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Integrated Management Solution for a Sustainable SME—Selection Proposal Using AHP

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Abstract: In the conditions of the pandemic crisis, implementing an enterprise resource planning (ERP) system with a sustainability component represents a crucial investment for a small and medium enterprise (SME) but critical for the organization, if it is not the matching solution. A comprehensive framework for selecting the S–ERP system was elaborated, including a set of relevant criteria for an SME to draw and assess the selection of an ERP system, considering that the factors extracted as well as the importance in the proposed model have been debated for years in the available literature. A methodology based on the brainstorming and questionnaire techniques was proposed in establishing the selection criteria, and the AHP decision analysis method was used for evaluating the weight of the criteria, all these in order to provide a model for ERP selection. This model was tested on a set of numerical, hypothetical, and applied data of the Romanian context. The use of the recommended model shows that it can be applied to improve decisions and decrease the time interval required for S–ERP selection. The results also show that AHP can fulfill the S–ERP selection objective for SMEs and the decisive factors that affect decision–making processes in a systematic way.

Keywords: sustainability; enterprise resource planning (ERP); small and medium enterprise (SME); analytic hierarchy process (AHP)

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1. Introduction

The star actors of economic life in the current digitized and digitalized era with strong and continuous digital transformations are technology, companies, and sustainability. Their alignment, or in other words, their collaboration, means that perhaps the most popular and valuable technological solution in business, namely enterprise resource planning (ERP), can receive new tasks in the field of sustainability. Intense competition in all economic spheres has led small and medium–sized enterprises (SMEs) to appreciate that a proper ERP solution is able to influence their business strategies, competitiveness, and sustainability clearly and categorically [1–3].

Sustainability is considered today a strategic and innovative engine that offers a clear competitive advantage [4]. Companies identify a key differentiating factor in sustainability and recognize that it drives business innovations in all economic and social areas. Historically, only large organizations were regular ERP customers. Nowadays, organizations of all sizes, from all industries, use ERP software [5,6].

Along with the massive rises in technological evolution with low entry costs, ERP software progress has unlocked many innovative and specific ERP options. A new generation is required, allowing for the reconsideration of traditional processes and user interfaces. ERP software becomes more accessible, more flexible, more specific (individualized, beyond a customization stage), allowing small and medium–sized organizations to step up and compete with what was once unattainable. Even the top ERP software vendors, such as SAP and Oracle, have focused on building specific ERP modules, niche solutions, which are accessible to SMEs [7,8].

In the last period, there has been a significant interest for the notion of sustainability for business development [9]. It is clear for all that sustainability is very important not only for large corporations but also for SMEs [10,11]. In this context, "environmental and social concerns, such as the rising prices of energy and increasing community involvement, can pose significant challenges and offer great opportunities to SMEs" [12] (p. 1360).

When talking about sustainable environmentally friendly practices, it is possible and very probable to expect SMEs to adopt an ERP system as a tool of progress and to fulfil the sustainability criteria. Due to SMEs' rapid growth, attaining a fully integrated ERP system in dynamic circumstances, such as applied sustainability principles, involves a well–organized feasibility analysis and well–managed implementation procedures [13,14].

A company's sustainability strategy must consider not only the business processes but also the basic system or systems that support the business processes [15]. An enterprise resource planning system that is outdated, fragmented, and lacks real–time information can increase costs and harm the environment. Ursachescu et al. [1] indicate that companies focus on the main advantages of ERP systems, the so–called operational and functional aspects, and to a lesser extent on the sustainability benefits.

Adopting an ERP involves the selection decision. A selection team may include internal/external IT staff, company staff who will use the integrated system, external experts, or consultants from companies that sell software. An incorrect selection of the ERP system can collapse the project or reduce it unfavorably and can prevent the company from working efficiently. ERP is a difficult and laborious task attributable to the deficiency of existing resources, the complex nature of ERP software and the many ERP options available on the market [16,17].

When we analyze in what manner organizations decide on the projects to be implemented, we observe a continuous aspiration to have "clear, objective and mathematical" standards [18]. Nevertheless, decision making represents an entirely rational and cerebral process brought about by the most appropriate selection, founded on perceptible and imperceptible criteria [19], arbitrarily selected by decision makers [18].

Selecting the right ERP software for a company can led to many business benefits if leaders consciously use the best methods and practices in the software selection process. The decision of ERP selection becomes complicated, as the holistic landscape of the latest generation of ERP technology speedily changes with the advance of social media, cloud computing, and big data [20]. Currently, any SME is compelled to consider moving to "As–Service" ERP systems and abandoning outmoded "On–Premise" ERP hosting habits [21]. There are several elements that are considered to be important in achieving success in a selection process; among these, we mention the following criteria that are take into account [7,8,22]: the advice of software vendors should be one of the criteria but not a very important one; company's staff must be involved in the process of S–ERP selection in order to be able to empathize with the change brought by it; management staff must have technical knowledge about the future system but also business knowledge in order to negotiate with suppliers. In other words, it is necessary to create an S–ERP selection team made up of company employees, with various specializations, who know the business and the company's culture very well and who are motivated to use the chosen system [8,22].

As with most of the multiple–criteria decision–making (MCDM) [22] approaches, the analytic hierarchy process (AHP) method pursues values relying on: (1) the presence of criteria and other alternatives or courses of action, (2) the analysis of the status of every criterion but also on the effect of every alternative to it, and (3) categorizing every possible one in order to find the finest. Alternatives embody the options of the decision–making authority, while the criteria are the decision limitations [23]. The AHP method was widely utilized for selecting the right brand–named ERPs in large organizations. Wei et al. [24] used AHP to decide on an appropriate ERP system for a Taiwanese electronics firm. Other researchers [25] used AHP to pick out ERPs for African organizations. We also found that there were more than a few studies based on AHP for selecting ERP software, providers, or even specific modules [26,27].

Various organizations are commencing to incorporate sustainability into their business processes, thus helping to reduce environmental issues. They need to align their sustainability strategy with their business model, while IT is envisaged to have an important role in attaining the objectives of sustainable business.

In order to reach the planned efficient alignment among business processes and sustainability, organizations need sustainable enterprise resource planning (S–ERP) systems. As with any other ERP implementation, implementing such systems has the same complexity, perhaps even more, in our opinion. Practitioners need guidance to provide details on the implementation of S–ERP systems. The research literature examination showed only some degree of guidelines, with several steps for the implementation of S–ERP systems or simply considerations about S–ERPs' advantages and disadvantages.

These facts inspire our research to support the reason that the incorporation of sustainability components in ERP systems is related to the capability to utilize IT in an innovative manner. In this context, we show that if even the selection practices include criteria to enhance the sustainability feature of an ERP system, firms would be more conscious of the relationship between technology and sustainability. All this made us consider as opportune the realization of our model to be used by the team of negotiators of the company in relation to the ERP vendors. The literature review uncovered only limited guiding principles that offer different steps for implementing S–ERP systems.

Based on our knowledge of the SME market in Romania, we aimed to approach the selection process of the most suitable ERP with implications on the sustainability of a company, to gradually describe a selection model of an S–ERP for SMEs based on the AHP method, implemented in Microsoft Excel, a largely popular software in our country. In a search on Google Trends, in 2021, Excel is still the most popular spreadsheet editor in Europe. In the following sections, we explain our research approach, which we appreciate as a novelty in Romanian studies.

Given the environmental impact of using an ERP, the purpose of our study is to present a model for selecting the most suitable S–ERP for an SME using the company's workforce, without incurring additional costs.

The research question that guided this study, at the same time a minus of current research, sounds like this—Can a model of selecting the best S–ERP for the company be made "in–house", based on employee knowledge (business knowledge, organizational culture, Excel, AHP), as a system that ensures the sustainable alignment of the company?

Our study responded to this question, concentrating on crucial aspects in selecting an integrated system—the selection criteria, using Excel, and using AHP, all at no additional cost. The core contribution of this study is displayed in a dual viewpoint. First, it offers a theoretical framework for training future specialists in economics and to reflect the closeness of economic studies to real life; second, given the criteria and the proposed model, companies can carry out a process of scientific selection of an S–ERP, in a greener approach.

In this paper, we indicate essential criteria affecting SMEs for decision–making process in the selection of a sustainable ERP system. We reached the criteria after a methodical review of the specialized literature. At that point, we chose three hypothetical S–ERP systems as alternatives, specially developed for small and medium–sized enterprises. All criteria and alternatives were then structured as an AHP hierarchy with the aim of selecting the most appropriate system among the other sustainable alternatives.

We employed the AHP model, designed by Saaty [28], for selecting and evaluating the ERP that shapes sustainability in SMEs, in which the objective followed has several, often contradictory characteristics. Even if AHP seems simple as a concept, mathematical calculations can be time consuming, so adequate software is needed [29]. Even though the S–ERP implementation process encompasses a few stages, we focus on and examine the S–ERP selection. Our research offers a comprehensive conjectural case study performed in a Romanian SME.

From the published studies, even during the pandemic, it is estimated that the issue of adoption and implementation/re–implementation of an ERP is still very current. Most of these articles focus only on adoption theories, on criteria and categories of criteria to be analyzed, on the correspondences between the criteria, and last but not least, on the frameworks, stages, steps required for an implementation or re–implementation [21,23,30–36]. Some of the reasons that led us to conduct this case study was that even if it presents the perceptions of suppliers and customers, there is a lack of studies in terms of developing a selection model that is very simple, very clear, and developed on their own "in–house". This aspect can be amplified by the idea that there are certain significant gaps/differences in terms of selection criteria and model based on areas of economic, local, and regional development.

The rest of the article is structured as follows: Section 2 comprises the related literature, which is followed by the research methodology and case description in Section 3. Section 4 illustrates the results and discussion according to the AHP numerical model, and finally, the conclusions of our research are represented in Section 5.

2. Literature Review

2.1. SME's Sustainable Development

The SME sector in Romania is currently considered by the European Commission in 2019 to be an expanding one [37], with 485,757 SMEs representing 99.7% of all enterprises in the Romanian economy. Of these, 430,925 are micro–enterprises with maximum 9 employees (88.4% of the total enterprises), 46,299 small enterprises with maximum 50 employees (9.5% of the total enterprises), and 8533 medium–sized enterprises with maximum 250 employees (1.8% of the total enterprises). Compared to the EU–28 average, which in 2018 was 56.7%, the added value brought by SMEs in Romania represents only 52.7%. Following the global crisis caused by COVID–19, preliminary statistical reports show a preservation of the share of SMEs in the total number of Romanian enterprises. In this context, the flexibility and adaptability of SMEs are considered key factors in the recovery of the national economy and the recovery of economic growth [38].

Sustainability represents an economic concept that gives importance to the community and the environment in the context of an obvious economic goal—profit. A business becomes sustainable using innovative techniques, the transition to green technologies and investment in the future by stimulating creativity [39]. A business's sustainable development strategy should consider the following main goals [40]:

- The optimal allocation of resources, which should consider not just economic efficiency but ecological and social efficiency at the same time. Economic efficiency has its important role for the well–being of each person, determining a social efficiency, while ecological efficiency has the role of preserving present resources for future generations.
- The optimal distribution of resources, which brings into question the need to address intra–generational inequity caused by the global situation, with billions of dollars spent on armaments and over billions of people living in developing countries.
- The optimal ratio between the place occupied by humans and the place of other life forms on the planet.
- Sustainability, sufficiency, equity, and efficiency should be the basis of sustainable development strategies, in this order of priority and importance.

There are authors [41,42] who highlight the difficulties of implementing a sustainable development model in companies, especially in the case of SMEs. In this sense, Costache et al. [40] by citing Gilespie [41], find that this difficulty in implementing sustainable development is related to a complex issue involving multidisciplinary interactions in areas such as philosophy, law, and economics.

In this complex and multidisciplinary context, we must consider another aspect, namely, that SMEs represent important resources in the activity of innovation, which is also related to sustainability issues [42]. We must also note that these SMEs also have a niche market orientation, easily adapting to demand changes and to the specificity of the products offered. Many studies about the implementation of sustainable development guidelines emphasize the importance of founding managers' decisions at the level of an SME [43], with strategic impact in the direction taken by the company.

The Romanian Government issued new initiatives in 2018 to stimulate the development of SMEs by funding from the Romanian National Program for micro–industrialization with grants of up to EUR 95,000, including the implementation of ERPs to develop a "micro–industrial" sector to contribute to the national economic growth [44]. Therefore, there is an important necessity for the digitalization of SMEs in our country, attributable to the fact that in terms of connectivity Romania ranks 11th out of 28 states in 2020, as shown in the Index of the Digital Economy and Society (DESI) [44,45]. Related to this aspect of digital maturity, according to the White Paper of the Romanian SME, the main elements used in this area can be listed as follows: computers (89.93%), email (88.14%), Internet (88.14%), Intranet (50.61%), social media (43.10%), the company's own website (34.62%), and online transactions (7.51%) [45].

ERP implementation can assist SMEs in improving their effectiveness. Nevertheless, they must wisely ponder every decisive aspect in order to make sure of the success of the ERP implementation.

In this regard, the adoption of ERP at the level of SMEs is a consequence of a complex of factors that arises from the need to adapt to the market but also very often from the decisions taken at the level of the founding manager.

The process of ERP adoption, as a support in the implementation of sustainable development policies and strategies for SMEs, must overcome specific barriers that include the limits given by the impact obtained and the associated benefits [46]. For that reason, in the scientific literature were identified three principal barriers [47]: deficiency of awareness of the effects and advantages related to the implementation of sustainable policies, deficiency of resources and time, and that of competences and know–how.

Through its construction phase, an ERP system has the ability to integrate and restructure business processes by providing an integrated set of functions, thus reducing costs and improving quality, leading to economic and commercial developments, social equity and justice, and environmental protection [48–50].

2.2. The Relationship between ERP and Sustainability

ERP systems have a growing potential for SMEs, and software vendors concentrate on this prospective market to provide advantageous solutions, such as cloud–based systems at lower investment and management costs, unlike the traditional ERP systems. The new ERP systems implemented in SMEs could allow them to join other top companies in the field for a sustainable and competitive growth. Environmental decisions of companies is also able to play a role in the creation of a more sustainable business ecosystem by improving efficiency across the supply chain, reducing waste considerably, increasing ecologically conscious customers, etc. [51,52].

Studies on long–established ERP systems have mainly concentrated on large companies, and there are numerous fissures in the research literature regarding the offer of new technologies for SMEs, both from the perspective of the seller and the consumer. Just like the rest of the companies, SMEs aim for a good value for money in implementing an ERP, which leads to an increase in productivity, as well as a good balance between cost and profitability of their invested money, increased data security, and improved performance, efficiency, and functionality [9].

In order to diminish environmental problems, several companies have started to incorporate sustainability in their business processes and want to bring the business sustainability approaches into line with the value chain. In order to achieve this strategic configuration, organizations necessitate sustainable ERP systems to join all sustainable business processes, also leading to better collecting, processing, assessing, and reporting of data and information. Nevertheless, S–ERP implementation should involve integration, and guidance for specialists on this process. Whether sustainability is brought to the forefront of the company through regulations or innovations, we must also consider the impact that the current or future ERP system has on the environment [51].

An ERP system joins together the tasks within a company and offers top acquiescent procedures to augment existing business processes by redesigning operations. It helps organizations reduce costs, integrate resources, share information efficiently, and handle functions seamlessly.

When considering the reduction of paper consumption and printed documents usage as a result of ERP implementation and enhanced efficiency, it is most certain that ERP systems can cope very well with the three main sustainability pillars: individuals, environment, and profit.

ERP systems can constructively favor sustainability strategies in several ways, by furnishing: ERP systems can constructively favor sustainability strategies in several ways, by furnishing some important constituents, such as [14] appropriate organizational environment for adopting a good sustainability strategy; tools for measuring and monitoring the consumption of data and information; suitable information on material costs, overheads, instrument panels, and data sharing for the benefit of everyone in the company; specific tools focused on sustainability to diminish the adversative influence (asset management, supply chain optimization modules, product life cycle management) [14].

There are a few major constraints for SMEs when adopting an ERP system, for example: cost efficiency, alignment of software and business processes, training, personalized governance, etc. [13].

Today's European and global strategies aim to achieve bold goals of reducing carbon emissions. In order to achieve this, detailed and timely information is needed in companies on carbon in product assortments, alongside processes and supply chains, which can be achieved through modern ERP systems. Zvezdov & Hack [53] identify several effects after scaling the carbon footprint in a food company's product based on ERP and recommend a way in which to use of such systems to increase general efficacy and performance for a more sustainable business ecosystem.

There are concerns among researchers about the environmental sustainability in companies and the introduction of innovation in technology to reduce resources, power consumption, and consolidated hardware assets by creating data centers and virtual environments [54]. They emphasize the need of E–waste reduction through optimizing the technologies of green computing, such as virtualization, cloud computing, grid computing, green data centers, etc. Kewat et al. [55] present their study on the trends and challenges of green computing, named "environmentally sustainable" computing, which focuses on diminishing resource/power consumption and adjusting the use of electronic waste, covering several aspects of technology, computing methods, energy efficiency, hardware recycling, and industrial policies. E–waste is a fast–growing waste stream, about 1% of the total solid waste in developed countries [56], while the recycling or reuse of computing equipment represents an important issue to green computing for governing the achievement of sustainability in an organization.

2.3. Criteria for S–ERP Selection

A sustainable ERP (S–ERP) becomes a chief nucleus for enterprises, which endeavor to confirm sustainability in their business. Nevertheless, choosing an S–ERP can become a key test attributable to the presence of some factors. Chofreh et al. [21,57] proposed the incorporation of sustainability parts in an ERP system with the intention of resolving the deficient integration of business functions and the necessity for sustainability.

The concept of a sustainable ERP system (S–ERP) is claimed as an all–inclusive and consolidative information system, which is powered by the concern for sustainability, covering all features of the value chain [58]. It is estimated that research in the S–ERP system is in its early stages, meaning that numerous studies can be conducted in this field.

Production, sales, services, and other and specific sustainable SME operations have developed as a central issue in the current setting for any company. Nowadays, any company is very interested in becoming sustainable in all three aspects: economic, social, and environmental [59]. Implementing an ERP with a sustainability component and that runs on a vendor's cloud platform should help companies "achieve sustainability".

The selection of ERP technology is considered to be a serious decision for investment and to also be critical to stay competitive [21], while technological sustainability through Social Networking, Mobility, Analytics, and Cloud computing (SMAC) is seen as a significant factor in the selection phase, in addition to connecting ERP solutions to business, IT functions and strategies. A wide–ranging strategic decision framework named "E4–arrowhead" [19] was made for the methodical selection of a suitable ERP solution, founded on five criteria (technology, functionality, TCO, provider, quality of software) evaluated on AHP methodology. There were also common sub–criteria originated for comparing the solutions, SMAC for ranking sustainability, and it was demonstrated in a case study the superiority of SMAC–ERP, the practical integration of the ERP system in the automotive industry from India [21].

Choosing the right indicators for evaluation is a complex and vital challenge for everyone [60,61]. There are several risks of choosing incorrectly, misusing indicators, or misinterpreting them, and all these may possibly result in misleading decisions. In addition, not all existing indicators can simply be utilized in every sector, considering that is very difficult to regulate which indicators to implement, as some of the indicators may be efficient while others may not [62]. To some extent, in order to choose the suitable indicators for sustainability assessment, it is essential to closely select the indicators together with the industries involved.

Despite the complexity in choosing appropriate and appropriate sustainable indicators and criteria, there are guidelines regarding the characteristic of indicators from previous studies [62–64] that can be utilized to support their process of selection [65].

The most extensive paper [65] considers 63 initial sustainability indicators, where each of them are grouped at the respective dimensions of performance in sustainability, specifically indicators for economic, social, and environmental performance. About 32 are selected as sustainability indicators, of which 11 of the indicators are listed as economic performance indicators, 9 indicators are listed as social performance indicators, and 12 indicators are listed as environmental performance indicators. Nevertheless, even the authors of the study acknowledge that not all of the 32 indicators have been recognized as significant in sustainability performance (in the last 10 years of academic literature review) [65].

In one of our last studies [29], we considered a view expressed by Deloitte & Touche [31] with successive interviews with representatives from the companies implicated in two ERP implementations. Initially, they implemented an ERP system and considered specific criteria, then they had a second implementation with criteria in another order of importance due to the experience and knowledge gained (which are probably missing at the time of the first acquisition/implementation), which offer an idea about an improved selection guide [29].

SMEs have a dynamic nature, necessitating a nearer examination of their business needs to avoid inadequacies. Venkatraman & Fahd [13] categorize the significant factors of a successful ERP implementation in SMEs by comparing them with the achieved results: aligning the ERP system with business processes, fulfilling the needs of clients and stakeholders, cutting down recurrent and maintenance expenses, aligning business and IT strategies to the client focus, and the adaptable reporting attributes of up–to–date ERP systems.

Due to the variety of factors that play an important role in making decisions for ERP selection, there is a need to rank and concentrate on those critical issues that can help ERP vendors to better understand the expectations of an SME. The limits of expertise, time, and cost for SMEs must also be considered. Bharathi & Mandal [9] conducted exploratory research on a group of consultants, ERP implementation partners for SMEs, and employed AHP to set priorities and classify critical factors for cloud ERP adoption.

They addressed 17 detailed factors classified based on costs, security, organizational factors, ERP performance, and functionality and showed that the factors related to costs (e.g., subscription, maintenance, and implementation costs) were included in the top 5 factors in the ranking. Supplementary factors involved service–level agreement conditions, the cost of IT resources, data security, and confidentiality [9].

Other authors [66] highlight the sustainability of an enterprise as an essential element in the development process and which confers a competitive advantage, while managers need to assess the durable dimensions and actions needed to increase the company's sustainability. They talk about the deficiency of a specific Sustainability Assessment (SA) method, incorporated with the processes within a company which are settled and assisted by the ERP system, and propose a methodology for the implementation of a S–ERP system in production SMEs because implementing a sustainable development in SMEs happens on a smaller scale compared to large companies. The approach proposed by Patalas–Maliszewska & Klos [66] aims to integrate the ERP implementation and measure sustainability based on criteria for the integration of sustainable production and business processes backed by the ERP system, SA–quantifiable indicators, and its relation to the ERP system.

Chofreh et al. [48] address the notion of sustainable enterprise resource planning (S–ERP) as a category that enables the process of integration between sustainable business units in the organization. These types of systems have emerged because traditional ERP systems are not able to assess sustainability indicators, such as the volume of resources used for production processes and the environmental impact. Although S–ERP implementation may be more problematic than traditional systems because they ought to take into account three features of sustainability (environmental, economic, social), they have a significant part in supporting the effective implementation of sustainability in organizations [20] and in reducing the ecological footprint during business processes. In another study, Chofreh et al. [58] propose and evaluate the guiding principles for implementing S–ERP systems through three main constituents (implementation steps, levels, activities) and state that practitioners need to firstly move to sustainable business, after which S–ERPs can be utilized as support tools of sustainability practices.

Another one of the few studies addressing the implementation of ERP for SMEs belongs to Alsharari et al. [67], who discuss implementing cloud ERP in SMEs in the United Arab Emirates and evoke three sets of factors (environmental, management, technological) shaped by this implementation. The authors take into consideration a cloud services market estimated at USD 1 billion in the United Arab Emirates, and one of the most rapidly rising world markets, although their country is still in the initial phases of the implementation. The cloud ERP model under the new regulations determines the slight expansion of business potentials and the acceptance of the "payment model" giving UAE SMEs an important competitive advantage [67].

In our search for studies that reflect the selection criteria of sustainable ERPs for SMEs, we found very few articles that reflect this fact. Moreover, there are few current studies that address the selection criteria of ERP for such enterprises, these being the focus of ERP manufacturers and implementers, especially in recent years. From this point of view, we try to bring something new, looking in the literature for the selection criteria of ERPs for a variety of companies of different sizes and fields, and proposing our own list of sustainable ERP selection criteria for SMEs.

We have compiled our list of criteria, starting from important studies conducted in the last decade for ERP selection, studies conducted by researchers from all over the world, from academia and the business arena, who commenced with case studies on one or more companies, interviews with managers and employees involved in the selection process, questionnaires, etc. Many of these criteria were found in most of the articles studied, being general criteria considered when selecting ERP systems, but some of them are more specific and novel for sustainability and SMEs (feasibility and quality of documentation). Feasibility is considered an important criterion to assess the ERP system's outcomes on sustainable development (considering also features on business travel, asset life cycle, user behaviors [1], while quality of documentation refers to the good quality manuals, procedures, plans, and work instructions related to the ERP system. Furthermore, the consideration of cloud ERP solutions [20] can offer an advantage both in terms of price compared to the classic solutions implemented on premises but also of energy efficiency in relation to the resources used in the data center.

All these criteria affect decision–making processes for the selection of the suitable S–ERP for Romanian SMEs. We must mention that the list for S–ERP selection contains both quantitative and qualitative criteria, and it is problematic to assess every one of them. Nevertheless, these kinds of difficulties may well be resolved by means of AHP.

3. Research Methodology

3.1. Collecting Data

Our study concentrates on the selection of a suitable S–ERP system for Romanian SMEs. For deciding on a sustainable system, we must outline the criteria involving the decision–making process. The existing S–ERP solutions ought to be assessed, and then the systems specifically developed for small to medium–sized companies should be identified among them. Henceforth, AHP is used to select the appropriate S–ERP for such a company. In Figure 1, we present the research methodology of this study.

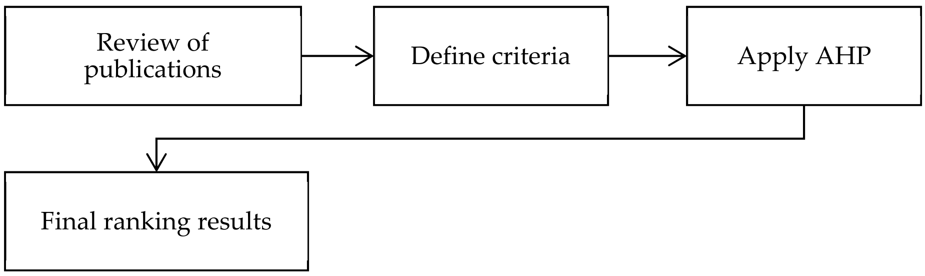

Figure 1. Research methodology framework.

It is recommended to create ERP selection teams to collect software requirements and participate in ERP vendor demonstrations. The team must take in at least one employee from each business unit, location or department. They should, at the same time, understand the way the business works relative to their department, and have a handle on the upstream and downstream processes in every functional area [7,8].

After brainstorming sessions conducted by the authors of the article (based on their teaching experience on ERP and Decision Support Systems (DSS) courses), after discussions with over 300 students from business specializations, we continued with the criteria presented in Table 1 Criteria for S–ERP selection.

Table 1. Criteria for S–ERP selection.

No	Criteria	Short Description	Articles
1	Functionality	Sufficient functions to fulfill all the requirements of an SME, (feature requirements, technical features, capability)	[1,20,23,29–36]
2	Ease of Use/usability	Ease of navigation, operability, comprehensibility, and learnability of the ERP to be user–friendly and to attain effectiveness and satisfaction in a specific use background	[1,21,23,29–32,35,36]
3	Feasibility	Assesses the outcomes of the ERP system advancement and implementation on sustainable development, integration, and performance	[1,36]
4	Portability	Efforts to transfer ERP from between different hardware platforms or software environments, mobility	[1,21,31,33,36]

Table 1. *Cont.*

No	Criteria	Short Description	Articles
5	Cloud ERP options and Energy Efficiency	ERP system runs on a vendor's cloud platform; optimization of ERP system's energy consumption in relation to resources used in the data center.	[1,21,30,31,33]
6	Ease of Implementation	Implementation time, pace, and difficulties of integrating business modules in the ERP system	[23,29,30,32,33,36]
7	Price of Software	ERP cost, affordability, detailed costs, total cost of ownerships (TCO)	[1,21,23,29–36]
8	Quality of Documentation	Quality manuals, plans and procedures, work instructions	[29,36]
9	Level of Vendor support	Technical support, consulting, education, maintenance, training, reseller support	[1,21,23,29–33,36]
10	Developer's Track Record of Performance	Vendor ecosystem, vendor's technical capability and credentials, vendor reputation and experience, credibility of the system, community of customers and case studies	[1,23,29,31–34,36]
11	Ability to fit to Business	Business strategic fits, compatibility, customization/parametrization	[21,23,29,31–36]

Thereafter, we present a suppositional example based on the opinions from [68,69] to illustrate the ways in which the AHP process can be utilized.

3.2. Analytic Hierarchy Process

AHP is employed as a methodology in our study because it appears to be a widely held multiple–criteria decision–making instrument for originating and studying decisions. At the same time, it is seen as a logical MCDM practice that helps decision bodies to shape multifaceted problems founded on human psychology and on mathematics [28,70,71].

AHP involves the decomposition, measurement, classification, organization, and analysis of complex problems by transforming it into a hierarchical structure which has dissimilar demarcated levels (e.g., purpose, criteria, sub–criteria, alternatives) [28,59,70]. It is recommended as an improved instrument because of its rapid applicability and usability [72–75]. It is acknowledged by numerous decision makers for its critical features as being suitable for various applications, and its results proved to match the expectations [76].

We retained from Tasnawijitwong and Samanchuen [23] another essential AHP characteristic: the possibility to assess between dissimilar criteria (qualitative and quantitative), allowing a minor inconsistency, because human decisions are not always consistent. A convincing feature of AHP is this ability to detect inconsistent assessments based on computing consistency ration.

The general purpose of the AHP is to create a matrix that indicates the relative importance of a factor over another. Given the relative importance, it represents a numeral on a custom scale adapted from Saaty from [18,23,27,59,76] (Table 2).

A fundamental notion is as follows: if a certain factor (A) is clearly preferred to another factor (B) and is valuated 9, then this would infer that (B) is preferred to a lesser extent than (A) and valued 1/9. All the factors are taken into account when performing pair comparisons. The next step is to assess the relative importance list of the relevant factors to the problem, and this is identified as the standardized table. The concluding step consists of computing the consistency ratio (CR) used to quantify the judgments' reliability. In the case the CR ≥ 0.1, then the decisions taken are not considered as dependable, and the whole procedure should be done again [76].

Table 2. The fundamental scale of absolute numbers [28].

Importance Intensity	Definition	Explanation
1	Equal	Two activities have equal contribution to the objective
2	Weak/slight	
3	Moderate	One activity is faintly preferred over another, established on judgment and experience
4	Moderate+plus	
5	Strong	One activity is strongly preferred over another, established on judgment, experience
6	Strong+plus	
7	Very strong (proved importance)	One activity is very strongly preferred over another, established on judgment, experience; its dominance is proved by practice
8	Very–very strong	
9	Extreme	The substantiation when one activity is preferred over another is at the topmost possible order of affirmation
Reciprocals of abovementioned	If activity i is attributed one of the abovementioned non–zero values when compared to activity j, then activity j when compared to activity i has the reciprocal value	A reasonable statement
1.1–1.9	When activities are very close to each other	Although it might be complicated to allocate the best value, but in comparison to other dissimilar activities the size of small numbers wouldn't be too perceptible, however they are able to denote the activities' relative importance.

The AHP methodology approach is largely explicated in most of the studies that apply it, but with differences related to stages: there are authors who break AHP in 3 stages [27,70], others summarize it in 4 stages [23,59,77], and others in 5 stages [25,78], while others refer to 7 stages in AHP [76]. We considered for our experiment the following top explanation and mathematical modeling from Bunruamkaew [79]:

Stage 1. Normalization with respect to weighted matrix or Eigen value, noted W:

For a matrix consisting of pair-wise elements:

$$X \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \quad (1)$$

(1.1) Calculate the sum of the values for every column of the matrix as:

$$C_{ij} = \sum_{i=1}^{n} C_{ij} \quad (2)$$

(1.2) Divide each element by the total of its column in order to create a normalized pair–wise matrix as follows:

$$X_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} \begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} \quad (3)$$

(1.3) Divide the sum of the normalized column of matrix by the number of criteria used (n) in order to create a weighted matrix as follows:

$$\mathrm{W}_{\mathrm{ij}} \frac{\sum_{\mathrm{j=1}}^{\mathrm{n}} \mathrm{X}_{\mathrm{ij}}}{\mathrm{n}} \begin{bmatrix} \mathrm{W}_{11} \\ \mathrm{W}_{12} \\ \mathrm{W}_{13} \end{bmatrix} \tag{4}$$

Stage 2. Consistency analysis in respect of CI and CR, [79]:

(2.1) Consistency Vector is computed by multiplying the pair–wise matrix with the weights vector as follows:

$$\begin{bmatrix} \mathrm{C}_{11} & \mathrm{C}_{12} & \mathrm{C}_{13} \\ \mathrm{C}_{21} & \mathrm{C}_{22} & \mathrm{C}_{23} \\ \mathrm{C}_{31} & \mathrm{C}_{32} & \mathrm{C}_{33} \end{bmatrix} * \begin{bmatrix} \mathrm{W}_{11} \\ \mathrm{W}_{21} \\ \mathrm{W}_{31} \end{bmatrix} = \begin{bmatrix} Cv_{11} \\ Cv_{21} \\ Cv_{31} \end{bmatrix} \tag{5}$$

(2.2) Then, it is completed by dividing the weighted sum vector with criterion weight as follows:

$$\begin{aligned} Cv_{11} &= \tfrac{1}{W_{11}}[C_{11}W_{11} + C_{12}W_{21} \ \ldots \ C_{13}W_{31}] \\ Cv_{21} &= \tfrac{1}{W_{11}}[C_{21}W_{11} + C_{22}W_{21} \ \ldots \ C_{23}W_{31}] \\ Cv_{31} &= \tfrac{1}{W_{11}}[C_{31}W_{11} + C_{32}W_{21} \ \ldots \ C_{33}W_{31}] \end{aligned} \tag{6}$$

(2.3) λ is computed by averaging Consistency Vector value as follows:

$$\lambda = \sum\nolimits_{i=1}^{n} Cv_{ij} \tag{7}$$

(2.4) The consistency index (CI) that measures the deviation is calculated (where n is the order of matrix) as follows:

$$\mathrm{CI} = \frac{\lambda - n}{n - 1} \tag{8}$$

(2.5) The consistency ratio CR is then computed (RI signifies a random inconsistency index) as follows:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{9}$$

Based on AHP, we can determine the consistency degree; in case it is unacceptable, we move on to revisions until the consistency ratio becomes CR < 0.10.

At that point, we can perform the computations to obtain the maximum Eigen value, CI, CR, and the normalized values (step 1 and step 2) for every criteria/alternative. In the case that the maximum Eigen value, CI, and CR are satisfactory, then a decision can be made founded on the normalized values. Otherwise, the whole process is performed again up until these values are arranged in the desired range [17]. In the example we used, there was no need to resume the trials, because we obtained CR < 1. The specialized literature also addresses the problem of a CR > 1 [19,80,81]. This can be a simple process that we repeat only once, or it can be a repetitive process. Discussions related to the elimination of inconsistency are addressed by Prof. Han, 2014 in paper [81]. In our paper, for simplicity, this being an argument of our exposition (in order to arouse interest in using this method), we propose the manual method of resuming the AHP steps.

In making the group decision, a consensus decision was reached between the 3 members of the work team. For each matrix, the decision was made by consensus. We are aware that if there was no consensus, then each team member could have their own set of matrices, with their own ranking. In this case, the result was harmonized either by proportionality of will or by the weighting of the vote [82,83].

The AHP framework developed for this research is presented, step by step, in the following section.

4. Results and Discussion of the Applied AHP Model

In our study, we chose to perform the AHP analysis in Excel based on the following steps:

Step 1. The decision–making problem is decomposed into a hierarchy.

Step 2. Pairwise comparisons are made and then priorities between the elements in the hierarchy are determined.

Step 3. Judgments are synthesized (in order to obtain the set of overall or weights for attaining the objective).

Step 4. The consistency of judgements is evaluated.

4.1. Results

We created the Hierarchy structure by decomposing the typical problem of decision making into a hierarchy of alternatives and criteria (Figure 2).

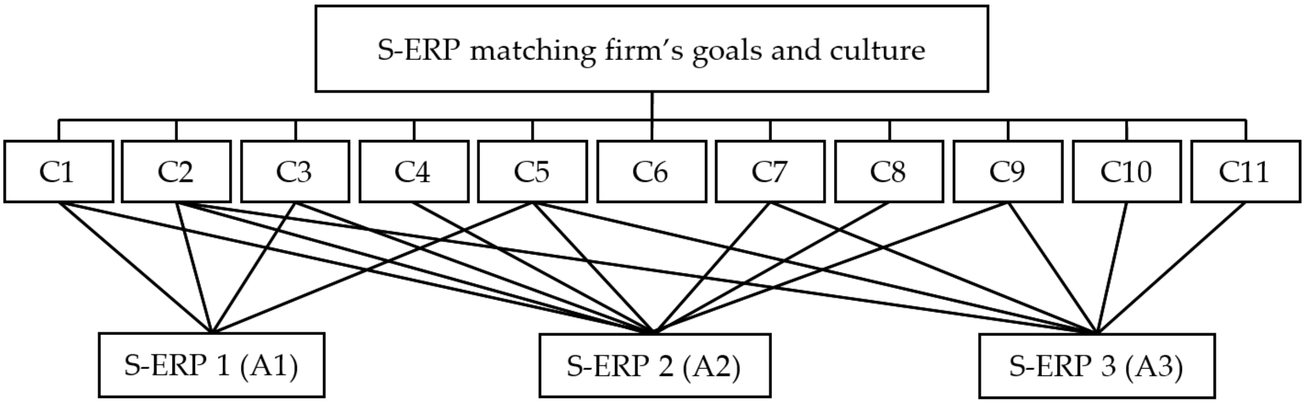

Figure 2. Decomposition of the decision making problem into a hierarchy.

Level 1 represents the objective of the analysis—to match the S–ERP to the firm's goal and business culture.

Level two contains an enumeration of the criteria that will be analyzed. We will name here each initial of criterion in relation to its explanation, such as: C1—Functionality, C2—Ease of Use/usability, C3—Feasibility, C4—Portability, C5—Cloud ERP options and Energy Efficiency, C6—Ease of Implementation, C7—Price of software, C8—Quality of documentation, C9—Level of Vendor support, C10—Developer's Track Record of Performance, and C11—Ability to fit to business.

Level 3 represents the three ERP systems to be analyzed (we prefer to leave their name undisclosed at this time for reasons of competitiveness and confidentiality): S–ERP1 is labeled A1, S–ERP2 is labeled A2, and S–ERP3 is labeled A3. There is a total of 12 pairwise comparison matrices: 1 matrix for the criteria with respect to the objective, and 11 comparison matrices for the tree alternatives with respect to all 11 criteria (Figures 3 and 4). In the numerical case used by us, we chose to make each matrix by consensus. Each comparison was established by consensus between the three authors.

Factor weighting score

Factor	More importance than				Equal	Less importance than				Factor
C1	9	7	5	3	1	3	5	7	9	C2
C2	9	7	5	3	1	3	5	7	9	C3
C3	9	7	5	3	1	3	5	7	9	C4
C4	9	7	5	3	1	3	5	7	9	C5

Pairwise comparison matrix holding the preference values

	C1	C2	C3	C4	C5
C1	1	1/7	1/7	1/7	
C2	7	1	1/7	1/7	
C3		7	1	1/7	
C4			7	1	1/5
C5				5	1

This table shows a simple comparison matrix of order for C1 to C5 criteria, compared to each other.
How to fill up the upper triangular matrix based on the following rules:
1. If the judgment value is on the left side of 1, we write the actual judgment value.
2. If the judgment value is on the right side of 1, we write the reciprocal value.

Figure 3. Questionnaire design.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	1.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
C2	7.00	1.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
C3	7.00	7.00	1.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
C4	7.00	7.00	7.00	1.00	0.20	0.20	0.20	0.20	0.20	0.20	0.20
C5	5.00	7.00	7.00	5.00	1.00	0.20	0.20	0.20	0.20	0.20	0.20
C6	5.00	5.00	5.00	5.00	5.00	1.00	0.20	0.20	0.20	0.20	0.20
C7	5.00	5.00	5.00	5.00	5.00	5.00	1.00	0.33	0.33	0.33	0.33
C8	5.00	3.00	3.00	5.00	5.00	5.00	3.00	1.00	1.00	1.00	1.00
C9	3.00	3.00	3.00	3.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00
C10	3.00	3.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
C11	3.00	3.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Figure 4. Criteria comparison.

This step continues the methodologic approach by making pairwise comparisons and determining priorities between the hierarchy elements. Each criterion is evaluated in comparison with the others, and then established on the evaluations from the previous step, we can generate the pairwise comparison matrix [29] based on the next rule:

$$a_{ij} > 0, \ \ a_{ji} = \frac{1}{a_{ij}}, \ \ \ a_{ii} = 1 \tag{10}$$

For the pairwise comparison matrix, the (i,j) position value is established based on Saaty's scale (1, 3, 5, 7, 9), where the assigned number's inverse value is allocated to the (j,i) position. First, we represent the questionnaire design: effective criteria and pairwise comparison (Figure 3).

Figure 4 shows in what manner to analyze the pairwise comparisons.

A pairwise comparison indicates that the criteria from the row are evaluated versus the criteria from the column.

In Figure 5 we represent the complete comparison matrix.

	A	B	C	D	E	F	G	H	I	J	K	L
1												
2		**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**
3	**C1**	1.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
4	**C2**	7.00	1.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
5	**C3**	7.00	7.00	1.00	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
6	**C4**	7.00	7.00	7.00	1.00	0.20	0.20	0.20	0.20	0.20	0.20	0.20
7	**C5**	5.00	7.00	7.00	5.00	1.00	0.20	0.20	0.20	0.20	0.20	0.20
8	**C6**	5.00	5.00	5.00	5.00	5.00	1.00	0.20	0.20	0.20	0.20	0.20
9	**C7**	5.00	5.00	5.00	5.00	5.00	5.00	1.00	0.33	0.33	0.33	0.33
10	**C8**	5.00	3.00	3.00	5.00	5.00	5.00	3.00	1.00	1.00	1.00	1.00
11	**C9**	3.00	3.00	3.00	3.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00
12	**C10**	3.00	3.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	**C11**	3.00	3.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14												
15	**SUM**	*51.00*	*44.14*	*35.29*	*30.43*	*21.63*	*16.83*	*8.03*	*5.36*	*5.36*	*5.36*	*5.36*

→ =SUM(B3:B13)

→ =SUM(D3:D13)

Figure 5. Complete comparison matrix.

The next step in this process is the matrix normalization. We achieve this by summing up the numbers in every column. Then, in each column, every entry is divided by its column sum in order to calculate its normalized score. The sum of every column is 1 (Figure 6).

In this step, step 3, the consistency ratio is computed, and we check its value. The reason behind this is to verify whether the original preference ratings were consistent. We complete another three steps in order to attain the consistency ratio (labeled CR1, CR2, CR3) [28,79]:

CR1 step: Calculate the consistency measure λ, based on Equation (7);

CR2 step: Calculate the consistency index (CI), based on Equation (8);

CR3 step: Calculate the consistency ratio (CR), based on Equation (9).

Random inconsistency indices (RI) for n between 1 and 10 adapted from [28] can be the following: 0.00, 0.00, 0.58, 0.9 . . . 1.49.

With the intention of calculating the consistency measure, we can use Excel's matrix multiplication function MMULT (). In our example, we calculate the column named CM (Consistency Measure) as follows: MMULT (B3:L3, $N$19:$N$29))/N19 (Figure 7).

Calculation of criteria's weight

Weight (average of sum of each line)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	*Total*	*Average*
C1	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.17	0.02
C2	0.14	0.02	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.31	0.03
C3	0.14	0.16	0.03	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.47	0.04
C4	0.14	0.16	0.20	0.03	0.01	0.01	0.02	0.04	0.04	0.04	0.04	0.72	0.07
C5	0.10	0.16	0.20	0.16	0.05	0.01	0.02	0.04	0.04	0.04	0.04	0.85	0.08
C6	0.10	0.11	0.14	0.16	0.23	0.06	0.02	0.04	0.04	0.04	0.04	0.98	0.09
C7	0.10	0.11	0.14	0.16	0.23	0.30	0.12	0.06	0.06	0.06	0.06	1.42	0.13
C8	0.10	0.07	0.09	0.16	0.23	0.30	0.37	0.19	0.19	0.19	0.19		0.19
C9	0.06	0.07	0.09	0.10	0.14	0.18	0.12	0.19	0.19	0.19	0.19		
C10	0.06	0.07	0.03	0.10	0.05	0.06	0.12	0.19	0.19	0.19	0.19		
C11	0.06	0.07	0.09	0.10	0.05	0.06	0.12	0.19	0.19	0.19	0.19	1.29	0.12
	1.00												**1.00**

Normalized inputs - Priority vector

Figure 6. Normalized inputs.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
16												Calculation of criteria's weight						
17												*Weight (average of sum of each line)*						
18		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	*Total*	*Average*			Consistency Measure (CM)	
19	C1	0.02	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.17	0.02			10.04	
20	C2	0.14	0.02	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.31	0.03			9.76	
21	C3	0.14	0.16	0.03	0.00	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.47	0.04			11.23	
22	C4	0.14	0.16	0.20	0.03	0.01	0.01	0.02	0.04	0.04	0.04	0.04	0.72	0.07			12.77	
23	C5	0.10	0.16	0.20	0.16	0.05	0.01	0.02	0.04	0.04	0.04	0.04	0.85	0.08			14.62	
24	C6	0.10	0.11	0.14	0.16	0.23	0.06	0.02	0.04	0.04	0.04	0.04	0.98	0.09			15.36	
25	C7	0.10	0.11	0.14	0.16	0.23	0.30	0.12	0.06	0.06	0.06	0.06	1.42	0.13			14.77	
26	C8	0.10	0.07	0.09	0.16	0.23	0.30	0.37	0.19	0.19	0.19	0.19	2.06	0.19			12.75	
27	C9	0.06	0.07	0.09	0.10	0.14	0.18	0.12	0.19	0.19	0.19	0.19	1.50	0.14			12.02	
28	C10	0.06	0.07	0.03	0.10	0.05	0.06	0.12	0.19	0.19	0.19	0.19	1.23	0.11			10.90	
29	C11	0.06	0.07	0.09	0.10	0.05	0.06	0.12	0.19	0.19	0.19	0.19	1.29	0.12			11.15	
30														1.00		λ_{max}	135.37	→ = SUM(Q19:Q29)
31																	12.31	→ = Q30/11
32																CI	0.13	→ = (Q31-11)/(11-1)
33																CR	0.09	→ = CI/1.49 (RI for 11 elements matrix)
34																	*In practice, a CR of 0.1 or below is considered acceptable*	

Figure 7. Calculate the CI and CR.

In summary, in order to find the weight of each criterion, we applied the subsequent instructions: first, we calculated the sum of every column, then we normalized the matrix by dividing each cell by the sum of its column, and lastly, we calculated the row's average [68,69] (Figure 8).

C1	0.02
C2	0.03
C3	0.04
C4	0.07
C5	0.08
C6	0.09
C7	0.13
C8	0.19
C9	0.14
C10	0.11
C11	0.12
SUM	**1.00**

Figure 8. The priority of each criterion related to the purpose.

Step 4 continues with the CR calculation, the derived scale based on the judgments in the matrix has a consistency ratio of 0.09; the CR consistency is below 0.1, so the priority of each criterion related to the purpose of the analysis is consistent.

Therefore, we obtained a total of 13 pairwise comparison matrices: 1 for the criteria regarding the objective, which is already shown in the aforementioned figure and 11 comparison matrices for the 3 alternatives regarding all 11 criteria.

We go further and follow steps 2, 3, and 4 for each of the 11 criteria in relation to the 3 alternatives. We present in the Figure 9 the three steps for criterion C1 (Functionality) for the three systems labeled A1, A2, and A3.

Criterion C1	A1	A2	A3
A1	1.00	0.14	0.20
A2	7.00	1.00	0.20
A3	5.00	5.00	1.00
SUM	13.00	6.14	1.40

Normalized pairwise comparison matrix

Criterion C1	A1	A2	A3
A1	0.08	0.02	0.14
A2	0.54	0.16	0.14
A3	0.38	0.81	0.71

Relative importance vector

Total	Average
0.24	**0.08**
0.84	**0.28**
1.91	**0.64**
	1.00

CI	-0.99
RI	0.58
CR	-1.71

Consistency Measure (CM)

1.28
0.64
1.12

λ_{max}	3.05
	1.0153225

Priorities vector for C1

A1	0.08
A2	0.28
A3	0.64

Figure 9. The three steps for criterion C1 (Functionality).

The three steps for criterion C2 (Ease of Use/Usability) compared to the three systems A1, A2, and A3 produced the following values: A1 with 0.07, A2 with 0.23, A3 with 0.70.

For criterion C3 (Feasibility) compared to the three alternatives, the values are: A1 with 0.22, A2 with 0.55, A3 with 0.23.

For criterion C4 (Portability) compared to the three alternatives, the values are: A1 with 0.08, A2 with 0.28, A3 with 0.64.

For criterion C5 (Cloud ERP options and Energy Efficiency), compared to the three alternatives, the values are: A1 with 0.08, A2 with 0.28, A3 with 0.64.

For criterion C6 (Ease of Implementation) compared to the three alternatives, the values are: A1 with 0.09, A2 with 0.25, A3 with 0.66.

For criterion C7 (Price of Software) compared to the three alternatives, the values are: A1 with 0.09, A2 with 0.25, A3 with 0.66.

The three steps for criterion C8 (Quality of Documentation) related to the three alternatives, the values are: A1 with 0.11, A2 with 0.26, A3 with 0.63.

For criteria C9 (Level of Vendor support) and C10 (Developer's Track Record of Performance) the values are the same as for criterion C8. For criterion C11 (Ability to fit to Business) the values emerged as in criterion C7 (Price of Software).

The final Priority vector was created by multiplying the priority vectors for the criteria by the priorities of every alternative for every objective.

In Figure 10—Ranking calculation—the priorities of criteria and the priority vector for every alternative relating to each criterion were calculated.

Final priority vector for the criteria

Criterion	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Priorities	0.016	0.028	0.043	0.066	0.077	0.089	0.129	0.188	0.136	0.112	0.117

Priority vectors of the alternatives given each criterion

A1 weights	0.08	0.07	0.22	0.08	0.08	0.09	0.09	0.11	0.11	0.11	0.09
A2 weights	0.28	0.23	0.55	0.28	0.28	0.25	0.25	0.26	0.26	0.26	0.25
A3 weights	0.64	0.70	0.23	0.64	0.64	0.66	0.66	0.63	0.63	0.63	0.66

Alternative

A1	`=C7*$C$5+D7*$D$5+E7*$E$5+F7*$F$5+G7*$G$5+H7*$H$5+I7*$I$5+J7*$J$5+K7*$K$5+L7*$L$5+M7*$M$5`
A2	`=C8*$C$5+D8*$D$5+E8*$E$5+F8*$F$5+G8*$G$5+H8*$H$5+I8*$I$5+J8*$J$5+K8*$K$5+L8*$L$5+M8*$M$5`
A3	`=C9*$C$5+D9*$D$5+E9*$E$5+F9*$F$5+G9*$G$5+H9*$H$5+I9*$I$5+J9*$J$5+K9*$K$5+L9*$L$5+M9*$M$5`

Figure 10. Ranking calculation.

4.2. Discussion

After the decision analysis that was completed using the AHP method, the SME is able to select the S–ERP vendor with the highest rating.

In the end, based on the 11 criteria, the data we collected, and following the use of AHP, we can affirm that S–ERP3 (computed weight = 0.627) is a more appropriate solution for the company compared to S–ERP1 (0.102) and S–ERP 2 (0.271) (Table 3, Final ranking results).

Table 3. Final ranking results.

Alternative	Weight	Rank
A1	0.102	3
A2	0.271	2
A3	0.627	1

Based on the obtained results, we can see that A3 is the top choice, A2 is the second choice, and A1 is the last choice. The composite weights are the ratio scale. We can affirm that choice A3 is 2.3 times more desirable than A2, and choice A3 is 6.1 times more desirable than A1. However, these scores are not absolute; they refer only to the set of criteria chosen by this hypothetical firm. For another company, the relative scores will be based on business interests.

After applying AHP, it is anticipated that the organization selecting the S–ERP system would find that it has chosen the best solution. The results show that S–ERP3 is the best ranked, therefore it could provide the best possible sustainability to the SME business.

An appropriate ERP system can radically improve a company's competitiveness and future performance. The choice of an ERP system from 3 ERP systems was made, considering the assessments of the members of the selection team which consists of 11 criteria combined in as many constructs. All these criteria have received due importance in the literature [7–9,17,18,20,23,29,32,48,60]. As companies have so far focused on the benefits of the operational aspects of an ERP, we have explored the relationship between ERP systems and sustainable practices, exemplified by the C3, C4, C5, and C10 criteria, i.e., those criteria that transform an ERP system into an at least partially ecological model.

We appreciate that the approach we proposed provided a structured and organized framework of the decision–making process in support of selecting a sustainable ERP system. Applying the AHP [18,20] method made it possible to achieve this goal and helped us achieve the values for every criterion and compare criteria from the same hierarchical level. As a final point, we believe that the utilized methodology assisted us in successfully achieving the desired goal of this research.

5. Conclusions

This paper presented the development of a model for selecting a S–ERP for SME based on AHP. We used this model considering that the criteria of choosing an ERP can be applied, and specific sustainability criteria can be added [57,80]. Moreover, the organizational structure of an SME is not as complex as that of a large company, therefore, a large number of over 30 to 45 selection criteria, as mentioned in the literature [9,13,49,60], is not necessary.

The hierarchical structure was created on basis of the key practices proposed for the evaluation of an ERP with a sustainable component for SMEs. Then, the weights of the importance of the measures were allocated by pair comparisons and computed by the AHP methodology. The score of each software was calculated to measure sustainability in choosing an ERP. Finally, the S–ERP rank was established based on their scores. The model offers recommendations and directions for SMEs to take suitable measures to improve the sustainability of software usage.

In contrast to previous studies that describe selection criteria and the correlations between criteria or those that assess the need to adopt S–ERP systems and for SMEs, our study proposes a framework of criteria for an SME already endorsed by the abundant research literature (Table 1). Furthermore, it also proposes a numerical model of multi criteria analysis that helps an SME select the system according to its business and culture.

The results of this study can stimulate SMEs to concentrate on the selection process, on the team that performs the selection of the S–ERP system. As a practical implication, this study offers useful information on the clear, simple, and concise selection method for an SME that intends to implement and use S–ERP systems.

Our study contributes to the presentation of a theoretical framework doubled by a numerical model and an uncomplicated and easy S–ERP selection, compared to the few existing both in terms of academic research and consulting firms, or even vendors of S–ERP systems. As a theoretical implication, this study can be a model of good practices for those who need to teach young persons or students decision–making techniques but also for those who need to choose such software. It creates a discussion that blends elements of decision theory with the ERP technology all in respect of sustainability theory. In a fast–growing society that is cyclically subject to crises (economic or health) in which technologies are vigorously developed, selection patterns along with selection criteria must also be updated to keep up with all changes and their implications.

The key factors proposed in the studies cited throughout the paper are not always current or applicable to SMEs. By introducing our model, we contribute to the research literature by bringing an update to existing business models. In an emerging economy, SMEs are characterized by few financial and human resources, while an ERP selection process is a big consumer of such resources.

This study introduces a selection model, simple and clear, based on the workforce in the company, who will be the future users of the S–ERP system. By analogy with software production, the model we propose is an "in–house" type, and knowledge related to ERP and Excel will be maximized, as well as decision making. In addition, we hope that this new model will inspire future researchers to rethink innovative models of multicriteria decision analysis.

This study has some limitations. First, the results represent just the perspective of a limited number of experts/practitioners in Romania. Therefore, diverse business, cultural or environmental backgrounds may produce dissimilar results for future research. Second, given the future evolution and uncertainties specific to the business environment, our study may not include all the criteria for a more accurate S–ERP selection model.

As future directions for further developing the model, the opportunity to establish more complex associations between criteria and sub–criteria, as alternatives in the sequence of the same criteria, could be evaluated in case interdependencies are detected among the hierarchical tree's levels. Another future direction is refining the value functions outlined for the indicators and the sources for acquiring the objective data, aiming at minimizing certain factors and facilitating the use of the method. In a future paper we will present a model that discusses consistency starting from existing works.

Future efforts will converge on developing a software tool for evaluating the most appropriate S–ERP for SMEs but adapted to the specifics of each industry and using fuzzy logic in the AHP process. It will be designed as way to operate on real cases of Romanian SMEs.

In conclusion, in the conditions of the pandemic crisis, implementing an ERP system with a sustainability component represents a crucial investment for an SME. The challenges that stand today in front of every SME when reasoning about ERP implementation concern various aspects: limited prospects of investments in technology; large resource consumers (finances, employees, and time) and several phases to be covered; and a new paradigm of sustainable or "green" ERP systems. Nevertheless, for a sustainable development, SMEs should start to analyze the possibility and select the most suitable ERP system for their business and their company culture, taking into consideration environmental protection and social issues using a simple but useful selection method as proposed in this paper.

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