Combination of an ERP system with other technological approaches to increase sustainability in discrete manufacturing

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Abstract. In the dynamic times of paradigm shift, which are characterized by rapid technological progress as well as the digitalization of the world, the future-oriented and technology-savvy manufacturing companies strive to optimally integrate IT applications into the success of the company. Enterprise Resource Planning (ERP) consolidates all business areas of an organization and enables the operational production factors of a company to be planned, managed, and controlled as efficiently as possible. The aim of this paper is to identify the current state of the art on the use of ERP systems in combination with other technological approaches in the discrete manufacturing industry based on numerous literature reviews. In this paper, the possible combinations of the approaches available in the literature with an ERP system are examined for their interaction with each other for the purpose of increasing corporate sustainability. The findings of this study can be applied to the strategic planning of a manufacturing company with the aim of increasing sustainability.

INTRODUCTION

The term sustainability refers to a principle of action for the use of resources, e.g., raw materials, energy, and water. Ideally, a sustainable company is oriented towards the three pillars of sustainability: ecological, economic, and social [1]. Numerous articles prove that a real and long-term improvement of sustainability in a company is only possible if all three pillars of sustainability are considered [2]. In an increasingly complex and interconnected world, several factors can have an impact on sustainability, often complementing each other. The business model, up-to-date processes, modern technologies as well as increasing digitalization in a company also have a positive influence on sustainability [3-6].

In his study, Ekins describes three different types of changes that are required for a company to become more sustainable.

"In conclusion, then, the path to environmental sustainability may require three possible types of change to current patterns of production and consumption:

(1) satisfying present wants with technologies of vastly improved environmental performance;

(2) changing present wants, so that the overall package of desired goods and services is far less environmental damaging than at present;

(3) constraining present wants where they relate to environmentally damaging goods and services, the production of consumption of which are not amenable to environmental improvement...

As has been seen in this book, not only are economic growth and environmental sustainability theoretically compatible, but there is also a good chance that the technologies required simultaneously to increase value-added and

reduce environmental impacts could, over the next five decades, become available and economically viable." [7, p. 324]

Therefore, to solve the problem of disconnect between sustainable business functions and processes, Alshawi et al, propose sustainable Enterprise Resource Planning systems (S-ERP) as a holistic, integrative, and complete solution for industry to solve sustainability issues in enterprises [8].

Abdoulmohammad Gholamzadeh Chofreh et al. claim that companies need to align their sustainability strategy with their information systems strategy. In the articles, they address the acute problems in collecting, integrating, and reporting sustainability information. It is from these problems that the productivity and effectiveness of sustainability work is compromised. An S-ERP system is mentioned as a solution to this problem, potentially becoming a focus area in solving integration problems for organizations through sustainability practices. S-ERP systems help an organization provide complete sustainability data and integrate all sustainability information and processes across all business functions. It can be seen as a holistic, integrative, and complete solution for industry to solve sustainability problems [9].

Huang et al. conducted an extensive literature review and a modified Delphi expert survey to identify the critical success factors for the implementation of ERP systems in B Corporations. In their study, the authors explained the concept of a B Corporation, which was created by B Labor's promotion of the company's own sustainable business model philosophy developments. The organizational form that emerged from this certification process is called a B Corporation and represents the implementation of and commitment to sustainable development. The research findings can support the sustainable value of B Corporations and contribute to the current literature on improving critical success factors. They led a summary of the critical factors in a tabular form. The results point to the importance four dimensions which included Business Organization Strategies, System Users, Counseling Team, and Software Vendor [10]. The overview of numerous factors indicates that an overarching goal can be achieved by considering as many levels of an organization as possible.

Numerous approaches have been developed in recent years to achieve corporate sustainability. These approaches can have a direct and indirect influence on social, ecological, and economic aspects of sustainability in a company. This paper pursues the idea of consolidating these approaches and establishing links between different known methodologies and tools, which can be efficiently ensured using an ERP system. The overview of possible combinations and synergy benefits of different approaches to increase sustainability follows in the next section.

LITERATURE REVIEW

Combination Of An ERP-system With Lean Management And Lean Green Approaches

In recent years, several outreaches have been established to increase corporate sustainability. According to the study by Pang et al. an important role the establishment of green manufacturing includes the research topics of green chemical materials, green manufacturing principles and approaches, common analysis tools, green manufacturing implementation of industrial enterprises, green supply chain, industrial ecology, greenhouse gas emissions, and green machining tools and processes [11].

One of them talks about the use of lean management tools. The use of lean practices in production combined with practices to increase sustainability has been termed "Lean Green" [11-12]. Martínez León et al.'s work extends previous literature reviews by analyzing lean and sustainability from a system thinking perspective. The authors identify and analyze the interrelationships between lean and sustainability and their impact on all pillars of corporate sustainability, especially performance from an operational, financial, social, and environmental perspective [12].

The aim of such discrete production is to increase efficiency by minimizing waste, for example, to reduce production costs and conserve resources. Waste can be eliminated in discrete manufacturing through numerous measures, by minimizing the qualitative defects in the products and the overproduction of unsaleable products, the unnecessary use of resources for the transport of materials and products as well as the waiting times in the production facilities but also if the unnecessary stocks are eliminated [13]. In Viles, Santos, Muñoz-Villamizar, et al.’s research a case study was presented in which water consumption in company activities is monitored. Through this, it is hoped to improve industrial processes based on Lean Green practices, leading to a zero-waste strategy for this critical resource [14].

Based on the goals of “Lean Green”, the use of a robust ERP system, through the ensured flexibility, efficiency, automation, and numerous analytics, provides the means to synchronize production and distribution activities with the demand for goods, thereby contributing to greater sustainability. Manufacturers can optimize work with their suppliers, thereby reducing inventory levels. These measures consequently lead to the reduction of the company's environmental footprint. Odenwald and Berg [15] also point out that the key to the success of leading companies lies in the management of resources. They integrate information technology with various corporate resources, which leads to ensuring the company's liquidity and responsiveness. As a result, companies can respond much faster to the market and remain competitive. By ERP systems, business processes are improved, and they lead to the skilled management of company resources [15].

An important aspect in establishing the sustainability strategy is therefore a well-functioning and efficient ERP system [16]. An ERP system follows the basic idea of controlling processes company-wide, reducing inventories, lowering costs, shortening delivery times, increasing productivity, promoting corporate communication, improving information transfer as well as improving customer service. In addition to increasing profits and creating new business value, modern and customer-oriented companies also strive for sustainability and development. Chofreh et al. mention in their research also higher complexity of such an S-ERP system including new data types, new data sources and new actors [16, 17].

In addition to the purchase of a product with the highest possible quality and at the lowest possible price, social and ecological aspects are gaining in popularity among consumers [15]. Legal regulation and consumer pressure are forcing companies to quantify the sustainability of their products. The availability and accuracy of high-quality data is thus becoming the focus of sustainable company reporting. Therefore, robust information systems are critical for the elevation and transformation of sustainability data, information, and processes [18].

Lean management uses many tools and has a positive impact on the performance of manufacturing companies. The most common lean management practices include value stream mapping, continuous improvement, kaizen, total productive maintenance (TPM), 5S, Six Sigma, total quality management (TQM) and Poka-Yoke. These practices and tools are used to optimize processes, minimize waste, reduce costs, and thereby optimize the value chain to make it sustainable [19-21]. To effectively achieve these goals, a timely information system, such as an S-ERP system, is needed.

By optimizing a company in terms of waste reduction and better resource utilization, lean management tools are becoming increasingly popular in increasing corporate sustainability. The impact of integrating sustainable ERP (S-ERP) and Lean Management practices on economic performance has already been extensively addressed by researchers [22]. The adoption of S-ERP systems positively supports the implementation of Lean Management practices [23]. Modern IT innovations and the development of hybrid "push-pull" production control mechanisms have recently led to the establishment of an integration of ERP and lean approaches so that ERP systems can be used to improve the adoption of Lean Management practices [24].

Combination Of An ERP-system With A Green Supply Chain Management (GSCM)

Especially in discrete manufacturing, supply chain management (SCM) plays a crucial role. It takes an approach of consolidating suppliers, companies, warehouses, and other storage areas (distributors, retailers, and retailers) so that products can be produced and distributed in the right quantity, at the right place and at the right time. In doing so, hoped-for outcomes relate to cost reduction and meeting customer needs [25].

SCM is critical for a manufacturing company when it comes to the sustainability of its products in the marketplace. To increase competitiveness by improving supply chain management while considering the basic principles of environmental protection, the term a green supply chain management (GSCM) became established [26].

Although GSCM plays an important role in increasing corporate sustainability, an important factor is the consideration of the company's upstream and downstream businesses. The goal of GSCM is to reduce waste, use raw materials efficiently and minimize environmental impact, which can be achieved by establishing innovative processes [27].

For successful communication with upstream and downstream companies with the aim of implementing a GSCM in the company, an internally and externally integrated information technology is necessary. The information technology used by companies should integrate all partners involved within the supply chain, which is why an ERP system is recommended. The implementation of an ERP system promotes communication between departments and supply chain partners as well as contributes significantly to the reduction of production costs [28-30]. In addition, an ERP system enables a company to systematically report on raw material availability, which supports the goals of

GSCM by ultimately enabling suppliers to meet the company's needs [8]. The coordinated flow of information between suppliers and the company provides timely data on raw materials and goods received in the warehouse, which in turn has a positive impact on other departments, such as purchasing and warehousing, and enables resource-oriented planning [31]. The internal integration of an ERP system increases the fast and reliable transfer of information between departments and thus improves response times [32], promotes internal communication and synchronization between processes [33].

The study by Tarigan et al. investigated the impact of improved enterprise resource planning (ERP) on business performance through green supply chain management, supplier integration and internal integration. A questionnaire with a five-point Likert scale was used for data collection. Out of 243 manufacturers, 150 questionnaires were distributed, and 135 questionnaires were considered valid for analysis. The result showed that enhanced ERP has a positive impact on supplier integration, internal integration, and GSCM. Likewise, the study showed that GSCM, internal integration and supplier integration mediate the effect of enhanced ERP on business performance [34].

Combination Of An ERP-system With Cloud Technology And Big Data Applications

The topic of increasing sustainability through the implementation of ERP systems has been gaining popularity for years, leading to the establishment of numerous concepts. One trend is the transformation of existing ERP environments into cloud-based systems known as cloud ERP [35]. “Cloud ERP is enterprise resource planning software that can be accessed via the internet. Companies thus have access to their business-critical applications regardless of time and place - and benefit from the almost limitless scaling and innovation possibilities”. [36] The paper by Alvi et al. described the use of cloud computing, which was described as an energy-saving method by reducing data path. By adopting the energy-saving measures, it contributes to increasing environmental sustainability, e.g., in the area of discrete manufacturing [37].

Several vendors such as SAP and Oracle present Big Data applications as a new technological innovation. Oracle Corporation developed Big Data Analytics, advanced analytics in Oracle database [38]. Following the development of this new technology, the slow speed of storing, processing, and analyzing diverse and large data sets in traditional ERP systems becomes the fundamental motive for vendors to develop Big Data applications. This technology helps companies perform Big Data analysis and strategies in real time using web-based applications [38].

Futuristic Approach: ERP 4.0 Systems

According to Rathnayake et al, another approach to increasing business sustainability can be to combine ERP systems with Industry 4.0 technologies. This study addressed how Industry 4.0 improves the capabilities of ERP systems. As a result of this paper, it was determined that Industry 4.0 technologies such as IoT and RFID can capture real-time data from manufacturing, thereby improving data accuracy. This in turn leads to ERP systems being able to provide more accurate analysis and forecasting. The productivity of ERP systems can be increased using Industry 4.0 technologies. Therefore, according to the authors, upgrading existing traditional ERP systems to support these new types of Industry 4.0 technologies will undoubtedly help improve the capabilities of ERP systems [39].

METHODOLOGY

The studies on the research topic were conducted in two steps. The first step consisted of a narrative literature research based on resources available in scientific databases such as SpringerLink [40], Emerald [41], ScienceDirect [42], ResearchGate [43] and Google Scholar [44]. Narrative literature review is a form of research synthesis in which authors synthesise and critically appraise findings from multiple studies on a research topic. The main topics and thus the search passwords were ERP systems, sustainable ERP systems, sustainability, lean management and discrete manufacturing. The results of this research form the literature review section. The results of the literature review formed the basis for the next phase of the study. In the second phase, the authors analysed the literature data collected and summarised it in a tabular form. In this phase, the authors relied on the approaches of Qualitative Content Analysis - a research methodology for the systematic analysis and interpretation of the content of texts. The aim of qualitative content analysis in the case of this study is to order and structure manifest and latent content [45]. The methodology used in this paper has been summarized in tabular form for illustrative purposes, see Table 1.

TABLE 1. Methodology of this scientific article

Phase	Name	Result
1	Narrative literature research	Synthesis and critical evaluation of the results of several studies on a research topic
2	Summary & approaches of Qualitative Content Analysis	Analysis of the collected literature data and summary in tabular form

DISCUSSION

For the purposes of clarity, this article does not allocate the countless scientific articles. The focus was on identifying the guiding core statements about scientific developments and possible combinations of an ERP system with other technological approaches in the context of increasing sustainability in discrete manufacturing. The results of the narrative literature search were summarized in Table 2 for illustrative purposes and briefly summarized to achieve better transparency.

TABLE 2. Compilation of the identified parameters that lead to an increase in corporate sustainability through the combination with an ERP system

Parameter	Description in context of sustainability	Number of Articles in this paper	Sources
Lean Management & Lean Green Practices	Reduction of production costs, conservation of resources, avoidance of waste	14	[11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24]
Cloud Technology	Energy-saving method by reducing data path	2	[35], [36], [37]
Big Data Applications	Increasing the speed of storing, processing, and analyzing different and large amounts of data	1	[38]
Green Supply Chain Management	Reduction of waste, efficient use of raw materials and minimization of environmental impact, which can be achieved by introducing innovative processes.	11	[8], [25], [26], [27], [28], [29], [30], [31], [32], [33], [34]
Industry 4.0 Technologies	Capture real-time manufacturing data, improve data accuracy, produce more accurate analysis and forecasts, increase productivity of an ERP system.	1	[39]

An analysis of the existing scientific literature revealed five parameters which, in combination with an ERP system, can lead to an increase in sustainability. These five parameters include: Cloud Technology, Big Data Applications, Green Supply Chain Management, Lean Management and Lean Green Practices, and Industry 4.0 Technologies. A fifth approach, ERP 4.0 systems, also a combination of ERP system with Industry 4.0 technologies is also considered as a possible continuation of the topic in future research activities. Furthermore, these parameters were summarized

together with the dimensions of sustainability in the form of a picture to underline the immense potential of ERP systems, see Figure 1.

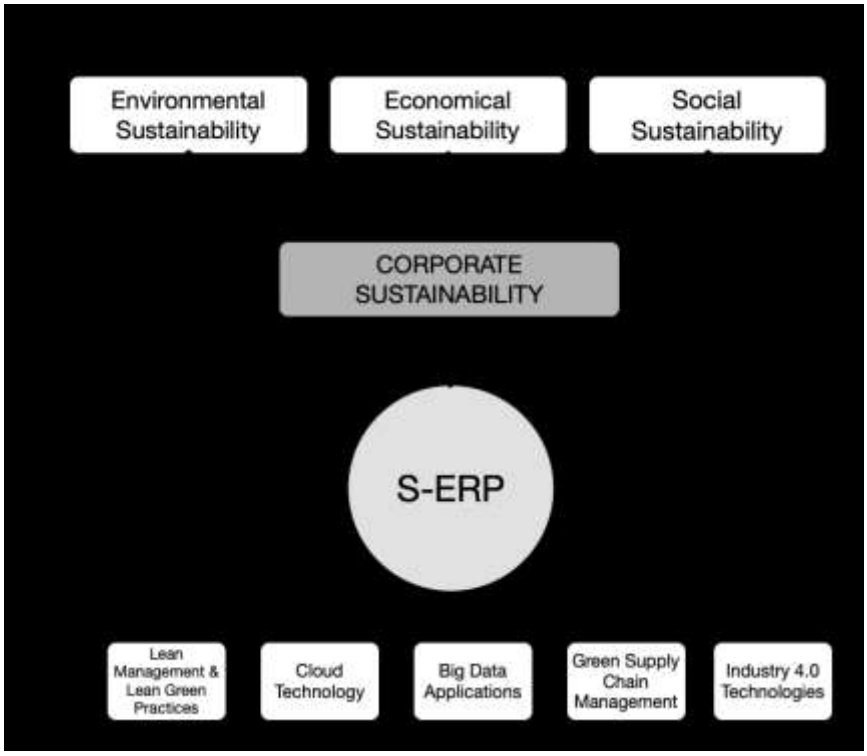

FIGURE 1. Parameters and dimensions influencing the sustainability of a manufacturing company when using sustainable ERP systems.

When using cloud computing or cloud technologies, the environmental dimension of sustainability is considered by using energy-saving methods to reduce the data path. In combination with an ERP system, this approach should provide more flexibility and transparency [35-36].

Lean management and lean-green practices enable a manufacturing company to minimize waste, make better use of resources and plan. Combining these practices with an ERP system enables the linking of reporting functions to demonstrate sustainability activities to consumers, suppliers, or regulators, for example. Other benefits have been discussed in detail in the literature review section [13-15].

The development of Big Data applications in combination with an ERP system enables the solution to the problem of slow speed in storing, processing, and analyzing diverse and large amounts of data in traditional ERP systems. This technology helps companies perform Big Data analysis and strategies in real time using web-based applications [37].

The Green Supply Chain Management approach aims to reduce waste, use raw materials efficiently and minimize environmental impact, which can be achieved by introducing innovative processes. The reason for integrating this approach with an ERP system is to create true integration with partners and suppliers. The implementation of an ERP system promotes communication between departments and supply chain partners and contributes significantly to reducing production costs [27-29]. In addition, an ERP system enables a company to systematically report on the availability of raw materials, which supports the goals of GSCM by ultimately enabling suppliers to meet the company's needs [8]. The coordinated flow of information between suppliers and the company provides timely data on raw materials and goods receipts in the warehouse, which in turn has a positive impact on other departments, such as purchasing and warehousing, and enables resource-oriented planning [30].

By combining Industry 4.0 technologies, manufacturing data can be captured in real time, data accuracy is improved, more accurate analyses and forecasts are produced, and the productivity of an ERP system is increased [39].

CONCLUSION

Using the narrative literature search based on the resources available in scientific databases such as SpringerLink, Emerald, ScienceDirect, Research Gate and Google Scholar, the five main directions of current scientific developments on the topic of implementing ERP systems in discrete manufacturing in combination with other technological approaches were found. In the further course of the scientific analysis, the manifest and latent contents were ordered and structured. As a result of this process, a graphical representation was created that summarizes the parameters and dimensions. To increase sustainability in a discrete manufacturing company in the long term, it is necessary to bundle activities considering the three pillars of sustainability. These include social, ecological, and economic sustainability. An idea arose from this well-known basic idea when a scientific gap was identified: the combination of different technological approaches with an ERP system. The advantages of an ERP system were related to the respective parameters and evaluated. The parameters presented in this paper were (1) Lean Management/Lean Green Practices, (2) Cloud Technology, (3) Big Data applications, (4) Green Supply Chain Management and (5) Industry 4.0 technologies. The mutual interactions have been roughly outlined and presented based on the large body of literature. All these parameters can be used in combination with ERP systems to increase corporate sustainability, whereby the greatest focus of their use was on minimizing waste and optimizing resource management. An important point in this context was also the improvement of supply chain management by combining the ERP system with GSCM methods. Other indicators were also the linking of the ERP systems with cloud technologies, with the industry 4.0 applications roughly outlined in this paper, as well as Big Data applications. The latter may represent further focal points of future research activities.

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