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Twin Transition – Sustainable Digital Decision Making in Enterprise Resource Planning

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Abstract:

The European Union is striving to achieve the goal of a climate-neutral Europe by 2050. A crucial factor for achieving this goal is the so-called twin transition. It describes the simultaneous digital and sustainable transition of the European economy. If implemented correctly, ongoing digitization contributes significantly to the desired sustainability. It, in turn, also means that digital processes supported by software should consider sustainability goals. Business software and, in particular, Enterprise Resource Planning (ERP) systems are the most applied tool for the digitization of business processes. For a successful twin transition, it is crucial to combine the idea of sustainability with ERP systems. For this purpose, we conduct a literature analysis. The outcome shows that some research work regarding sustainability and ERP systems and their implementation as a whole exists already. However, a detailed process-oriented examination about the consideration of sustainability in ERP-based business processes is still missing. It should focus on the specific decision processes of business processes and functions within ERP systems. For generating impact on sustainability, the decision-making processes are of particular interest. Therefore, our research aims to examine the twin transition of decision-making processes in ERP-supported business processes. The focus is on considering sustainability in these decisions. Thus, we introduce an approach that integrates both the ERP support by automation and the consideration of sustainability. Subsequently, we apply the model to the process of creating a purchase requisition.

JEL Classification: M11 (Production Management), M15 (IT Management), Q56 (Sustainability)

Keywords: ERP, Sustainability, Procurement, Modelling, Decision-making

1 Introduction

Sustainable management is increasingly demanded of companies by legislators and customers. It includes environmentally friendly decisions, the consideration of social interests, and economic success. Within companies, many operational decisions are made with the support of planning systems such as systems for Enterprise Resource Planning (ERP), Manufacturing Execution, or Logistics Execution. Such decisions are material or production planning via personnel scheduling up to route planning. Often, they are partly automated. The systems provide decision-relevant information, and the users decide. The availability of Artificial Intelligence, Robot Process Automation, and complex algorithms for a broad range of companies and systems require a new evaluation of the potential for automation in operational decisions (Soprakan and Kiattisin, 2021). Operational decisions consider the framework of tactical decisions. They refer, for example, to the utilization of resources, the quantity and dates of product variants to be produced or to be purchased (Buzacott et al., 2012, 2).

Currently, the majority of these decisions are based on costs. The cost rates are stored in the machine, material, personnel, or logistics master data to enable margin calculations for customer orders and cost overviews at any time. It is questionable to what extent this approach meets the goal of sustainability in companies. We distinguish between three perspectives on sustainability and ERP systems: Perspective 1 focuses on the influence of ERP systems as a whole on the sustainability of a company (for example, Chofreh et al., 2016). Perspective 2 refers to the sustainable operation of ERP systems, for example, the low-CO2 operation of data centres (for example, Harmon et al., 2010). Perspective 3 involves the ERP system application in processes and thus the support provided by ERP systems in making decisions (for example, Fajriani et al., 2020). While the first two perspectives have been extensively addressed in the literature, authors have hardly considered the third perspective so far.

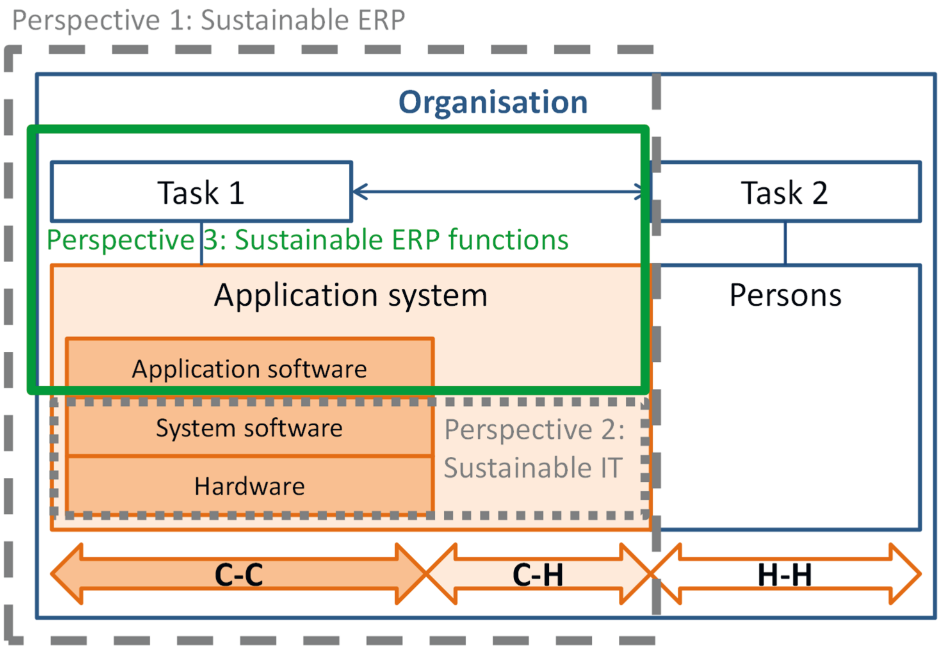

Figure 1: Perspectives on application systems

The figure above illustrates the described differences, when looking onto application systems (Ferstl and Sinz, 2013, 5). While perspective 2 focuses strongly the physical system operation, which is essentially characterized by hardware and the system software, perspective 1 refers to the application system as a whole and thus also to the implementation process. Perspective 3 analyses individual application system elements, namely the decisions made by or with the ERP system and their influence on sustainability.

According to this differentiation, plus the fact, that the third perspective has been neglected in the existing literature, we will give insights into the following research question:

> *How can sustainability be integrated into operational, ERP-based decision processes?*

To answer that question, we intend to examine the decision-relevant relation between both elements of twin transition. Another objective is to describe specific measures that ensure the consideration of sustainability in ERP-based processes. Furthermore, we want to introduce an approach for describing the automation and sustainability level for operational decisions. So, it will be possible to identify automation and sustainability potentials for operational decisions.

To reach the objectives, we first provide the results of a literature review on ERP systems, operational business decision-making, and sustainability. Subsequently, we introduce a model for sustainable decisions and adapt it to an ERP-based process. The model serves as the basis for describing ways to ensure and integrate sustainable

ERP-based operational decisions. It is followed by an example for a sustainable decision in the ERP-based process of creating a purchase requisition.

2 Theoretical Background

2.1 Sustainable ERP

The Sustainable ERP (S-ERP) research follows three different perspectives (cf. introduction). Articles of the first perspective cover the impact of ERP systems, as a whole, on sustainability. Chofreh et al. contribute extensively to this perspective. They introduced in several articles a framework for S-ERP implementations. In 2014 they defined an S-ERP system "as a holistic solution to support sustainability initiative" (Chofreh et al., 2014). The research paper addresses the different stages of the S-ERP lifecycle. For each, the authors examine the integration of business and sustainability. They state a lack of integration in companies. In addition, they figured out a lack of research regarding each stage of the S-ERP lifecycle. Motivated by these findings, Chofreh et al. developed a framework for S-ERP implementation. They assumed the availability of S-ERP systems on the market. However, companies fail to establish them in their organizations. To succeed with the S-ERP system implementation, they developed a master plan consisting of a framework, a roadmap, and guidelines.

In Chofreh et al. (2017), the authors derived from existing ERP roadmaps an S-ERP roadmap with three phases (pre-implementation, implementation, post-implementation) and nine stages (twice: initiating, planning, executing, closing; once: monitoring). Subsequently, the researchers described the evaluation of their roadmap by 12 experts and specified the different elements of their roadmap (Chofreh et al., 2018a). However, the roadmap does not include specific dimensions and criteria. Therefore, Chofreh et al. (2018b) add a framework to the roadmap. It combines the decisional paradigm (strategic, tactical, operational) with the sustainability paradigm (environmental, economic, social). Following the decisional paradigm ensures the involvement of all internal stakeholders in an implementation process. The sustainability paradigm leads to a comprehensive list of criteria and objectives when implementing an S-ERP system. As for the roadmap, several experts confirmed the framework's applicability (Chofreh et al., 2018c).

As the last element of their master plan, Chofreh et al. (2020) derived guidelines from the roadmap and the framework. For specifying them, the authors combined the implementation levels of the framework (strategic, tactical, operational) with the implementation steps of the roadmap (initiation, plan, execution, monitoring/controlling, closure). Furthermore, they defined detailed activities considering the sustainability paradigm for each step-level combination. According to the authors, following their approach would improve production effectiveness, minimize energy consumption, and reduce carbon emissions. Figure 2 gives a good overview of the different levels within the approach described above.

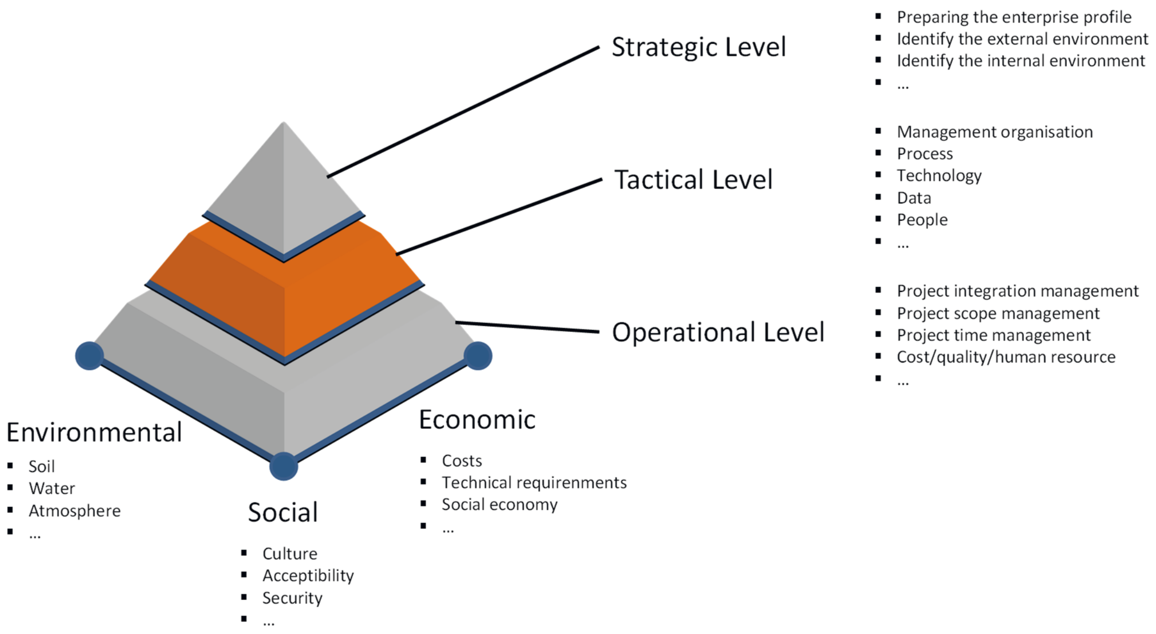

Figure 2: S-ERP systems implementation framework (Figge et al., 2002; Goldman and Nieuwenhuizen, 2006)

Unquestionably, the research work of Chofreh et al. is a valuable and comprehensive contribution to the S-ERP research. The extensive literature fundament combined with the expert-based evaluation of their approach built a broad fundament for the sustainable implementation of ERP systems in organizations. They consider the sustainability of decisions about the entire ERP system and its implementation. However, the authors did not investigate the specific ERP functions and decisions in operational processes from a sustainability perspective in detail.

The same holds for the other publications of the first perspective on S-ERP systems. Huang et al. (2019) identify critical success factors for the ERP system implementation by executing a literature review and carrying out a Delphi study within the Taiwanese B corporation. According to the results of the literature review and the Delphi study, there are 41 critical success factors (such as top management support or user training and education) in the five dimensions business organization strategies, system users, counselling team, software vendor, enterprise performance. Considering success factors increases the internal control, which leads to a better brand image and higher sustainability in operations. Alsaid (2021) describes the ERP system implementation for an Egyptian state-owned enterprise for electricity distribution. The paper further examines how an ERP system supports sustainably running the business. Ibrahim et al. (2018) refer to ERP-based Reverse Logistics and describe a use case about it. Unlike the other authors of perspective 1, Slaman and Haddara (2019) show in their case study that ERP systems do not automatically increase sustainability. According to them, ERP systems mainly lead to higher efficiency and better time management.

The second of the three research perspectives on S-ERP mainly includes all research regarding sustainable Information Technology (IT) in general, and Green IT, in particular. It addresses how a company can sustainably run an ERP system. As the name indicates, Green IT reduces sustainability to eco-friendly ERP Systems. It refers to their use, disposal, design, and manufacturing. A system includes both software and hardware. As concrete measures, Murugesan (2008) suggests reducing the energy consumption of computers, refurbishing and reusing old computers, designing eco-friendly hardware, and manufacturing with minimal impact on the environment. Loeser (2013) confirms this definition for Green IT for the research work until 2013. Over the last decade, the research focus expanded from Green IT to Sustainable IT (Harmon et al., 2010). In addition to the eco-friendly system operation and the business impact, researchers considered aspects such as partnerships, voluntary codes, or NGOs, when evaluating IT sustainability. Ursacescu et al. (2019) examined the relation between Green IT and ERP systems in the context of sustainability. For their empirical study, they combine sustainable management criteria with green IT criteria to assess the greenness of ERP systems. Mmeah et al. (2018) give an overview of the research about Sustainable IT. They summarized the development of green IT to sustainable IT. According to them, it started with the first wave of green computing, which allows cost optimization. As a second wave, Sustainable IT services appear, which take into account the social role of IT. During that wave, Sustainable IT comes along with the concept of corporate social responsibility.

The third research perspective addresses the sustainability of specific ERP-supported processes and ERP functions. Unlike the articles of perspective 2, the research work does not refer to the ERP system as a whole. Instead, it focuses on specific ERP functions and ERP-supported processes. Kandananond (2014) concentrated his research on the environmental impact of supply chain activities over the entire product lifecycle. Following his results, ERP systems should support the product-related tracking of energy, resource, and material consumption. Also, transportation efforts should be available and information about the daily use of the product. Finally, monitoring waste disposal is necessary for the ERP system. In addition, the ERP system should offer a function for environmental reporting. Zvezdov and Hack (2016) refer to the latter, as well. They examined how ERP systems can support the carbon footprinting within a supply chain and developed an ERP data framework for determining the carbon footprint of companies. They use a case study for designing and applying their approach. Fajriani et al. (2020) analyze the Greenness of the ERP-based procurement process for the Leather Tanning industry. They propose a system that includes sustainability data in the supplier master data to incorporate environmental aspects when selecting a supplier. They implemented their proposals for the open-source ERP system odoo.

In summary, there has been some research work regarding the sustainability of ERP systems. The literature of perspective 1 describes the impact of an ERP implementation in an organization on sustainability. Authors of perspective two mainly cover how companies can sustainably run an ERP system (or IT systems in general). However, only perspective 3 includes detailed examinations of ERP-based processes and ERP functions. We structured the literature review according to the different elements of an application system. Alternatively, figure 3 illustrates that it is possible to organize the perspectives from general (2 – sustainable IT) to specific (3 – sustainable ERP functions).

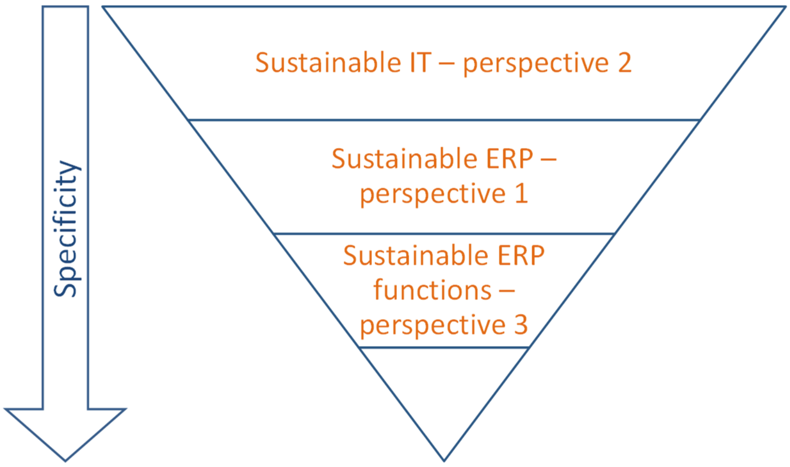

Figure 3: Research perspectives

Furthermore, the literature review reveals that there is still future research required. When it comes to sustainable ERP functions, in particular carbon footprinting and sustainable lifecycle management, it becomes clear that operational ERP-based decisions are crucial for sustainable companies. Thus, decision tasks in a process are the tasks that are relevant for process sustainability and process automation. Therefore, we will shed light on sustainable decisions in ERP systems in the subsequent paragraphs.

2.2 Sustainable and Automated Decisions

Sustainable development "[...] meets the needs of the present without compromising the ability of future generations to meet their own needs [...]" (WCED, 1987, 8). This formulation of the Brundtland Report is the starting point of the global sustainability discussion. Furthermore, the report specifies that primarily the fundamental needs of the world's poor must be met and that this must be done within the planetary boundaries of the global ecosystem (WCED, 1987). Thus, sustainability includes an ecological dimension as well as a socio-economic one. However, it is also noted that sustainability will have different manifestations in different countries and systems. Within the United Nations framework, the goal of sustainable development has found its expression in the Sustainable Development Goals (SDGs) and the associated Agenda 2030 (United Nations, 2014). These request policymakers worldwide to take action to achieve sustainability. Implementations in national strategies, such as the German Sustainability Strategy (Bundesregierung, 2021), and multinational measures, such as the European Green Deal (European Commission, 2019), set conditions that increasingly require decision-makers in companies to integrate sustainability into decision-making processes and organizational structures.

As the sustainability concept covers a broad spectrum, there are also different views on sustainable decision-making processes (Bolis et al., 2017). The scientific literature on sustainable decision-making includes, for example, contributions to the integration of social factors and public participation processes in waste management (Hung et al., 2007). It also refers to the influence of a desired positive legacy on ethical business decisions (Fox et al., 2015), the use of life cycle assessments in decision-making processes (Dong et al., 2018), or sustainable decision-making in the software management process (Bokolo and Mazlina, 2016). Additionally, it includes contributions that generally address the integration of sustainability factors in decision-making processes (He et al., 2017; Ashley et al., 2003). A general understanding of sustainable decision-making processes does not emerge from the existing literature.

Decisions are specific activities within a business process. Machines, application systems, or persons carry out the tasks (figure 4). If persons solely execute the tasks, they are not automated (manually). If software partly or completely overtakes a task, it is partly or fully automated (Ferstl and Sinz, 1998). Application systems include all types of software and hardware plus the users, in case of partly automated tasks.

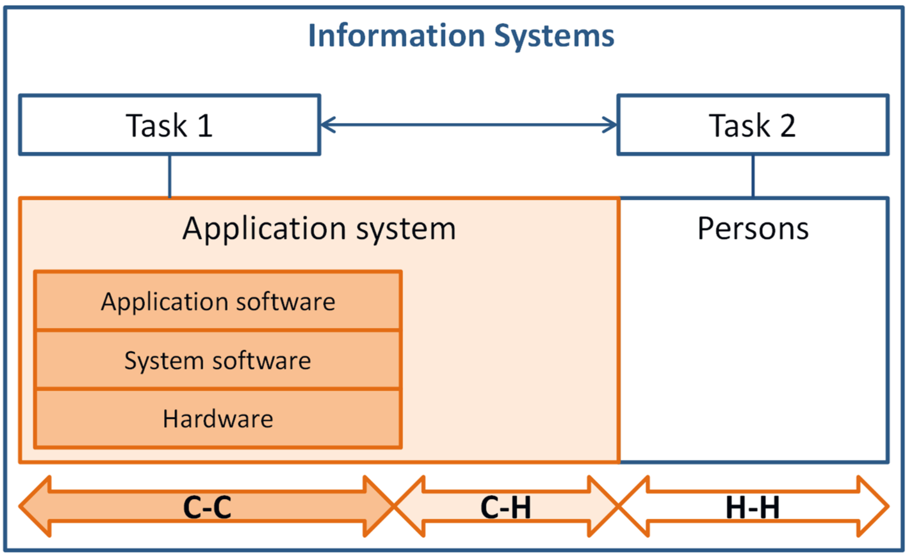

Figure 4: Application systems (Ferstl and Sinz, 2013, 5)

If a decision is carried out manually, none of its elements is automated. Partly automated decisions are decisions with manual and automated elements. In the case of partly automated decisions, a decision support system automatically generates numerous decision alternatives, whereas managers are responsible for their assessment. Automated decisions are decisions without any manual doing. The proliferation of artificial intelligence causes an increase in the automation level of decision-making. Each decision consists of the subsequently described sub-tasks, derived from the five decision elements in figure 5 (Sieben and Schildbach, 1994, 15-31).

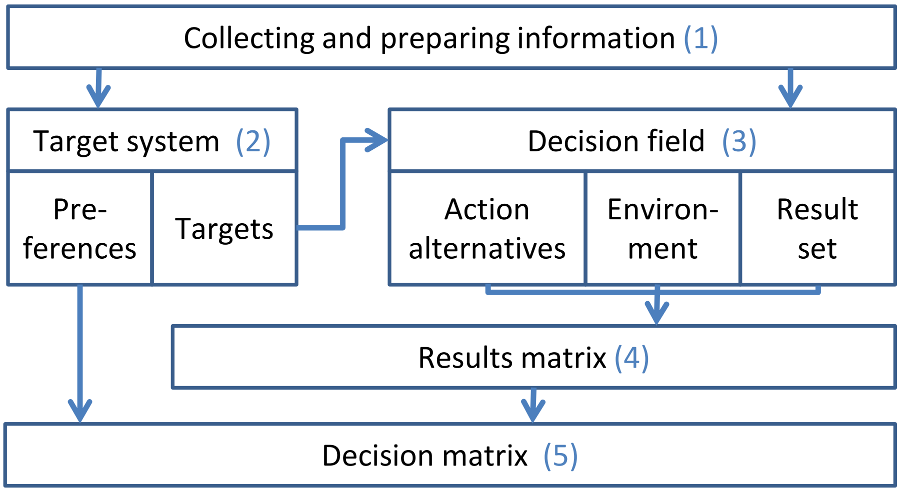

Figure 5: Decision process according to Sieben/Schildbach (1994)

Collecting and preparing information about the decision situation includes gathering all necessary information. It contains decision contents, decision conditions, and the targets and preferences of the responsible person or department. Defining the *target system* means determining the target values that should be reached by the decision. Preferences indicate which targets and target values are advantageous compared to others. The *decision field* consists of the decision-related alternatives, conditions, and result sets. Thus, it describes all kinds of decision inputs and decision outputs. The *result matrix* gives an overview of all possible scenarios with their results without evaluation. Unlike the result matrix, the *decision matrix* includes a ranking of different scenarios. It applies the preferences and target values on the result matrix. So, the best alternative becomes obvious (Sieben and Schildbach, 1994, 15-31). Further on in this article, we introduce solutions for the automation of the five decision elements. Thus, we illustrate the digital aspect of the twin transition and distinguish between different levels of automation for each decision. Thereby we reveal opportunities and solutions for automation.

Additional to digitization, the decisions in the twin transition context comprise the aspect of sustainability. Therefore, we speak about sustainable decisions when sustainable factors play a relevant role in the target system. Minimum standards on sustainability (Hersh, 1999) lead to a reduction of the number of alternatives to sustainable alternatives. Sustainability as an object of optimization in the context of a decision ensures optimal decisions regarding sustainability, for example, when choosing an alternative with minimal CO2 emissions. Usually, the operationalization of sustainability requires more than one factor and the underlying decision problem also includes at least one factor to be optimized. Therefore sustainable decision-making is often accompanied by multi-criteria optimization problems (Hersh, 1999; Zavadskas et al., 2018; Paul et al., 2021).

Sustainable decisions thus integrate additional, sustainable criteria into the decision-making process, which increases the complexity of decision-making. Several target criteria have to be taken into account, and trade-offs and conflicts of objectives between individual criteria usually arise. Therefore, procedures are necessary to weigh the target criteria (Penadés-Plà, 2016). Additionally, minimum standards can serve as a framework for an optimization decision (Hersh, 1999).

Another challenge of sustainable decision-making lies in choosing suitable indicators for quantifying sustainability. It comes from the broad and partly differing understanding of the term sustainability. In addition to the SDGs at the international level, various approaches and systems exist both at the national level (for example, indicator report of the German Federal Government) (Statistisches Bundesamt, 2021) and in the context of supply chains (for example, Life Cycle Assessment) (Egilmez et al., 2014) and companies (for example, Global Reporting Initiative or German Sustainability Code) (Rat für nachhaltige Entwicklung, 2020) for measuring the different sustainability dimensions. Also, in the (economic) scientific literature, no uniform procedure is used to operationalize sustainability. Therefore, it is necessary to make a strategic decision about the criteria or a criteria system that operationalizes sustainability within a company. Only then do these criteria support sustainable decision-making on an operational level. This conclusion is the fundament for the following examination.

3 Model for the Twin Transition

Twin transition of operational business processes means the integration of sustainability and the automation of these decision processes. Therefore, we suggest a model for the twin transition in the light of the theoretical background in section 2. It covers both automation and sustainability of the various decision elements of a decision process (see figure 6).

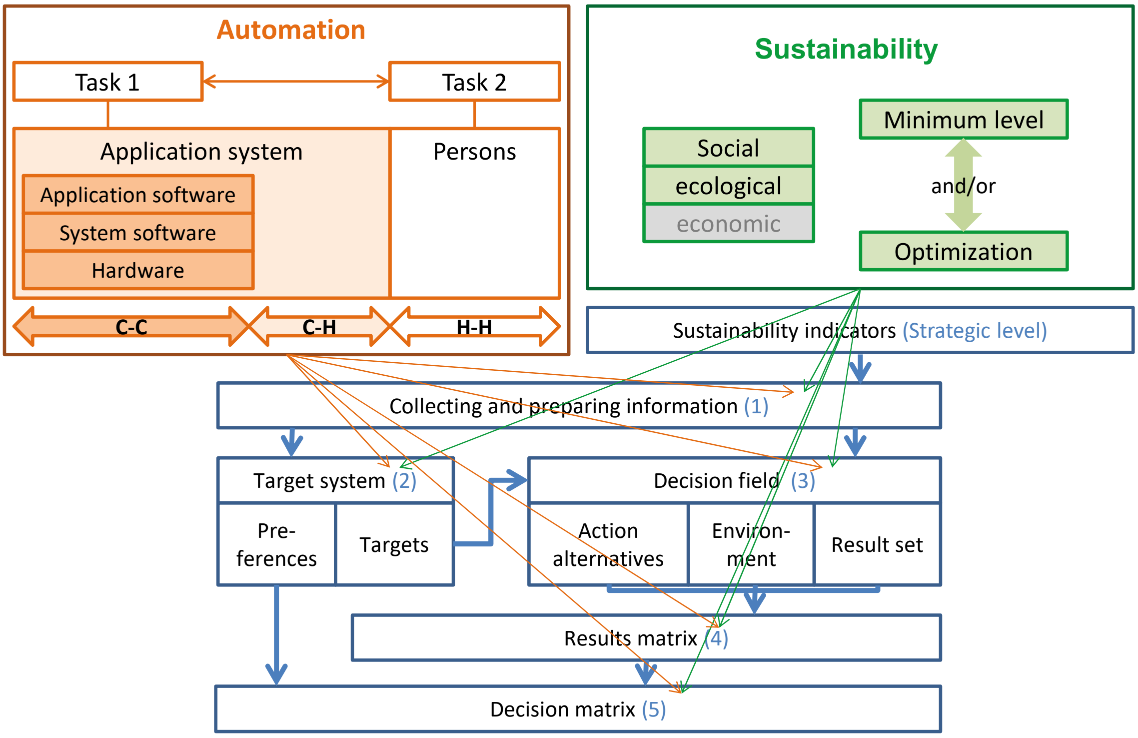

Figure 6: Twin transition of operative processes

3.1 Automated Decisions

For our research, we focus on operational ERP-supported business processes. Therefore, we analyze how ERP systems can increase the automation level for each element. The examination about ways of automation in ERP systems starts with element (1), as we take the strategic level as element (0) which is a prerequisite that is not crucial for the automation of decision and will be explained in section 3.2. Another prerequisite are thoroughly maintained Master Data in the relevant context.

The first element *refers to the information collection and preparation concerning the decision situation* (1). ERP system automation for that element means the digital availability of reports that contain relevant information for decision-makers. In addition, an ERP system provides information, when entering values. If, for example, a sustainable lot size is predefined for a product, the system should take it as a suggestion for the product-specific production or purchase order. If there is an end date for product availability, a hint should appear on the screen during the order creation. Usually, the relevant information comes from Master Data that was maintained before.

The second decision element refers to the *target system* (2). The ERP system considers targets by weights in target functions, for example, for different cost types or target values for run times. Users maintain them as Master Data for suppliers, items, or other objects. For automated decisions, the application of a function to an object or the consideration of target values is automated.

The third decision element is the *decision field* (3), consisting of alternatives, environmental conditions, and possible results. Altogether, the decision field includes a set of unassessed scenarios as a basis for the decision. ERP systems allow working with unassessed scenarios, by using plan versions or Master Data alternatives, such as bill of materials or routing alternatives, or alternative suppliers. In particular, plan versions allow the consideration of varying environmental conditions. They complement the information that is available from the first decision element.

The fourth decision element combines the previous decision elements to assess the alternatives. ERP systems, which automate the *creation of a result matrix* (4), assign values (in terms of the target function or the difference to target value) to the alternatives of the decision field. Thus, users achieve an overview of assessed scenarios to support their decisions.

Finally, if the ERP system overtakes the fifth decision element, it identifies the best decision. Thus, the *decision matrix* (5) in the ERP system includes all relevant information about the decision result. The system overtakes the entire decision for the user. In that case, the decision is fully automated.

For achieving automation concerning decision elements (4) and (5), (1), (2), and (3) are prerequisites. Furthermore, it is hardly possible to automate (2) and (3) without an automated or at least partly automated decision element (1).

An example of a fully automated decision process is the Material-Requirements-Planning (MRP) job in numerous ERP systems. It automatically decides about quantities and dates. It applies the provided information about the environmental conditions, such as demand or delivery times. The target function usually focuses on achieving inventory goals, ensuring timeliness, or reaching a suitable capacity load. The MRP run evaluates numerous alternatives by following predefined rules and returning a precise result. Table 1 includes an overview of automation approaches for the elements of a decision.

Element	Automation	Explanation
1	Reports, information fields, pop-up messages, drill-down lists.	Relevant information are automatically available, when making the decision (for example, drill-down list of available products during the creation of a production order).
2	Weights in target functions, target values	For example, a target function for finding an economic order quantity or order sequence consider weights, Master Data contain target values (for example for run times).
3	Set of unassessed scenarios (plan versions, bill of materials / routing alternatives, alternative suppliers…)	The ERP system provides an overview of a certain plan version with the respective decision objectives, but not assessed with relevant criteria
4	Overview of assessed scenarios (total value concerning target criteria for plan versions, alternative routings…)	Similar to 3, but now with an assessment according to multiple decision criteria.
5	Result matrix with the preferred plan version, routing, bill of materials	ERP system makes a decision and return information on the selected alternative, for example, plan version.

Table 1: Automated decisions in ERP systems

3.2 Integration of Sustainability

Since decisions in ERP-based processes are mostly cost-oriented, the economic dimension of the triple bottom line (TBL) is already considered (Elkington, 1998). Social and environmental criteria still need to be defined for the twin transition. Alternatively, managers and researchers overcome this differentiation and choose a holistic approach that considers sustainability as a whole (Milne and Gray, 2013). Additionally, it has to be determined if minimum levels or optimization models are suitable for ensuring a sustainable decision process.

Section 2.2 explained that it is necessary to decide on the operationalization of sustainability before integrating sustainability aspects into the elements of a decision-making process. Thus, as already mentioned we add a decision element about *sustainability indicators* (0) to the model. It defines the qualitative and quantitative criteria for sustainability on a strategic level. Here, suitable sustainability indicators are defined for each decision in an enterprise separately or as an example for all decisions in the procurement process.

The sustainability indicators, defined on the strategic level, are applied to the operational decision processes. They serve as inputs for the *collection and preparation of information* (1). Integrating sustainability into the decision-making process increases the amount of input data compared to decision-making processes that do not consider sustainability.

The additional data is also relevant for the *target system* (2). Here, sustainability represents another multi-criteria target dimension or even the only target. It is necessary to adapt the existing target hierarchy and define weightings and preferences. For sustainability, it is crucial to determine the minimum standards that a sustainable decision must fulfil. Additionally, relevant sustainability indicators are to be defined as optimization criteria.

Information from element (1) and relevant targets for the decision (2) have to be integrated into the third element, the *decision field* (3). The integration of sustainability into the previous elements thereby expands the result set.

The *result matrix* (4) comprises all evaluated alternatives with the respective target values for the sustainability indicators. For automated decisions, the integration of sustainability into elements (3) and (4) follows automatically from the sustainability in (1) and (2).

If some alternatives in (4) do not meet the minimum sustainability standard, they are not part of the *decision matrix* (5). The decisions matrix describes the decision result considering the sustainability information and target values from (1) and (2).

Element	**Integration of sustainability**	**Explanation**
0	Definition of sustainability indicators	Select appropriate indicators to assess the sustainability of the decision. Should tie in with the organization's understanding of sustainability and reporting.
1	Extension of master data	Systematically collect and maintain indicators defined in Element 0.
2	Adjustment of the target system related to sustainability	Introduction of minimum standards that alternative courses of action must meet in terms of sustainability and definition of the sustainability indicators to be optimized. The hierarchy of objectives may need to be adapted.
3	Extension of the result set	The result set is expanded with sustainability indicators, and alternatives that do not meet the minimum standards are eliminated.
4	Presentation of the sustainability indicators in the result matrix	Sustainability impacts for each scenario extend the result matrix.
5	Adjustment of the decision matrix	The evaluation of alternatives considers sustainability indicators.

Table 2: Integrating sustainability into ERP decision making

Table 2 summarizes the integration of sustainability in decision-making processes. Although data changes in all elements of the decision-making process, only the definition of indicators in (0), the collection of sustainability-related information in (1), and the adjustment of the target system in element (2) are crucial for the integration of sustainability. The modifications there lead to an integration of sustainability into (3), (4), and (5) and thus into the entire decision-making process. Table 3 summarizes the twin transition by combining table 1 and table 2. It shows ERP functions that enable the digital part and the consequences of the sustainable part for operational ERP-based business processes.

Element	**Automation**	**Integration of sustainability**
0	-	Definition of sustainability indicators
1	Reports, information fields, pop-up messages, drill-down lists.	Extension of master data
2	Weights in target functions, target values	Adjustment of the target system related to sustainability
3	Set of unassessed scenarios (plan versions, bill of materials / routing alternatives, alternative suppliers…)	Extension of the result set
4	Overview of assessed scenarios (total value concerning target criteria for plan versions, alternative routings…)	Presentation of the sustainability indicators in the result matrix
5	Result matrix with the preferred plan version, routing, bill of materials	Adjustment of the decision matrix

Table 3: Summary of the twin transition of sustainable decisions in ERP

4 Twin Transition for Creating Purchase Requisition

Due to the functionality of ERP systems, reference models for business processes typically exist for the purchase to pay, order to cash, or plan to production processes (Whitelock, 2020; Kurbel, 2016, 105-119). To illustrate the application of our previously defined model, we take the creation of a purchase requisition as an example. We selected this task as it belongs to the procurement process, which has been the topic for many articles regarding sustainability. Furthermore, the purchase requisition includes not just one but several decision object. A purchase requisition requires a decision on the type of material or service, the delivery date, the delivery address, and the preferred supplier(s) (although the final decision is part of the purchase order). (Kurbel, 2016, 105)

Before we discuss the sustainability and the automation of a decision, it is necessary to select suitable sustainability indicators (0) (cf. section 3). As already mentioned in section 2, there is a multitude of indicator systems and even more individual indicators to capture sustainability aspects. As there is currently no consensus on a generally accepted indicator system for sustainability, the assessment system developed by the Global Reporting Initiative (GRI) seems to be suitable for the following explanations. The GRI is an independent international organization that develops standardized reporting guidelines regarding sustainability (GRI, 2022; Woods, 2003). All guidelines are transparently communicated and can be accessed by anyone. The advantages of using the GRI guidelines as indicator set are their global applicability and modular structure. The latter makes it possible to reduce the application effort, as only the relevant guidelines need to be applied in a certain business area. Integrating GRI indicators into the ERP system simplifies the sustainability reporting for a company, as that is the origin of the standards.

Eight GRI standards with selected indicators are relevant for the process of creating purchase requisition and its sub-processes. The standards 204 (Procurement practice), 301 (Materials), 305 (Emissions), and 308 (Supplier environmental assessment) with their indicators consider ecological aspects of sustainability. Social indicators relating to the process under consideration are described by standards 407 (Freedom of Association and Collective Bargaining), 408 (Child Labor), 409 (Forced or Compulsory Labor), and 414 (Supplier Social Assessment). Table 4 lists the GRI standards to be applied and the individual indicators to be integrated.

After defining the indicators for integrating sustainability, elements (1) to (5) are discussed for the ERP-based creation of purchase requisitions. We show for each element, how sustainability and automation is considered:

The data for the indicators listed in table 4 must be collected concerning the creation of purchase requisitions. It is stored in the suppliers' master data and is aggregated to a report (1). For getting information on 414-2 we need to save data about the social impact for each supplier. However, not all indicators are relevant for the result set of the decision field (3). When determining the material to be procured, the GRI indicators on the material (301-1, 301-2, 301-3) and emissions (305-3, 305-6) must be listed. The result set of the quantity decision does not change when using the GRI Standards.

The same applies to the result set for the delivery date and location. In the result set for supplier selection, the indicators for procurement practice (204-1), supplier environmental assessment (308-1, 308-2), freedom of association and collective bargaining (407-1), child labor (408-1), forced or compulsory labor (409-1) and supplier social assessment (414-1, 414-2) must be listed to integrate sustainability.

Area	Disclo-sure	Indicator
Procurement Practice (204)	204-1	Percentage of the procurement budget spent on suppliers local to the operation
Materials (301)	301-1	Weight or volume of materials that are non-renewable/renewable
	301-2	Percentage of recycled input materials
	301-3	Percentage of reclaimed products
Emissions (305)	305-3	Gross other indirect (Scope 3) GHG emissions
	305-6	Import of ozone-depleting substances (ODS)
Supplier Environmental Assessment (308)	308-1	Percentage of new suppliers that were screened using environmental criteria
	308-2	Number of suppliers assessed for environmental impacts; number of suppliers identified as having significant actual and potential negative environmental impacts
Freedom of Association and Collective Bargaining (407)	407-1	Suppliers in which workers rights to exercise freedom of association or collective bargaining may be violated or at significant risk
Child Labor (408)	408-1	Suppliers considered having significant risk for incidents of child labor or young workers exposed to hazardous work
Forced or Compulsory Labor (409)	409-1	Suppliers considered having significant risk for incidents of forced or compulsory labor
Supplier Social Assessment (414)	414-1	Percentage of new suppliers that were screened using social criteria
	414-2	Number of suppliers assessed for social impacts; number of suppliers identified as having significant actual and potential negative social impacts

Table 4: GRI-standards with relevance to the creation of purchase requisitions

Following the above findings, the target system needs to be adapted for the material and supplier decision (2). If the ERP system calculates an overall score for each supplier with the help of a target function, the sustainable criteria with the respective weights are added to the ERP target functions. Concerning the material decision, the target system can, for example, include the requirement not to procure any materials that contain ozone-depleting substances (GRI 305-6). Furthermore, the renewability of materials can be specified as a minimum standard (GRI 301-1). The requirement for recycled materials or reused goods (GRI 301-2 and 301-3) can also be part of the target system. If the target value refers to a share of the procurement quantity, historical data about material decisions must also be available in (3). Minimizing GHG emissions as a target in the materials decision can be integrated into the target system by always preferring material with the lowest scope 3 emissions (GRI 305-3). For increasing the sustainability of the supplier selection process, the GRI indicators should be successively defined as minimum standards in the target system. In the first step, social standards relating to child labor and forced labor (GRI 408-1 and 409-1) should be introduced, followed by the right to employee representation (GRI 407-1). In the process towards a sustainable supply chain, environmental and social assessment (GRI 407-1, 414-1, and 414-2) should also be part of the target system as qualifying characteristics of a supplier.

The result matrix (4) of the sustainable decision-making process is derived from the decision field and the defined target variables of the target system. The ERP system provides an overview for various suppliers considering the relevant indicators. With appropriate data integration, this step can be automated and includes the selected indicators for the sustainability of the GRI standards and the evaluation of the alternative courses of action. The transfer from preferences from the target system to the result matrix (4) and the resulting decision matrix (5) is done according to the procedure for the other target criteria and preferences. In the ERP system the best supplier according to the given criteria is filled into the respective field of the purchase requisition. The decision matrix contains information on the selected alternative. Specific modifications for achieving sustainability are not necessary here. As a result of the specifications in the target system, the material and supplier decision during the creation of purchase requisitions may result in a different choice than without taking the sustainability indicators into account. However, the decision made can be considered more sustainable.

The creation of purchase requisitions shows exemplarily the integration of sustainability indicators into ERP systems. It reveals that sustainable decision-making requires adjustments in (1) the collection and provision of information and (2) the target system. It is also essential to define indicators that reflect sustainability in the decision-making process on a strategic level (0). For this purpose, we chose the GRI standards, although they do not consider all relevant aspects of sustainability. For example, they do not include indicators for a sustainable purchasing quantity. However, quantity decisions can have a significant impact on sustainability. Small order quantities lead to frequent deliveries and, thus, increased GHG emissions if the means of transport are not GHG neutral. In contrast, large order quantities can lead to material not being used and ultimately destroyed. Therefore, further efforts are required for a sustainable indicator system as complete as possible and yet practical. Figure 7 summarizes for each element, how the twin transition of the supplier selection in the ERP-based creation of purchase requisitions could be achieved. The green elements require actions for the integration of sustainability. The orange elements are to be automated.

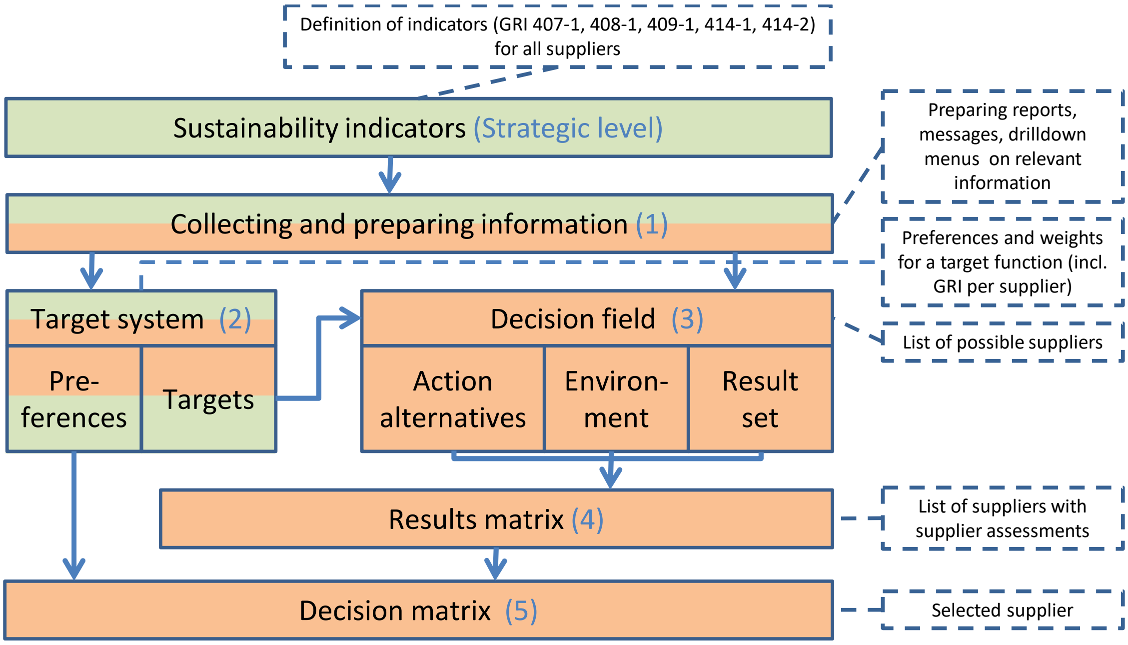

Figure 7: Twin transition of the supplier selection for the creation of purchase requisitions

5 Conclusion

Our research intended to examine the question of how we can integrate sustainability into operational, ERP-based decision processes. To answer this question, we developed the automation and sustainability perspective for the five main elements of the decision model of Sieben and Schildbach (1994). Furthermore, identified two prerequisites for the application of the model:

- It is crucial to define a set of sustainability KPIs before applying the model.
- The relevant Master Data has to be available in the system.

The model is based on a broad literature review in section 2 that mainly addresses the research in the field of S-ERP and sustainable automated decisions. Moreover, we applied our model to the initial supplier selection as part of the creation of the purchase requisition (section 4).

The model describes the relation between decision automation and sustainability. It shows that automation fosters the spread of sustainability. For achieving a sustainable decision, it is crucial to consider predefined (0) sustainability indicators when collecting and providing information and setting up the target system. Afterward, automated decisions incorporate sustainability targets like other targets (for example, costs, quality, etc.). Modifications for elements (3) to (5) are not necessary. For automated decisions, the ERP system automatically executes elements (3) to (5) considering the sustainable targets.

Furthermore, our approach allows the determination of the current automation and sustainability level for a decision and reveals actions to increase the level of the twin transition. If there are, for example, reports with supplier-specific sustainability indicators available, but not yet considered in the decision, the next step should be to redefine the target system in a sustainable way. Afterward, the KPIs for each supplier should be visible on the screen when making the decision. In the best case, the system automatically decides considering the sustainable targets. Then, the decision matrix should be available for the users.

In the next step, our model should be applied to a specific ERP system to prove its usefulness. Here, it is to be defined how the implementation of each step for an automated, sustainable supplier selection is realized. The model should also be transferred to other decisions in different processes (for example, production-order-related decisions).

Future research is required, to embed the model into the entire business process. Each decision represents just one subprocess or just a task within a business process (for example, in the purchase-to-pay process). Examining all decision tasks of a process allows determining the decision automation and sustainability level of the entire process. Thus, it would be possible to define twin transition potentials not only for a decision but for the whole process and even the company. Following this, a business process maturity model for twin transition would allow a comparison between processes and even companies.

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