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## SUSTAINABLE DEVELOPMENT FROM THE PERSPECTIVE OF ERP SYSTEMS

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Enterprise Resource Planning (ERP) systems play a key role in the digitalization of enterprises, supporting their transition towards sustainable development. The aim of this research was to analyze the impact of ERP implementation on economic, environmental, and social aspects of manufacturing organizations. The study used in-depth, non-standardized interviews with representatives of three medium-sized enterprises that had implemented an ERP system.

The research results indicate that ERP systems improve operational efficiency, reduce waste and costs, and increase stakeholder satisfaction. Practical application includes optimizing machine uptime, improving inventory management, and eliminating errors resulting from outdated data. ERP systems also support the environmental dimension of sustainable development by reducing post-production waste and the ability to monitor production's environmental impact. In the social aspect, ERP implementation noticeably improves working conditions, employee satisfaction, and their professional development.

The conclusions from the research emphasize the importance of properly adapting ERP systems to the needs of an organization and their impact on the improving business processes. Despite large financial and organizational outlays, investment in ERP implementation brings measurable benefits in the field of sustainable development. Moreover, the study highlights the need for further research on human cooperation with ERP systems and the impact of generational changes on the effectiveness of using these tools.

**Keywords:** sustainable development, manufacturing enterprise, ERP system

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## 1. INTRODUCTION

Enterprise Resource Planning (ERP) systems play a crucial role in supporting the digitalization of enterprises. Digital transformation refers to the application of new information technologies aimed at achieving significant improvements in business operations (Begnini et al., 2023; Szopa et al., 2020). A comprehensively and effectively implemented ERP system enables real-time operations and enhances organizational efficiency (Huang et al., 2019; Stojkić et al., 2015; Stachowiak et al., 2019). This translates into process optimization and opens access to new markets that were previously out of reach for the enterprise, for instance, due to limited resources (Bresciani et al., 2021; Mitrega et al., 2021; Vial, 2019; Vuchkovski et al., 2023). Moreover, ERP systems can significantly contribute to supporting the sustainable development of organizations, particularly in the context of efficient resource management and monitoring activities for their environmental impact. Moreover, ERP systems enable the optimization of supply chain management in a sustainable manner by improving coordination with suppliers and streamlining logistical processes (Wahid, 2013; Yu et al., 2020).

Sustainable development is defined in the ISO standard as “a state of the global system, encompassing environmental, social, and economic aspects, in which the needs of the present generation are met without compromising the ability of future generations to meet their own needs” (ISO Guide 82:2014).

The literature on the subject features numerous studies addressing the role of ERP systems in sustainable development. These topics include, among others, sustainable business models supported by information systems, such as SBM-ERP – Sustainable Business Model and the Enterprise Resource Planning system (Patalas-Maliszewska et al., 2022); the creation of sustainability reports based on the integration of green KPIs with traditional ERP solutions (Papagiannidis, Marikyan, 2022; Chofreh et al., 2020); and the implementation of „green” ERP systems, which account for all three dimensions of sustainability: economic, social, and environmental (Rasanjali et al., 2022; Yuzgenc, Aydemir, 2023). Most studies, however, focus on the economic dimension related to ERP system implementation, both in terms of enhancing this dimension through the system’s use in daily operations and leveraging system data to report organizational compliance with economic objectives. Nevertheless, a knowledge gap persists in connecting ERP implementation with sustainable development across all three dimensions – economic, social, and environmental. This gap has been highlighted in the works of Abobakr et al. (2024), Chofreh et al. (2020), Nguyen et al. (2023), Patalas-Maliszewska et al. (2020), and Saif et al. (2020).

The identified research gap led to the formulation of the research problem: how ERP systems support the sustainable development of organizations. The objective of the study was to analyze various aspects of ERP system implementation in manufacturing enterprises within the context of sustainable development. In-depth,



semi-structured interviews were conducted with representatives from three manufacturing companies that had successfully implemented an ERP system provided by a global software vendor serving over 2000 clients worldwide. The respondents were purposefully selected for their expertise and ability to compare organizational performance before and after ERP implementation. Their active participation in the change process enabled them to acquire extensive practical knowledge on the subject. Based on the formulated research gap, as well as incorporating practitioners' experiences, this article provides a new perspective on the impact of ERP implementation on sustainability in manufacturing enterprises.

## 2. LITERATURE REVIEW

### 2.1. ERP system

Enterprise Resource Planning (ERP) systems are information solutions that integrate data from various areas of a company's operations, such as finance, sales, procurement, human resources, and more (Ibrahim et al., 2024). Additionally, ERP systems enable the connection of internal supply chains with external ones, fostering stronger relationships with suppliers and customers (Maiga et al., 2015; Njihia et al., 2014).

An ERP software optimizes operational workflows, reduces inventory levels, facilitates better data analysis and customer service, improves planning, control, and decision-making processes. As a result, companies can reduce operational costs, increase efficiency and profitability, and ultimately gain greater market share (Jayamaha et al., 2023; Mahmood et al., 2020).

ERP systems have been implemented worldwide across various industries since the mid-1990s (Behera et al., 2020; Katuu, 2020; Martins et al., 2023; Momani et al., 2022). They originated from advanced manufacturing technologies aimed at improving quality, reducing inventory, enhancing customer service, and increasing production flexibility (Al-Amin et al., 2023; Spathis et al., 2004).

With the progressive digitalization of processes, ERP systems now play a critical role, particularly in manufacturing companies. Initially, their primary function was to support decision-making in optimizing business, production, and logistics processes. However, in light of the growing need to align with sustainable development principles, the role and functionality of ERP systems must evolve accordingly (Abobkar et al., 2024; Patalas-Maliszewska et al., 2022).

The implementation of an ERP system brings numerous benefits but is a complex and challenging process that requires thorough preparation and effective change management within the organization. It is crucial that the software meets the specific needs of the enterprise and that employees are convinced of its value for their daily tasks (Stachowiak et al., 2023).



The literature highlights various success factors critical to the successful implementation of an ERP system. The seven most commonly cited key success factors include top management support, a dedicated project team, robust IT infrastructure, effective communication, skilled personnel, monitoring, and evaluation (Al-Amin et al., 2023; Al-Mashari et al., 2003; Botta-Genoulaz et al., 2006; Butarbutar et al., 2023; Harun et al., 2023; Loh et al., 2004; Mahraz et al., 2020; Qachar et al., 2022; Stone et al., 2021). One of the pivotal elements that can determine the success of an ERP implementation is the involvement of consultants with the requisite knowledge and experience, which can significantly contribute to the project's positive outcome (Ragin-Skorecka et al., 2020). Conversely, failures in ERP implementation can stem from various issues such as project management problems, lack of executive support, insufficient training, poorly selected project teams, inappropriate organizational culture, unclear project scope, ERP software misalignment, weak solution providers, or communication challenges (Coşkun et al., 2022; Menon et al., 2019).

## 2.2. Sustainable ERP

Sustainability encompasses three interconnected dimensions: economic, environmental, and social, often referred to as the triple bottom line (TBL) or Triple-P (People, Planet, Profit) (Alhaddi, 2015; Slaper et al., 2011). The concept of sustainability is based on achieving a balance among these three areas (Dalibozhko et al., 2018).

Research conducted by Jayamaha et al. (2023) has shown that ERP systems have a significant impact the sustainability of organizations. This is due to their ability to handle and import large amounts of data, which reduces human error and enhances the quality and transparency of information. As a result, this leads to lower costs and increased productivity across the organization. Many researchers emphasize the need to develop and modify traditional ERP systems to account for all dimensions of sustainability (Chofreh et al., 2020; Rasanjali et al., 2022; Yuzgenc et al., 2023). According to Goni et al. (2017), organizations should integrate sustainable development initiatives with their information systems, which should also be implemented in a manner consistent with sustainability principles.

Spathis et al. (2004) identified the growing demand for real-time decision-making information and the need to integrate various applications as the main reasons for replacing traditional IT systems with integrated ERP systems. Initial studies focused primarily on the economic aspects of ERP implementation, highlighting two key features of these systems that improve financial performance. The first feature is the quality of ERP functionalities, such as user response speed, reliability, flexibility, system integration, and ease of access to information.

The second critical feature is the quality of data, including both internal and external financial and non-financial information, as well as their transparency, usefulness, reliability, and timeliness (Goumas et al., 2018; Jabłoński et al., 2018; Lutfi

et al., 2022; Ou et al., 2018). Research by Abobakr et al. (2024) confirms the positive impact of S-ERP (Sustainability ERP) system implementation on companies' financial performance, reflected in rising indicators such as ROA (Return on Assets), ROE (Return on Equity), and return on sales (Dhongadi et al., 2023). This demonstrates a clear relationship between sustainable enterprise resource planning using S-ERP and achieved economic results.

The positive relationship between S-ERP and environmental performance in sustainable development stems from real-time access to process information, which enables optimization by quickly detecting waste, identifying areas for improvement, and addressing irregularities in the value chain (Abobakr et al., 2024). Combining ERP with lean manufacturing practices can reduce waste, thereby improving environmental outcomes (Fakoya et al., 2013; Rasanjali et al., 2022). ERP systems also support the measurement of production's environmental impact, as their data structures allow for the assessment of various production processes and their effects on the environment, enabling the selection of more environmentally friendly solutions (Morawiec et al., 2022). Leyh et al. (2014) indicated that incorporating „green” KPIs into ERP systems and integrating ERP with environmental management systems can be effective methods for managing sustainability. Yuzgenc et al. (2023) found that S-ERP integration helps organizations achieve greater sustainability, including through energy savings and carbon footprint reduction. However, according to Chofreh et al. (2020), the S-ERP concept has not yet been widely implemented in practice.

In the social context of sustainability of S-ERP, a key issue is how system implementation affects working conditions, employee knowledge and skill development, change management, and resistance to new technologies (Abobakr et al., 2023). This is reflected in KPIs such as customer satisfaction, collaboration, employee empowerment, environmental responsibility, scalability, and flexibility, all of which support effective ERP implementation (Ruivo et al., 2011). Furthermore, ERP systems contribute to staff knowledge development, as their implementation requires employees to acquire new skills (Rouhani et al., 2018).

Chofreh et al. (2020) and Zakrzewska (2022) note that the number of studies on sustainable ERP implementation is limited. They emphasize the need for continued exploration, particularly through empirical analyses of actual projects implemented within the context of sustainable development.

### 3. MATERIALS AND METHODS

The aim of the research was to analyze various aspects of ERP system implementation and their role in supporting sustainable development within an organization. The study was conducted following the steps outlined in the schematic (fig. 1).



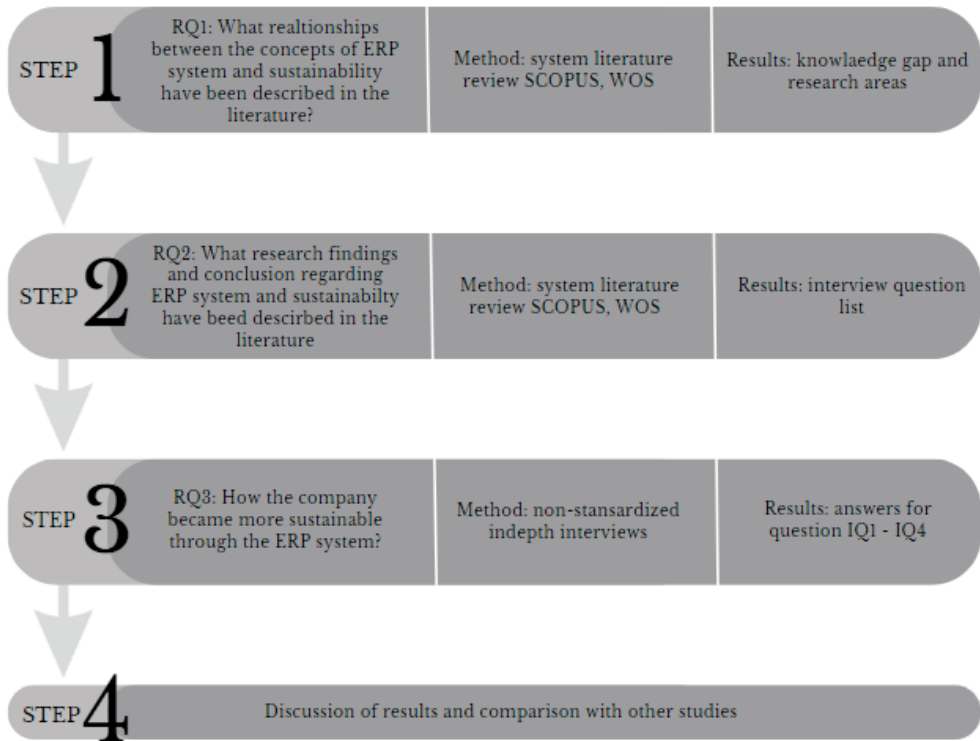


Fig. 1. Research methodology (own study)

The study began with a review of the literature, which provided insights into ERP systems and their role in sustainable development. This process also revealed a research gap, helping to refine the focus for further investigation (RQ1). Based on the collected information, interview questions were developed and later posed to representatives of three medium-sized manufacturing enterprises (RQ2). In the final step, the gathered data were analyzed, discussed, and compared with findings of existing research.

The use of semi-structured interviews allowed for the collection of information from practitioners who work with ERP systems daily and could describe the changes that occurred in their organizations. The flexibility of the interview format facilitated more comprehensive data collection, enabling participants to discuss aspects particularly relevant to their industry that may not apply to other sectors.

Drawing from the literature review, interview questions were designed and subsequently expanded to gather as much information as possible, tailored to the specific context of each company. This prior preparation helped structure the main topics to be discussed during the interviews and consider which aspects could influence the research topic.

The interviews aimed to answer the question: How has the company become more sustainable through the implementation of an ERP system? (RQ3). To address this, the following questions were posed to company representatives:

- IQ1: How did the companies function before the implementation of the ERP system? – this information allowed us to learn about the company’s situation before the implementation and to notice the changes that were influenced by the introduction of the ERP system.
- IQ2: How did employees accept and adapt to the change being introduced?
- IQ3: What impact has the ERP system had on the production process?
- IQ4: Have any improvements or improvements in the organization of company processes been noticed?

During the interviews, efforts were implicitly directed at gathering information about how the ERP system influenced the company’s sustainable development. The chosen method and the ability to ask additional questions allowed for exploring a broader perspective and obtaining real-life examples from daily operations. Respondents were deliberately not asked directly about changes in the company’s sustainability aspects since the introduction of the ERP system. This approach was intended to assess their awareness of this topic and to collect information for an objective comparison and analysis of the company’s operations before and after the ERP system implementation.

#### 4. ANALYSIS AND DISCUSSION OF RESULTS

Three medium-sized manufacturing enterprises participated in the semi-structured interviews. The first company is a producer of trailer systems, enabling the transport of various load sizes using a single trailer.

The production of such systems involves a large number of components, such as screws, washers, and nuts, which necessitates the development of extensive bills of materials. Before the implementation of the ERP system, the primary challenge was regular inventory management to maintain constant control of stock levels. Consequently, the company was unable to determine whether they had sufficient components for production, leading to overstocking, inventory corrosion, and additional costs. The second company is an electronics manufacturer specializing in cable harnesses that can be tailored to meet individual customer needs. This production approach not only enables the creation of products for specific applications but also ensures compliance with quality standards.

The company’s biggest challenge is managing substitutes, series, and revisions. Documentation is critical in this industry, as there is rarely a need to produce single items, apart from prototypes. Typically, thousands of products are manufactured at a time, and the use of incorrect documentation generates not only costs and waste

but also requires additional production resources to fulfill customer orders within the promised timeframe.

The third company interviewed is a producer of ventilation and ignition systems. Production is order-based, with customers providing specifications and awaiting for technical drawings from designers. Therefore, this production approach can be described as project-based. The biggest challenge is archiving technical documentation and importing it into the appropriate system locations. Before the ERP system implementation, the company only used software for financial management and document workflow. The lack of a production management tool, coupled with rapid growth, resulted in chaos caused by highly complex Excel spreadsheets and partially handwritten production plans or notes on paper. This approach was very time-consuming and frustrating for employees while also being unprofitable for the company – even the simplest tasks were not automated and required significant human resources.

One might question whether implementing an ERP system is a cost-effective investment. As is well known, such implementations often involve expenses reaching hundreds of thousands or even millions of currency units. However, it is worth noting the potential savings that can be achieved through software that supports enterprise management processes. The interviewed participants unanimously emphasized that the greatest value of ERP systems lies in their ability to collect data and provide constant access to it.

This capability enables cost calculations and analyses, which are particularly critical when prices are dynamically changing. During the interviews, it was repeatedly mentioned that ERP system support facilitates the calculation of production profitability and allows for necessary adjustments to ensure continuous profitability. Another significant aspect is effective production planning. Thanks to bills of materials developed in the system for finished goods, constant monitoring of inventory levels is possible, enabling regular replenishment based on incoming customer orders. Planners, through the integration of warehouse, sales, and production modules, have a realistic view of production capabilities based on inventory levels, customer demand, and the workload of machines and employees. With a complete set of information, production can be planned in a way that minimizes the need for constant rescheduling. Moreover, production halts are much less frequent. As a result, machine operating time is maximized, which also has a positive impact on environmental sustainability. Bottom of Form The optimization of production time and the efficient use of machine working hours are among notable outcomes. This is further supported by a functionality referred to as setup optimization. This feature enables production to be arranged in a way that minimizes the time required to adjust machines for manufacturing the next product or semi-finished good.

Additionally, through the use of previously mentioned order disposition lists, not only are costs reduced, but inventory management and waste reduction are also



significantly improved. As highlighted in the interviews, employees have observed the tangible impact of the ERP system and the support it provides. Inventory levels are updated in real-time, annual inventory checks are smoother, and unnecessary surplus stock is no longer found. The results of these checks are less surprising, making the process more of a formality. An additional advantage of the system, particularly emphasized by the interviewee from the electronics sector, is the ability to block components in the system – most often used when a client requests a product revision. This functionality prevents production staff from accessing data or reporting on the manufacturing of the item. Workers are automatically notified of the component block, and production is halted until the appropriate documents are uploaded, changes are implemented, and the order is unblocked. This not only enhances production potential but also positively impacts the environment by reducing the generation of production waste.

The positive effects of ERP system implementation described above also influence the social aspect of a company's operations. With greater process control and the ability to halt production when technical data for a product is revised, customers are far less likely to receive products that do not meet their specifications. Additionally, production plans based on up-to-date information and access to real inventory data enable accurate determination of order delivery times. This results in higher customer satisfaction and an increased willingness to continue collaboration due to a lower error rate. Accurate system information also contributes to better organization of working time, leading to greater employee satisfaction. Automating simple and routine tasks allows employees to focus more on activities that foster professional development and enable them to gain new experiences. As noted by Yuzgenc et al. (2023), ERP systems positively influence the development of employees' professional competencies, improve interdepartmental collaboration through efficient data flow, and enhance workplace safety. The system's ability to generate sustainability reports contributes to greater enterprise transparency and can strengthen relationships with both suppliers and customers.

The implementation of an ERP system impacts all three dimensions of sustainable development: economic, environmental, and social. It enhances stakeholder satisfaction, increases efficiency, and optimizes production, thereby reducing waste. Interviewees frequently emphasized the value of having access to up-to-date, structured data centralized in one location. Analyzing this data enables rational organizational management and highlights how decisions affect aspects such as the environmental balance of products, which is becoming increasingly important to customers.

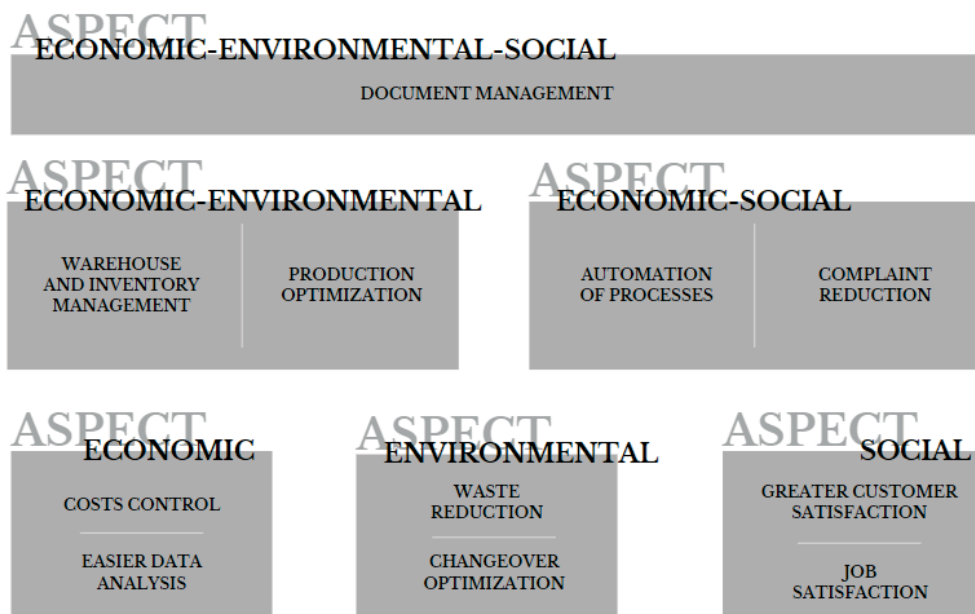


Fig. 2. Sustainable development by ERP system functionalities (own study)

It is worth noting, however, that many of the benefits associated with ERP system implementation cannot be unequivocally attributed to a specific pillar of sustainable development. As illustrated in figure 2, these aspects complement each other and correlate, influencing the course of processes and the organization of work throughout the enterprise.

## 5. CONCLUSIONS

Investment in ERP software requires substantial financial, human, and time resources, and the success of such a project depends on numerous variables (Al-Amin et al., 2023; Al-Mashari et al., 2003; Botta-Genoulaz et al., 2006; Butarbutar et al., 2023; Harun et al., 2023; Loh et al., 2004; Mahraz et al., 2020; Qachar et al., 2022; Stone et al., 2021). A well-chosen and effectively implemented ERP system has a significant impact on an enterprise, with benefits that are clearly recognized by investors, management, and employees alike.

Although many publications emphasize that ERP software plays a crucial role in business growth and process improvement, few acknowledge its contribution to sustainable development (Huang et al., 2019; Stojkić et al., 2015; Stachowiak et al., 2019). The economic aspect of ERP is often the most frequently discussed and relatively easy to observe. However, considering the current market challenges for manufacturing companies, particularly due to the political and economic uncertainties,

the social pillar in S-ERP is becoming increasingly important. By fostering strong relationships with both suppliers and customers, enterprises can position themselves as trusted partners, enabling them to establish long-term collaborations and contracts (Kenge et al., 2020).

While ERP systems do not directly influence relationships with contractors, they indirectly impact satisfaction by providing reliable data and system functionalities that employees can effectively utilize (Anaya et al., 2023; Ebirim et al., 2024).

In the authors' view, future research on sustainable ERP systems should focus on the collaboration between users and the system, as well as the opportunities offered by fully utilizing its functionalities. An additional question to explore is the impact of generational shifts and the skills required to effectively use enterprise management software.

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## ZRÓWNOWAŻONY ROZWÓJ ORGANIZACJI Z PERSPEKTYWY SYSTEMU ERP

### Streszczenie

Systemy ERP odgrywają kluczową rolę w cyfryzacji przedsiębiorstw, wspierając ich transformację w kierunku zrównoważonego rozwoju. Celem badań było przeanalizowanie wpływu implementacji ERP na aspekty ekonomiczne, środowiskowe i społeczne w organizacjach produkcyjnych. W badaniu zastosowano pogłębione wywiady niestandardyzowane z przedstawicielami trzech średniej wielkości przedsiębiorstw, które wdrożyły system ERP.

Wyniki badań wskazują, że ERP poprawia efektywność operacyjną, redukuje odpady i koszty oraz zwiększa satysfakcję interesariuszy. Przykłady praktycznego zastosowania obejmują optymalizację czasu pracy maszyn, lepsze zarządzanie zapasami oraz eliminację błędów wynikających z nieaktualnych danych. Systemy ERP wspierają także środowiskowy wymiar zrównoważonego rozwoju poprzez redukcję odpadów poprodukcyjnych oraz możliwość monitorowania wpływu produkcji na środowisko. W aspekcie społecznym zauważalne są poprawa warunków pracy, wzrost zadowolenia pracowników oraz ich rozwój zawodowy.

Wnioski z badań podkreślają znaczenie właściwego dostosowania systemu do potrzeb organizacji oraz jego wpływ na poprawę procesów w firmach. Mimo dużych nakładów finansowych i organizacyjnych inwestycja w ERP przynosi wymierne korzyści w zakresie zrównoważonego rozwoju. Zidentyfikowano również potrzebę dalszych badań dotyczących współpracy człowieka z systemem ERP oraz wpływu zmian pokoleniowych na efektywność wykorzystania tych narzędzi.

**Słowa kluczowe:** zrównoważony rozwój, przedsiębiorstwo produkcyjne, system ERP

