. These cost criteria are offset by a medium non-quality cost and a low hourly rate, and thus this outsourcing was performed with a medium cost. In addition, Figure 3 depicts provider 1 as providing a low benefit because of a low increase in cash flow, a low improvement in the work environment at provider 1's workplace, as well as a low reduction of the client firm's lead-time. In the light of these findings, it was determined that provider 1 needed to be replaced.

Insert Figure 2

Figure 2. Evaluation of provider 1 in the first evaluation

Focusing our attention on the results of provider 2, a medium cost and medium benefits can be seen, situating it exactly in the middle of the evaluation grid. Accordingly, this provider will need to improve its performance in some criteria. On the one hand, the impact of outsourcing metallic pieces and equipment to provider 2 was low, although the rest of the cost criteria generated a medium cost. As inventory, cost and non-quality cost were considered the most important cost criteria for the client firm, provider 2 ought to mainly focus its efforts on reducing them. This provider would thus provide the client firm with a better performance in a more effective way. On the other hand, provider 2 received either low scores or medium scores in all the benefit criteria. In light of this result, the provider should carry out several actions. It ought to encourage the establishment

of further commercial agreements between its partners and the client firm. It should also allow outsourcing additional functionalities to improve health conditions at the client firm's workplace. In addition, provider 2 offered a medium reduction of the client firm's lead-time, this benefit criteria being the most important. Hence, provider 2 ought to additionally make efforts in this issue. For example, it could implement an automatic completion method and/or look for alternative transportation routes to shorten the delivery time, and thus the client firm might reduce its lot size. If these improvements are achieved, the client firm should carry on outsourcing metallic pieces and equipment to provider 2.

The outsourcing of metallic pieces and equipment to provider 3 led to a low cost and a high benefit to the client firm. Indeed, this caused a low cost in 4 out of the 5 criteria considered. Furthermore, provider 3 offered high benefits thanks to its high performance in specialisation, cash flow and lead-time. Hence, it was concluded that this offshore provider provides a good performance.

Finally, provider 4 generated a high cost to the client firm. More specifically, this offshore provider generated a high cost in 4 out of the 5 criteria, only being low for its hourly rate. That is just the opposite performance of provider 3, where the unique high cost criterion was its hourly rate. Provider 4 also presented a bad performance from the benefit criteria point of view. In this way, this offshore firm brought low improvements in cash flow, lead-time and the work environment. These under-performances were not offset by a medium benefit in the criteria specialisation and a better cooperation in the global Supply Chain. Therefore, it was determined that provider 4 needed to be replaced.

Table 6. Local priorities for providers and limiting profiles according to each criterion in the first evaluation

Insert Table 6

4.2.3 Second evaluation

The first evaluation allowed the client firm to develop a benchmarking of its offshore providers' performances. These results were individually shared with these providers so as to more accurately undertake targeted action improvements. Once the transitional period was completed, the decision maker carried out a second evaluation. The procedure was the same as in the first evaluation. Tables 7 and 8 show the global performance reached by offshore providers according to the cost and benefit criteria, respectively, whilst Table 9 gives a more detailed breakdown of the offshore providers' performance from each criterion perspective.

Table 7. Global priorities for providers and limiting profiles according to cost criteria in the second evaluation

Insert Table 7

Table 8. Global priorities for providers and limiting profiles according to benefit criteria in the second

evaluation

Insert Table 8

Table 9. Local priorities for providers and limiting profiles according to each criterion in the second evaluation

Insert Table 9

Provider 1 achieved a lower value ($p_{c1}=0.154$) compared to the limiting profile low-medium score ($lp_{c1,1} = 0.247$), and therefore was reclassified into the class “low cost”. This was made possible through the development of certain improvement actions. In this way, it was agreed to adopt a vendor inventory management system. This implied that provider 1 takes over maintaining the outsourced pieces and components on consignment until the time these arrive at the client firm’s warehouse. This action enabled a moderate reduction of the inventory cost as well as a small decrease of the logistic cost. Indeed, Table 9 reveals that provider 1 generated a medium inventory cost for the client firm in the second evaluation. This provider also agreed upon maintaining a buffer of finished pieces and components so as to minimise delays and delivery time. Provider 1 therefore managed to cause a low impact on the assembly/adherence time of the client firm in the second evaluation. Furthermore, this provider minimised faulty pieces or equipment submitted on account of automatizing the statistic control of its process. This allowed the generating of a low non-quality cost for the client firm in the second evaluation. These actions involved a rise of the hourly rate paid by the client firm, although, as Figure 9 notes, this continued to be low. Focusing our attention on the benefit criteria, this provider has also generated higher benefits in the second evaluation. More specifically, it attained a value ($p_{b1}=0.187$) between the limiting profiles low-medium score ($lp_{b1,1} = 0.123$) and medium-high score ($lp_{b1,2} = 0.691$) and was therefore assigned to the class 'Medium benefits'. The agreement on consignment material also caused provider 1 to go from generating a low benefit in the cash flow criterion in the first evaluation to a medium benefit in the second evaluation. Considering these advances, it was determined that provider 1 had made important and effective efforts to currently provide a good performance.

In the case of provider 2, enough enhancements in both the cost and benefit criteria to significantly change its ratings were not reported. This provider also accepted to maintain the outsourced pieces and components on consignment during transportation in return for a slight rise in the hourly rate received. As a result, the client firm could drive down its inventory levels in safety stock, and hence achieved a lower inventory cost than in the first evaluation. Notwithstanding, this reduction was not enough to reach the class “low inventory cost”. Provider 2 had also achieved a better performance in the criteria cash flow and reduction of lead-time, although it was again classified between the limiting profiles low-medium and medium-high. In spite of these improvements, provider 2 continued to generate “medium cost” and “medium benefits” for the client firm and, in consequence, further efforts are requested to provide a good performance.

Provider 3 already got a good performance in the first evaluation. Yet, these findings did not hold

up to the progress made with additional action improvements. Both parties agreed on introducing a common measurement analysis system that allowed aligning their quality criteria. By doing so, provider 3 led to a lower cost ($p_{c3}=0.077$) compared to the limiting profile low-medium score ($lp_{c3,1} = 0.303$) or low cost. Likewise, healthier conditions at the client firm's workplace were noted because of outsourcing additional functionalities to provider 3. The second evaluation showed that this provider led to a higher benefit ($p_{b3}=0.764$) than the limiting profile medium-high score ($lp_{b3,2} = 0.163$) or high benefit. The results therefore highlight that this provider 3 sustained its high level of performance.

On the other side of the coin, provider 4 made some progress although this was not enough to improve its performance. From the cost criteria perspective, the logistic cost has changed into the class "medium cost". This reduction derives from starting up making drop shipments through a new logistic operator. This provider also accepted maintaining the outsourced material on consignment until the client firm received it, which moderately minimised the inventory cost of the client firm. Moreover, this action enabled attaining a medium level of performance in both the cash flow criterion and the reduction of lead-time criterion. Provider 4 has also gone from generating a high impact on the client firm's assembly/adherence time to a low impact. This was due to this provider agreeing to maintain a buffer of the finished pieces and components supplied in return for a moderate increase in the hourly rate charged. In spite of these efforts, provider 4 again achieved a higher cost criteria score ($p_{c4} = 0.498$) compared to the limiting profile medium-high value ($lp_{c4,2} = 0.417$), at the same time that it went from the "low benefit" class to the "medium benefits" class. Consequently, it was recommended that provider 4 be replaced.

5. Conclusions

An adapted Cost-Benefit AHPSort was developed to facilitate the performance evaluation of offshore providers. This method provides the benchmarking of provider performance in the outsourced process based on isolated targeted cost and benefit criteria. The results are subsequently represented in a grid that facilitates the decision making in each case.

The usefulness and applicability of Cost-Benefit AHPSort have been proven through evaluations in two different periods of offshore providers in the aerospace manufacturing sector. Since managers pursue minimising cost criteria and maximising benefit criteria in the performance evaluation, these criteria must not be considered in the same way. Therefore, the performance measures were broken down into cost criteria and benefit criteria, which makes the problem more manageable and realistic. Thus, managers will be able to be aware of the negative effect of cost criteria at the same time as the positive effect of benefit criteria in a unique benchmarking of providers. Furthermore, this was set at three performance levels, being clearly defined by the limiting profile on each criterion. The findings contributed to a better understanding of the decision maker about the performance offered by the providers in the outsourced process, both at the global level and locally within each criterion. The decision quality was hence enhanced at the same time

as valuable improvement recommendations to offshore providers were given. They could translate this feedback into coordinated actions that significantly improved their performance, which were post-evaluated again with Cost-Benefit AHPSort.

Other benefits of choosing AHPSort in the selection of offshore service providers are also highlighted from this study. The structured methodology reduces the time and efforts required by managers in the performance evaluation of offshore providers. Furthermore, AHPSort is not only about telling if a provider meets or fails to meet the desired performance. It has also the advantage of providing an exact position as regards the targets [in a decision grid](#). This strong point in the model can [visually](#) help the managers to set their next improvement targets. Looking to future offshore outsourcing decisions, benchmarking would be an excellent mechanism to perform further evaluations, since the whole decision-making process has been already formulated. This would be easily adapted if further elements (i.e., criteria, classes, etc.) are added to the current model.

Our research also provides new advances in the offshore outsourcing literature because it is the first time that a Cost-Benefit method has been proposed to evaluate offshore provider performance. In addition, it incorporates the definition of limiting profiles and classes to make decisions that are more accurate and provide feedback to offshore providers. Additionally, the proposed multi-criteria decision sorting method presents certain strengths in comparison to previous methods. [Cost-Benefit AHPSort solves the problem of the incommensurate ratio scaled derived from the benefit and cost comparison matrices by having fixed benchmarks](#). This allows the minimisation of the cost criteria and the maximisation of the benefit criteria in separated hierarchies, reducing the pairwise comparisons needed in the evaluation phase.

Despite the progress achieved in this article, new issues should be addressed in future studies. Cost-Benefit AHPSort could incorporate fuzzy approaches to handle the impreciseness and vagueness of the evaluation process. Moreover, the proposed method can be easily adopted to track other offshore outsourcing challenges. In this way, it would be combined with other techniques. Finally, since this research was developed in a concrete case, when applying this model to other industries analysts must be aware that other costs (e.g., human resources or talent cost in offshoring design and software development services) and benefits (e.g., strategic flexibility and productivity) could be considered.

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Appendix. Extract of AHPSort questionnaire

Circle one number per row below using the scale:

1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

2, 4, 6, 8 are intermediate values

Question 1. Compare the relative performance of offshore providers with regard to the limiting profiles of logistic cost criterion.

Provider 1

Provider 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile low-medium
Provider 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high
Limiting profile low-medium	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high

Provider 2

Provider 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile low-medium
Provider 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high
Limiting profile low-medium	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high

Provider 3

Provider 3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile low-medium
Provider 3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high
Limiting profile low-medium	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high

Provider 4

Provider 4	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile low-medium
Provider 4	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high
Limiting profile low-medium	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Limiting profile medium-high