



# GAHPSort: A new group multi-criteria decision method for sorting a large number of the cloud-based ERP solutions



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## ABSTRACT

Companies are increasingly introducing cloud-based ERP systems as a solution for integrating all-in-one business functions into the Internet. To support this decision, this paper proposes the Group Analytic Hierarchy Process Sorting (GAHPSort) method, which extends the classical AHP for sorting problems with a large number of alternatives. Our study is specifically based on two steps: Firstly, the cloud-based ERP vendors are sorted with GAHPSort into two classes: accepted or rejected. Secondly, a single solution is selected with Analytic Network Process (ANP) among accepted vendors. To validate our model, we present the results obtained from a real case study.

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## 1. Introduction

Multi-criteria decision analysis (MCDA) methods have been developed to solve choice, sorting, ranking, description, elimination and design problems [1]. Among them, the Analytic Hierarchy Process (AHP) is a useful and widespread method for solving choice and ranking problems [2,3]. It has been recently adapted to solve sorting problems with AHPSort [4]. This means that alternatives are sorted into predefined ordered classes, for example good, average and bad classes. This type of classification is not possible with a ranking method. AHPSort allows simultaneous qualitative and quantitative criteria treatment. This means that a table of performance is not needed a priori. Moreover, GAHPSort inherits the advantages of AHP: it has associated consistency measures. Thus, inconsistent answers from participants can be discussed or discarded. Finally, AHPSort requires far less pairwise comparisons than AHP, which facilitates decision making within large scale problems. As most problems are solved by several people (committees, task force, etc.), we further extend AHPSort to group sorting problems with Group Analytic Hierarchy Process Sorting (GAHPSort) in this paper. This new method has been used to select

the cloud-based ERP system that best suits the adopter firm's needs.

The cloud computing paradigm has in the last years been propagated in the enterprise systems industry. Nowadays, more and more ERP vendors offer cloud-based systems [5]. Unlike on-premises packages, cloud-based ERP applications do not locate end-users' data and computing resources in the IT infrastructure of the adopter company [6]. These are based on a distribution computing architecture that allows its users to easily access software and associate data in the cloud at any time and regardless of their location [7]. The complexity of the in-house IT infrastructure thus decreases, thereby leading to a reduction in capital expenditure [8,9] have found that cloud computing investment significantly increases the firm's market value.

Cloud-based ERP packages are not licensed or owned by the adopter firms. They only pay a monthly fee for the services that they use in the cloud, enabling operative cost savings and a more efficient use of IT resources [10,11]. The cloud computing model also provides other benefits to business performance derived from the improved productivity, security, flexibility, and scalability of enterprise IT infrastructure [8,12–14]. Likewise, it makes the deployment and upgrade of IT-related resources easier, allowing a continuous and agile alignment between the rapidly changing business need of the adopter firm and its operative ERP.

Given the above-mentioned benefits, more and more firms are currently deciding to adopt cloud-based ERP applications. A study

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of [15] estimates that cloud-based systems accounted for 2% of the total ERP market by 2011, although this figure was expected to grow by about 21% annually through 2015. In order to attain the expected benefits derived from cloud-based ERP adoption, the selection of the most suitable package from among a large number of options on the market is a critical decision. In fact, a wrong choice can adversely affect the adopter's performance [16,17].

Selecting a cloud ERP system can be considered more challenging than choosing an on-premise ERP. Cloud ERP services are still new and unfamiliar to firms in comparison with products offered in the mature market of traditional ERP systems. [18] carried out an extensive market analysis of 651 cloud providers for enterprise systems. They point out the lack of transparency in the cloud providers market, which make cloud enterprise system selection more difficult. Some cloud ERP packages do not even provide the advanced functionality of classical ERP systems [19]. In the same line, a recent report reveals companies carry on largely implementing on-premise ERP rather than cloud ERP [20]. This also denotes a lack of understanding of cloud products and the perceived risks of security breaches.

As a result, when a firm decides to adopt a cloud ERP system it is advisable for it to carry out a screening of cloud technology providers. Accordingly, we propose a two-step based selection framework based. In the first step, the most relevant criteria in the evaluation of cloud-based ERP vendors are identified and cloud ERP vendors are screened with GAHPSort. This method provides a comprehensive way to sort cloud ERP providers into different classes, considering multiple conflicting criteria. Moreover, decision makers can establish additional criteria and constraints using the limit profile mechanism. The results enable them to substantially reduce the initial number of alternatives following the company requirements, at the same time as decision makers attain a better understanding of solutions offered by cloud ERP providers.

GAHPSort sorts alternatives, while traditional MCDA methods, such as AHP, TOPSIS or ANP, prioritize them. According to Vetschera [21], "sorting is significantly different from ranking or choice and therefore requires the use of specific methods". Hence, GAHPSort cannot be used alone to select the most appropriate cloud ERP.

In the second step, the cloud-based ERP systems of the qualified vendors are evaluated with ANP (Analytic Network Process (ANP)). Saaty provided this as a generalization of AHP [22]. ANP has proven to be an effective instrument for supporting ERP selection process [23–25]. This is specifically very suitable to solve problems when the decision criteria cannot be organized in a unidirectional hierarchical way, by applying a network structure. Furthermore, ANP allows considering feedback between criteria. It has proven to alter the final ranking of ERP alternatives [26]. TOPSIS has also been applied in the ERP selection process [27]. However, this method has the weakness of assigning reliable subjective preferences to the criteria. By contrast, ANP is considered a very valuable mechanism when subjectivity exists. To use this, decision makers evaluate criteria using pairwise comparison. Subsequently, ANP enables estimating the relative importance of the weightings of each criterion considered in the cloud-based ERP system selection process. In addition, it generates a cloud-based ERP systems ranking according to the company's requirements and expectations.

In the following sections, we introduce related works and the theoretical focus upon which this research is grounded. Section 2 introduces the cloud-based ERP systems. Section 3 describes the studies developed for supporting the selection of the accurate ERP system. The technique proposed for sorting cloud ERP vendors is detailed in Section 4. Section 5 presents the case study carried out in order to validate our proposal. Finally, Section 6 provides

conclusions as well as possible directions for the development of related works in the future.

## 2. Cloud-based ERP systems

The adoption of advanced technology solutions by companies is taking place at an accelerated pace. Continuous advancement in information technology (IT) has been modifying the ways we do business. This has motivated a transition from an industrial economy to a network economy [28], where companies take part in a hyper-connected world over the Internet [29].

In the last few years, there has been a growing demand for cloud-based technological resources. A report [30] suggests that the share of the cloud-based market will reach \$244 billion by 2017, growing by a compound annual rate of 17%. Cloud-based tools are developed, deployed, delivered, used, and maintained as virtualized computing services on the Web [31]. Adopter companies can thus easily access a shared pool of configurable computer resources [32], purchasing only what they need and paying for only what they really use.

Enterprise Resource Planning (ERP) packages are among the most widespread enterprise applications. This is due to these solutions integrating the whole business functions, improving their productivity and operational efficiency [33], providing more accurate information to business decision making, and, finally, improving financial performances [34,35]. ERP helps companies to gain or maintain competitive advantages over competitors [36]. Nonetheless, the ERP adoption process is never exempt from challenges and significant hazards [37–40]. In spite of this, numerous companies assume the associated risk and they get the ERP adoption process underway.

The emergence of the cloud computing phenomena is specifically transforming the way ERP solutions are designed, developed, supplied, implemented, updated, maintained, and even paid for. The majority of today's on-premise ERP vendors have expanded their products portfolio with cloud-based ERP solutions, and at the same time new providers have entered into the market [5].

Firms are increasingly adopting cloud-based ERP solutions to re-invent their enterprise systems, decreasing their complexity and costs derived from hardware, software, upgrades, and IT support, and thereby improving their productivity, scalability, and flexibility and making an agile deployment of services easier [8,10–14]. Cloud ERP adoption also makes better use of the IT resources available, enabling access to data and services system functionalities.

To achieve the expected results of ERP adoption, it is necessary to choose the package that best suits the firm's requirements [41]. However, no single ERP commercial solutions can meet all business needs and the specific particularities of any adopter firm [17,26]. Likewise, ERP system selection is a difficult and highly complex undertaking, owing to the great number of ERP vendors and packages available in the market, the limitation in available resources, the continuous improvements and upgrading in IT, the existence of interdependences and incompatibilities between the old and new hardware and software systems, the complexity of the business environment, and decision makers' lack of knowledge and experience for system selection decision making methods [42,43]. This has led to the development of numerous studies which support the ERP system selection process in a better and more structured way. The next section examines these studies in detail.

## 3. ERP selection studies

Choosing the most suitable ERP package from among a large number of options in the market is a complex and uncertain

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