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From Words to Results: The Role of IS in Bridging the Sustainability Strategy-Implementation Gap

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Abstract

After many years of reluctance and lack of commitment, companies are increasingly prioritizing sustainability and setting ambitious goals. Along with the rise of organizational sustainability strategy (OSS), the role of information systems (IS) in sustainability has increased and become a source of sustainability at the organizational level. Although ever more companies consider sustainability a top priority, they struggle to turn sustainability strategies into practice and observe measurable results. We followed a mixed methods approach combining qualitative interview data (n=13) and quantitative data from a multi-continental industry survey (n=551) to generate an in-depth understanding of the role of IS-enabled sustainability practices in influencing the organizational sustainability strategy-implementation gap. With our study, we demonstrate that IS-enabled sustainability practices mediate the impact of OSS on organizational sustainability performance (OSP) and that these practices are enabled by IS capabilities that are critical to implementing sustainability practices (technology intelligence, data analysis, and digital twinning capability).

Keywords: Information Systems, Organizational Sustainability Strategy, IS-enabled Sustainability Practices, Sustainability-Strategy Implementation Gap, IS Capabilities, Green IS, Environmental Sustainability

Introduction

The notion of "sustainability" has never been more popular in the corporate world. According to the World Economic Forum (Rafi, 2022), 90 % of executives consider sustainability to be critical for the future success of their companies. Increasing pressures from the capital market, regulators, and customers are motivating companies to focus on sustainability at the top management level. This is reflected in the rising prevalence of dedicated sustainability strategies and structures and the emergence of a new C-level role, Chief Sustainability Officer (Farri et al., 2023). Although ever more companies consider sustainability a top

priority, many struggle to turn sustainability strategies into practice and achieve measurable results (Watson & Kranz, 2021). Given that investors, regulators, and the public are keeping an increasingly watchful eye on companies' sustainability performance, the ability to turn sustainability strategies into concrete actions is a source of competitive advantage (Lloret, 2016).

Information systems (IS) play a large role in helping companies bridge this sustainability strategy-implementation gap (Watson et al., 2008). Most of the studies on this topic were conducted in the first half of the 2010s and focused primarily on enabling factors of IS-enabled sustainability practices, such as general internal and external drivers (Ijab et al., 2012; Seidel et al., 2010), IS-affordances (Seidel et al., 2013), IS-enabled traceability (Seidel et al., 2010), and factors related to routinization (Grant & Appan, 2014). However, when the United Nation published its Sustainable Development Goals in 2015, the role of sustainability for organizations changed dramatically – from a cost driver to a strategic opportunity (Kranz et al., 2021; Van Zanten & van Tulder, 2021). As a result, companies are making sustainability a strategic priority, adopting specific sustainability actions increasingly being accompanied by a dedicated organizational sustainability strategy (OSS). According to a global study by Morningstar Sustainalytic, today 64 % of organizations have an OSS and 26 % are developing one (Morningstar Sustainalytics, 2022). Along with the rise of OSS, the strategic role of IS in sustainability has increased and has become an enabler of companies' sustainability transformations (Kranz et al., 2021; Watson & Kranz, 2021). Thus, a shift is needed from research that focuses narrowly on sustainable practices (i.e., any organizational activity that serves to increase corporate sustainability) related to managing IS resources to an emphasis on the broader impact of IS resources on companies' sustainability agendas. Loeser et al. (2017) were the first to address the broader role of IS as an enabler of sustainability beyond IS resource management, investigating the relationship between IS practices and organizational sustainability orientation as well as sustainability outcomes. However, their study does not consider the influence of increasingly widespread organizational sustainability strategies which have a great impact on companies' resource allocation and prioritization (Hermundsdottir & Aspelund, 2022). To address this shortcoming, this study poses the following research question:

> RQ: How do IS-enabled sustainability practices relate to the impact of an organizational sustainability strategy on organizational sustainability performance?

To answer this question, we follow a mixed methods approach, analyzing qualitative interview data and quantitative survey data to generate an in-depth understanding of the role of IS in bridging the sustainability strategy-implementation gap. First, we conducted an exploratory qualitative pre-study including n=13 interviews with firm executives (Pre-Study) that informed a large-scale survey with a sample size of n=551 respondents (Study 2) to quantify and generalize our insights from the interviews. This approach has two advantages for our study. First, combining qualitative and quantitative methods allows us to examine exploratory and confirmatory questions within the same emerging research context (Venkatesh et al., 2016). As little is known on the research question, this approach results in a deeper understanding of this emerging field (Venkatesh et al., 2013). Second, mixed-methods research offers more robust and accurate conclusions than a single-method approach (Tashakkori et al., 2020).

Our findings from the pre-study suggest that a specific OSS is an important prerequisite for the success of IS-enabled sustainability practices. However, such a strategy is not sufficient; the company also needs specific IS capabilities, namely technology intelligence capability, data analysis capability, and digital twinning capability, to activate sustainability strategies. IS-enabled sustainability practices play a critical role in translating companies' sustainability strategy into practice. More specifically, we found that IS-enabled sustainability practices mediate the impact of OSS on organizational sustainability performance (OSP). In turn, IS-enabled sustainability practices are enabled by technology intelligence capability, data analysis capability, and digital twinning capability. The core contribution of our study to the literature on sustainable IS practices is that our results show that OSS must be aligned with investments in corresponding IS resources that facilitate IS-enabled sustainability practices and ultimately measurable OSP. We extend the existing literature, which focused narrowly on sustainable practices related to managing corporate IS resources by demonstrating the larger impact of IS resources on enabling companies to turn sustainability strategies into measurable results.

The remainder of this paper is organized as follows. First, we present the theoretical underpinnings of our study. Second, we describe the methodology, including the development of research models and hypotheses based on the results of the qualitative analysis of the interview data (Pre-study) and the data collection and

data analysis of the qualitative study (Study 2). After presenting our results, we describe and discuss our findings and contributions, the limitations of the study, and potential avenues for future research.

Theoretical Background

Organizational Sustainability Strategy

Organizational sustainability strategy is a "roadmap to achieve sustainability[1] and it is about understanding and considering the positive and negative impacts and minimizing the risk of unintended consequences across sustainability dimensions" (Ahmed & Sundaram, 2007, p. 2). The formalization of sustainability into sustainability strategies makes it a strategic management topic that enables companies to successfully manage their progress toward sustainability (Engert & Baumgartner, 2016).

Two aspects comprise strategic management: strategy formulation and strategy implementation (Henkel et al., 2017; Mintzberg & Waters, 1985). Strategy formulation refers to the process of strategy development, while strategy implementation refers to the process of putting strategy into practice (Mintzberg & Waters, 1985; Seidel et al., 2017; Seidel et al., 2013). Although the development of an OSS is crucial, it does not define its implementation in concrete organizational actions (Epstein & Roy, 2007). As such, strategy implementation has become the most important management challenge (Engert & Baumgartner, 2016; Yang et al., 2010). Despite the fact that a large number of companies already have sustainability strategies in place (Epstein & Roy, 2007), many of them still face the challenge of translating these strategies into concrete organizational practices (Engert & Baumgartner, 2016). According to Hummer and Chumpy (1996, p. 103), no matter how important a strategy may be to a company's success, a strategic plan without the process to implement it is unfortunately "just talk, a pile of worthless documents."

Two main barriers hinder the implementation of sustainability. First, ceremonial adoption is when the strategy is accepted only for ceremonial purposes and not actually implemented (Hermundsdottir & Aspelund, 2022). This phenomenon is well-known in the sustainability literature, usually referred to as "greenwashing" — meaning companies communicate their sustainability strategies internally and externally without genuinely pursuing them or being able to put them into practice (De Vries et al., 2015). Second, non-implementation can also result from inertia and the inability of organizations to manage the complexity of sustainability issues. Implementing sustainability strategies can be difficult and time-consuming and often requires significant organizational change (Engert & Baumgartner, 2016). Given that sustainability practices are critical to a company's survival, targeted sustainability actions that stem from a company's strategy can become a source of competitive advantage (Lloret, 2016). Hence, overcoming the inability to implement a sustainability strategy is of great importance and critical to an organization's capacity to leverage sustainability to achieve competitive advantage.

Organizational capabilities are defined as "company's abilities developed from a complex bundle of resources including skills, practices, relationships, accumulated knowledge and organizational processes that enable it to conduct certain tasks or activities" (Eitiveni et al., 2018, p. 176). Capabilities are complex routines that determine the effectiveness with which organizations transform inputs into outputs (Collis, 1994), or a means of putting organizational ideas and plans into practice (Munajat & Kurnia, 2015). While resources are considered basic inputs for gaining and sustaining competitive advantage, organizational capabilities are the organization's ability to acquire and use its resources to perform tasks and activities (Barney, 1991; Bharadwaj, 2000).

Applied to IS research, IS-capabilities are defined as "an organizational ability to mobilize and deploy IS resources in combination or coexistent with other organizational resources and capabilities" (Chen et al., 2010, p. 250). As more business activities are developed based on the affordances of digital technologies, companies are leveraging IS capabilities to achieve a variety of general (i.e., business strategy) as well as specific (i.e., HR strategy, marketing strategy, digitalization strategy) business objectives (Steininger et al., 2022). This also applies to sustainability objectives. Building on resource-based-view (RBV), IS scholars have posited that organizations could effectively coordinate bundles of intricate IS and business resources to develop IS capabilities that have the potential to support them in achieving sustainability objectives (Dao

[1] In the context of this study, we consider only the environmental dimension of sustainability. Hence, when we speak of sustainability, we are referring to environmental sustainability.

et al., 2011; Dzhengiz & Niesten, 2020). Moreover, IS scholars argue that capabilities can support IS-enabled sustainability practices (Dao et al., 2011; Gohar & Indulska, 2020; Loeser et al., 2017). They enable companies to undertake a range of activities that help them effectively address sustainability, such as increasing business process efficiency (e.g., Watson et al., 2008), business process redesign (e.g., Kranz et al., 2021; Seidel et al., 2010), digital transformation for sustainability (Loeser et al., 2017; Vial, 2019), collaboration with supply chain partners (e.g., Eitiveni et al., 2018; Loeser, 2013), or stakeholder engagement (Grant & Appan, 2014). Thus, IS capabilities help to translate OSS into practice (Munajat & Kurnia, 2015).

Concept	Definition	Source
Organizational Sustainability Strategy	Organizational sustainability strategy is a roadmap to achieve sustainability and it is about understanding and considering the positive and negative impacts and minimizing the risk of unintended consequences across sustainability dimensions.	Ahmed and Sundaram (2007), p. 2
Organizational Sustainability Practices	Organizational sustainability practices are those practices aimed at minimizing emissions, waste and water, improving efficiency and minimizing the total environment footprint of a business.	Ijab et al. (2012), p. 3
IS-enabled Sustainability Practices	IS-enabled sustainability practices refer to the positive environmental impacts that can be achieved by decreasing the negative environmental effects of business operations and advancing corporate sustainability.	Loeser et al. (2017), p. 517
Organizational Capabilities	Company's abilities developed from a complex bundle of resources including skills, practices, relationships, accumulated knowledge and organizational processes that enable it to conduct certain tasks or activities.	Eitiveni et al., (2018), p. 176

Table 1. Definitions of Key Theoretical Concepts

IS-enabled Sustainability Practices

IS have the potential to afford action possibilities to mitigate negative environmental and social impacts (Seidel et al., 2013). IS scholars have addressed this issue in the subfield of sustainable resp. Green IS practices (e.g., Ijab et al., 2012; Samuri & Rahim, 2018; Seidel et al., 2010; Seidel et al., 2013). In his comprehensive literature review on the concepts of Green IS and Green IT, Loeser (2013) presents a list of Greens IS practices, which enable environmentally sustainable business processes and end products, categorized and consolidated into a comprehensive list of relevant practices. Other studies investigate the antecedents, drivers, and outcomes related to IS-enabled sustainability practices (Ijab et al., 2012; Opitz et al., 2013; Seidel et al., 2010; Seidel et al., 2013). Ijab et al. (2012) investigate the emergence and recurrent use of Green IS practices in organizations. They find internal and external factors influence the emergence and recurrent use of Green IS practices. Applying a case study approach, Seidel et al. (2010) identify strategy definition, organizational support, motivation, and IS-enabled traceability as important enablers of sustainability practices. Further, drawing on IS affordance theory, Seidel et al. (2013) seek to understand how IS-supported affordances such as reflective disclosure and information democratization can change behavior toward sustainability (Seidel et al., 2013). Grant and Appan (2014) note that simply adopting such practices is not enough, and examine how such practices become routinized in organizations. Lastly, Loeser et al. (2017) draw a bigger picture by examining how an organization's environmental orientation influences Green IS practices and their organizational benefits. They find that environmental orientation plays a mediating role between sustainable orientation and organizational benefits. With their study, they are the first to address the broader role of IS as an enabler of sustainability beyond the management of IS resources. However, they limit these considerations only to a sustainability orientation, while a specific sustainability strategy can have a much stronger impact on implementation practices as it involves changes in resource allocation and priority setting. Therefore, this expanded role of IS needs to be further explored in order to best leverage IS for achieving sustainability in organizations.

Table 2 provides an overview of publications which highlight an interplay between Green IS and organizational strategy.

Article	Context	Key Findings
Seidel et al. (2010)	Study on the important barriers and enablers for the effective adoption of sustainable business practices.	Four major categories of enablers, namely, strategy definition, organizational support, motivation, and IS-enabled traceability.
Ijab et al. (2012)	Drawing primarily on practice theory, the paper investigates the local actions set against the external origins which shape and reshape Green IS practice in a case organization.	Green IS practices emerge and are recurrently used due to a number of internal and external factors, as well as the power relationships of the human actors. In addition, the ability to manage and allocate resources by the powerful actors enables Green IS practice to become tangible in the company.
Loeser (2013)	Based on a literature review the concepts Green IT and Green IS are contrasted and defined and practices are examined.	Greens IS practices, which enable environmentally sustainable business processes and end products, are categorized and consolidated in a comprehensive list of relevant practices.
Seidel et al. (2013)	Study on the identification and underlying mechanisms of IS affordances that assist organizations in establishing environmentally sustainable work practices.	Four functional affordances, namely, reflective disclosure, information democratization, output management, and delocalization, are required to initiate behavioral change through organizational sensemaking and sustainable work practices to enable organizational sustainability transformations.
Optitz et al. (2013)	Study on the the success of Green IT practices by analyzing performance metrics.	While enterprises can measure and control the success of Green IT practices, the appropriateness of the metrics depends on firm attributes such as size, sustainability orientation and Green IT expertise.
Grant & Appan (2014)	Drawing from the literature on structuration and internal market orientation, the authors examine the impact of organizational structures and processes on employee commitment and its subsequent impact on routinization of Green IS Practices (GISP).	Identification of important factors for GISP routinization, such as top management support, organizational readiness and effectiveness of Green-IS standards, and internal marketing orientation towards Green-IS will positively impact employee commitment toward GISP routinization and subsequently have a positive effect on organizational performance.
Loeser et al. (2017)	Study on the antecedents and benefits of Green IS initiatives. Specifically, how environmental orientation and IS-strategies influence Green IS initiatives and whether Green IS initiatives yield organizational benefits in general.	Green IS strategies mediate the relationship between environmental orientation and the implementation of Green IT/IS practices, which in turn lead to organizational benefits in the form of cost reductions, corporate reputation enhancement and green innovation capabilities.

Table 2. Overview on Prior Sustainable IS Practice Research

Methodology

Following a mixed methods approach, we combine qualitative interview data and quantitative survey data to generate new understanding on how IS-enabled sustainability practices relate to the impact of organizational sustainability strategy on organizational sustainability performance. To understand how information systems can be used effectively for sustainability we performed an exploratory qualitative pre-study (n=13 interviews), asking about general drivers for sustainability as well as relevant capabilities that

companies need to realize sustainability (i.e., environmental sustainability). We conducted interviews with company representatives from international operating companies with sustainability being on their corporate agendas. Interview partners included employees working in the field of sustainability for at least two years (see Appendix). Interviews were analyzed using the software N-Vivo following a Grounded Theory-inspired approach to generate new insights from data (Gioia et al., 2013). Findings from the pre-study informed our multi-continent industry survey (n=551) and allowed to quantify and generalize our research model. The findings from the interviews and the literature review informed the development of our constructs and hypotheses which we tested in an international survey.

Research Model

In the following, we develop our research model (see Figure 1). We build upon a qualitative pre-study in which we collected and analyzed empirical data from 13 interviews with sustainability organizational experts following Grounded Theory-inspired coding methods.

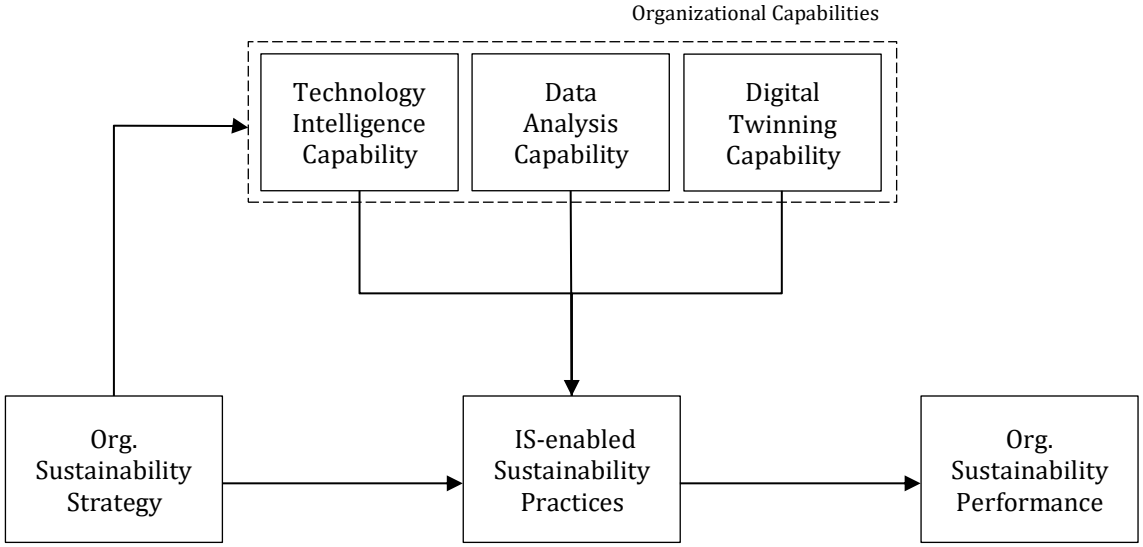

Figure 1. Research Model

Existing research shows that strategy and sustainability practices are intertwined (Henfridsson & Lind, 2014; Jarzabkowski, 2003, 2008). Banerjee (2002) emphasizes that sustainability concerns must be translated into strategy if sustainable business performance is to occur. Without such a strategy, the implementation of sustainability aspects in practice would not be possible (Erek et al., 2011). Before a company can implement sustainability initiatives, it must first develop a specific sustainability strategy that defines its vision, identity, overarching goals, and long-term objectives (Loeser et al., 2012; Porter, 1987). Such a strategy anchors the topic of sustainability in the organization and thus also causes top management to make a strategic commitment including the provision of resources.

> *"It is set out in the vision and clearly positioned strategically.", and "When asking for strategic implementation in our company, it is important to set goals." (Interviewee 10)*
>
> *"And, of course, they need the support of the company's top management to implement the topic. Equally, it needs a vision and a clear signal […]. Yes, we want to move in this direction and make this a core part of our strategy." (Interviewee 8)*
>
> *"This is also similar to a […] corporate strategy, which also has a higher goal and other subordinate goals." (Interviewee 6)*

IS-enabled sustainability practices refer to organizational efforts that can be improved through IS solutions (Loeser et al., 2017). They represent one specific bundle of practices organizations follow to implement formulated sustainability strategies (Seidel et al., 2013). Vice versa, the OSS defines the sustainability

related objectives, structures, processes and targets necessary for IS practitioners to integrate sustainability into IS practices (Ahmed & Sundaram, 2007; Baets, 1992). As sustainability strategies and processes provide a roadmap to achieve sustainability, IS-enabled sustainability practices consequently provide a means to achieve sustainability success (Ahmed & Sundaram, 2007). Therefore, we hypothesize that IS-enabled sustainability practices are a potential mediator between OSS and OSP. We hypothesize as follows:

> H1: As companies increasingly intend to address sustainability strategically, the growing implementation of IS-based practices leads to improved organizational sustainability performance.

Bridging the gap between the formulation of a company's sustainability strategy and its implementation requires the ability to put the strategy into action (Engert & Baumgartner, 2016; Epstein & Roy, 2007). For implementing sustainability initiatives, organizations follow several sustainability practices including IS-enabled sustainability practices (Ijab et al., 2012). IS-enabled sustainability practices refer to the positive environmental impacts that can be achieved by decreasing the negative environmental effects of business operations and advancing organizational sustainability (Butler, 2011). For organizations to practice sustainability, certain capabilities need to be developed.

> *"To a certain extent, this also includes the topic of digital competence. Simply because it will be about [...] data. For example, how to communicate knowledge along the value chain. This type of information is best determined and processed digitally." (Interviewee 8)*

Among them are technology intelligence capability (Cetindamar et al., 2020; Eitiveni et al., 2018; Peng et al., 2022), data analysis capability (Cetindamar et al., 2020; Peng et al., 2022), and digital twinning capability (Cetindamar et al., 2020; Mithas et al., 2011). Technology intelligence capability refers to a company's ability to detect, use and exploit advanced information systems (e.g., digital technologies for Industry 4.0). These information systems (e.g., digital twin, blockchain) go beyond traditional IT. They are more complex and require additional knowledge, which is why companies need to be equipped with specific capabilities for dealing with such systems (Huber et al., 2022).

The use of such information systems requires a lot of data, but also the ability to analyze that data, for example, in the context of advanced data analytics, machine learning, and IoT applications (Cetindamar et al., 2020).

> *"So, dealing with data is a key competence. Incidentally, [a lot of] industries have a very complex value chain, and a CO2-neutral value chains are needed. So, data analytics [...] is a really important issue. In fact, we need to combine digitalization and CE. That is [...], I think, an absolute prerequisite." (Interviewee 11)*

Further, it is said that digital twins can be particularly helpful in addressing environmental sustainability challenges like environmental sustainability by providing the required information about resources, materials, and products to the relevant actor in a timely and decentralized manner. By creating virtual replicas of physical systems, digital twins enable information to travel with products and materials. Further, digital twins allow stakeholders along the value chain comprehensive monitoring and analysis of resource flows and lifecycles. This provides unparalleled insight into product, material and resource usage, reuse opportunities, and end-of-life scenarios (Watson & Kranz, 2021). Yet digital twins require special capabilities (Wache & Dinter, 2021).

> *"Technology helps because technology means that you can track everything. And you know, you know, you can track everything, you can see where your products are, you can see you know where the materials are, you can make sure that you're delivering on your commitments." (Interviewee 12)*

Therefore, technology intelligence capability, data analysis capability, and digital twinning capability are important prerequisites for the deployment of IS-enabled sustainability practices. Thus, we hypothesize:

> H2a: Technology intelligence capability has a positive influence on IS-enabled sustainability practices.
>
> H2b: Data analysis capability has a positive influence on IS-enabled sustainability practices.
>
> H2c: Digital twinning capability has a positive influence on IS-enabled sustainability practices.

Strategy, as well as the resulting changes to an organization, including its structure, processes, and culture are required to yield the capacity to generate new paths for value creation (Vial, 2019). The strategy determines how strongly the sustainability issue is anchored in the company.

This determines the importance of the topic for corporate, strategic decision making and the availability of financial resources (Hermundsdottir & Aspelund, 2022). As outlined earlier, IS are needed to successfully pursue sustainability issues. Applied to this context, as soon as sustainability has become a corporate imperative and a specific sustainability strategy has been put in place, firms allocate financial resources to achieve the sustainability objectives that have been set. Since information systems play an important role in achieving sustainability, these financial resources are used to leverage information systems resources for sustainability that activate IS capabilities for sustainability. In short, once the OSS is taken seriously, IS potentials for sustainability are prioritized, resources are allocated, and IS capabilities are activated. Therefore, we hypothesize:

H3a: Organizational sustainability strategy is positively associated with technology intelligence capability.

H3b: Organizational sustainability strategy is positively associated with data analysis capability.

H3c: Organizational sustainability strategy is positively associated with digital twinning capability.

Data Collection

We conducted a large-scale survey focusing on companies from manufacturing industries. Manufacturing is a resource-intensive industry characterized by its innovative nature, making it a suitable empirical setting for a study of IS in the context of environmental sustainability. We used the panel of a market research company to gather data from respondents in Europe, North America, and Asia. We followed standard psychometric scale development procedures to develop constructs and items (see Appendix). As far as possible, existing validated scales are used or adapted to the context of the study. For constructs without previously validated scales, new instruments are developed based on related theory, discussions with experts from academia, and supported by the insights from the qualitative study conducted prior to the quantitative study (MacKenzie et al., 2011). The constructs are validated qualitatively (n=10) and quantitatively (n=24) in a pilot study with IT professionals and scholars. To control for common method bias, we ensured careful construction of the items (i.e., ambiguous, or unfamiliar words, vague concepts, double-barreled questions) (Tourangeau et al., 2000). To further reduce common method bias, we secured respondents' anonymity, assured them that there are no right or wrong answers, and that they should answer questions as honestly as possible (Podsakoff et al., 2003).

Participants are employees of companies of different sizes, industries, and locations. Most companies in the survey are headquartered in Europe (n = 319), followed by North America (n = 149), and Asia (n = 83). 57 % of companies are considered large businesses with a total number of more than 500 full-time employees. The majority of participants (65 %) belonged to the top three hierarchical levels of organizations[2] and over 70 % of participants have been with their company for more than four years. From 911 participants in the dataset, we excluded 360 due to short completion times and incomplete responses to relevant questions. The resulting dataset of 551 participants are used to answer the above stated research question.

Results

To test the hypotheses, we conducted a mediation analysis, a multiple linear regression, and a set of linear regressions. Descriptive statistics, scale internal consistency reliability, and correlation matrix are shown in Table 3. All variables show no issues related to skewness and kurtosis and the scale internal consistency reliability of all variables exceed the required threshold (Cronbach's $\alpha > 0.6$) (Hair et al., 1998).

Linear regression requires the assumptions of linear relationship, interdependence, homoscedasticity, and normality to be met. To ensure this, we conducted tests for linearity (scatterplot), autocorrelation (Durbin-

[2] Top three hierarchical levels: Participants either were part of the management/board chair, directly report to the management/board chair, or their supervisor reports to the management/board chair.

Watson test), heteroscedasticity (P-plot), and non-normality of residuals (Q-Q plot). Further, to rule out the potential threat of multicollinearity, variance inflation factor (VIF) values were examined in all subsequent regression models and Cook's Distance is calculated to check for outliers (Hair et al., 1998). In addition, we performed Harman's one-factor test to check for common method bias. With an overall variance extracted by one factor of 37.46 %, which is below the recommended threshold of 50 %, we find that common method bias is not a problem in this study (Aguirre-Urreta & Hu, 2019).

Moreover, we assessed the effect of the company location as control variable. To control for the country in which the company is headquartered, we included dummy variables in the regression analyses.

Variable	Mean	σ	α	OSS	ISSP	OSP	TIC	DAC
Organizational Sustainability Strategy	4.03	1.38	0.85	-	-	-	-	-
IS-enabled Sustainability Practices	4.63	1.31	0.85	0.65*	-	-	-	-
Sustainability Performance	4.65	1.19	0.82	0.74*	0.65*	-	-	-
Technology Intelligence Capability	4.35	1.48	0.65	0.47*	0.48*	0.42*	-	-
Data Analysis Capability	2.98	1.09	0.80	0.34*	0.30*	0.31*	0.36*	-
Digital Twinning Capability	3.37	0.90	0.80	0.46*	0.46*	0.43*	0.59*	0.43*

Table 3. Descriptive Statistics, Scale Reliability and Correlation Coefficients

Note. * Correlation is significant at the 0.01 level (2-tailed), σ = Standard Deviation, α = Cronbach's Alpha; OSS = Organizational Sustainability Strategy, ISSP = IS-enabled Sustainability Practices, OSP = OSP, DTC = Digital Twinning Capability, DAC = Data Analysis Capability

Mediation analysis was performed to assess the mediating role of IS-enabled sustainability practices (ISSP) on the linkage between OSS and OSP. Hayes's (2013) SPSS PROCESS macro helps test the model that includes the direct and indirect effect of OSS on OSP. This study used Hayes's Model 4 in testing the mediation. 5,000 re-samples of the data were drawn at a 95% confidence interval to estimate the hypothesized effects. The results presented in Table 4 show that the total effect of OSS on OSP was significant ($\beta = 0.64$, $p < 0.001$). With the inclusion of the mediating variable (ISSP), the impact of OSS on OSP (direct effect) remained significant ($\beta = 0.47$, $p < 0.001$). Further, the indirect effect of OSS on OSP through ISSP is found significant[3] ($\beta = 0.16$, LLCI = 0.108, ULCI = 0.215)[4]. Hence, H1 is supported.

Total Effect (OSS→OSP)		Direct Effect (OSS→OSP)		Indirect Effect (OSS→ISSP→OSP)		
Coefficient	p-value	Coefficient	p-value	Coefficient	95% CI	
0.64	<0.001	0.47	<0.001	0.16	0.108	0.215

Table 4. Mediation Results (H1)

We investigate H2a, H2b, and H2c with multiple linear regression analyses. We find support for all three hypotheses. The independent variables significantly predict IS-enabled sustainability practices ($F(5, 545) = 57.61$, $p < 0.001$) indicating that the three factors under study have a significant impact on IS-enabled sustainability practices. Moreover, the $R^2 = 0.34$ depicts that the model explains 34 % of the variance in IS-enabled sustainability practices. Technology intelligence capability ($\beta = 0.23$, $p < 0.001$), data analysis

[3] A significant relationship between the mediator and the predictor is said to exist if the p-value is less than 0.05 and the confidence interval does not contain 0 (i.e., both limits of the confidence interval are greater than 0 or less than 0).

[4] LLCI = Lower limit confidence interval, ULCI = Upper limit confidence interval

capability ($\beta = 0.28$, $p < 0.001$), and digital twinning capability ($\beta = 0.13$, $p < 0.04$) have a positive impact on IS-enabled sustainability practices (see Table 5).

Variable	Model 1[1]	Model 2[2]	Model 3[3]	Model 4[4]
Explanatory Variable				
Technology Intelligence Capability	0.23**			
Data Analysis Capability	0.28**			
Digital Twining Capability	0.13*			
Organizational Sustainability Strategy		0.45**	0.27**	0.27**
Control Variables				
Dummy_Europe	0.96**	0.57**	0.28*	-0.11
Dummy_NorthAmerica	0.96**	1.02**	0.59**	0.13
(Adjusted) R^2	0.34	0.26	0.25	0.12
F-Score	57.61	64.05	62,35	25.80
Hypotheses	H2a, H2b, H2c Supported	H3a Supported	H3b Supported	H3c Supported

Table 5. Regression Results

Note. * Significant at the 0.05 level, ** Significant at the 0.01 level; [1] DV = ISSP, [2] DV = TIC, [3] DV = DAC, [4] DV = DTC

We investigate H3a, H3b, and H3c with a set of linear regression analyses. Results regarding H3a, H3b, and H3c reveal that OSS has a positive impact on each of the capabilities, namely technology intelligence capability ($\beta = 0.45$, $p < 0.001$), data analysis capability ($\beta = 0.27$, $p < 0.001$), and digital twinning capability ($\beta = 0.27$, $p < 0.001$). Hence, H3a, H3b, and H3c are supported. The results are presented in Table 5.

Discussion

After many years of reluctance and lack of commitment, companies are increasingly prioritizing sustainability and setting ambitious goals. Along with the rise of OSS, the role of IS in sustainability has amplified and become a source of sustainability at the organizational level. Our study considers this expanded role of information systems in the context of IS-practice research, thus enhancing current understandings in the field.

Notwithstanding the rise in OSS, there is still a gap between sustainability ambition and action which we refer to as the strategy-implementation gap (Farri et al., 2023). To address this gap, we examined the role of IS-enabled sustainability practices in translating organizational sustainability strategy into organizational sustainability performance. In particular, we examined how IS-enabled sustainability practices impact the relationship between OSS and OSP and the enablers of IS-enabled sustainability practices. We find that IS-enabled sustainability practices mediate the impact of OSS on OSP and that these practices are enabled by IS capabilities that are critical to implementing sustainability practices, including technology intelligence capability, data analysis capability, and digital twinning capability.

Our study contributes to the existing literature in several ways. First, it underscores the importance of IS for the activation of sustainability strategies. However, a sustainability strategy alone is not sufficient. It must be translated into lived practices, with IS practices playing a key role, as underscored by scholarship demonstrating that sustainability is often seen as an information problem (Watson & Kranz, 2021). Our study supports the importance of IS for sustainability on a strategic level. As sustainability takes its place at the top of corporate agendas, IS scholarship help businesses achieve their sustainability goals and increase business success (Loeser et al., 2017; Watson et al., 2008). Furthermore, our study demonstrates that companies need certain IS capabilities to overcome the strategy-implementation gap. Specifically, our study reveals technology intelligence capability, data analysis capability, and digital twinning capability as key IS capabilities that enable businesses to have the ability to execute IS-enabled sustainability practices. Further research is needed to verify our findings and explore other potential capabilities that support such

practices. Moreover, IS are not the only means of translating sustainability strategies into practice. Research in the fields of management and sustainability find for examples factors such as top management support, customer awareness, knowledge of sustainability, governmental support, and legislation as important drivers of sustainability practice (Moktadir et al., 2018). Therefore, further research should take a broader perspective in which IS are only one means among others to create a holistic understanding of how to bridge the sustainability strategy-implementation gap.

Second, our findings highlight the relevance of sustainability strategies for the IS research field. Companies demonstrate their commitment to sustainability by adopting and acting on a sustainability strategy. Such engagement is important because it enables investment in IS capabilities that help companies adopt IS-enabled sustainability practices (Hermundsdottir & Aspelund, 2022). An OSS enables companies to give higher priority to the use of information systems for sustainability and thus to leverage the potential of IS for sustainability. Hence, IS researchers should be aware of the importance of the OSS for our own field and emphasize its role more in future research. Another interesting topic for future research is how OSS relates to traditional business strategies as well as IT-strategy and how they could and should be aligned (Loeser et al., 2011).

Third, our study underscores the complementarities of sustainability and IS. The World Economic Forum (Blüm, 2022) and the European Union (2022) speak of a so-called "twin transition" in this context, emphasizing the relevance of alignment among IS and sustainability. Our study shows that OSS must be aligned with investments in appropriate IS capabilities to enable IS-enabled sustainability practices and ultimately measurable OSP. IS sustainability researchers can build on our findings to further examine the alignment of sustainability and IS strategy. Conversely, researchers in the field of IS alignment can use our findings to examine how established organizational alignment practices (e.g., strategizing, planning, budgeting, prioritizing) help or impede corporate IS to support sustainability strategies (Loeser et al., 2017). Understanding how OSS, sustainability practices, sustainable IS strategy, and IS-enabled sustainability practices are interrelated and integrated, and examining the capabilities required for each is of great academic and practical interest.

This study also has some implications for practitioners. Our study suggests that corporate decision-makers need to "think sustainability and digital transformation together". As companies strive to advance sustainability beyond a formulated strategy, CSOs should invest strategically in IS capabilities that enable IS-enabled sustainability practices (Loeser et al., 2017). In turn, CIOs should see the role of IS in the broader context of sustainability. Overall, closer cooperation between these two cross-cutting areas is required to ensure coordination and alignment. Furthermore, sustainable IS should not be seen as a cost of doing business, but as a source of value creation (Kranz et al., 2021). Although researchers have long emphasized that IS and sustainability are opportunities, many companies still cling to the outdated mindset that they are primarily costs (Watson et al., 2008). Neglecting the opportunities of IS for sustainability and as a source of competitive advantages through sustainability might turn out as a missed chance in the future. While we focused our study on the environmental pillar of sustainability, our findings are also transferable to the social dimension of sustainability and thus relevant for a holistic view of sustainability.

As with every research project, our study is limited in several ways. First, we use a series of independent regressions instead of structural equation modeling (SEM), the latter being an appropriate method to test individual relationships as a whole. However, according to Evermann and Tate (2014), regression-based methods are closest to structural equation methods. Second, the constructs technology intelligence capability is a two-item constructs which may oversimplify the underlying concept. Overall, designing a survey specifically with the purpose of measuring sustainability strategy, IS-enabled sustainability practices, sustainability performance as well as the investigated capabilities with all their dimensions and nuances would be beneficial to replicate the results of our research in a more rigorous manner. Third, since sustainability issues and priorities vary across industries, we decided to focus on an industry where sustainability is a major concern. However, to ensure generalizability, we encourage follow-up studies to replicate the research in other industries.

Conclusion

Our study elucidates the role of IS-enabled sustainability practices in implementing organizational sustainability strategy to achieve sustainability performance. In doing so, we address the shortcomings of

existing research, particularly the need for more studies on the role of IS as a source of sustainability at the organizational level. We analyzed how IS-enabled sustainability practices contribute to the effect of an organizational sustainability strategy on the sustainability performance of a company. Thereby, we extend the findings of Loeser et al. (2017) by providing evidence that IS practices are not only influenced by sustainable orientation, but that IS-supported sustainability practices are an important means of translating an organizational sustainability strategy into sustainability performance. Moreover, we show that certain capabilities influence the ability to implement IS practices and are thus an important prerequisite for a company to act. Overall, our study offers a new perspective on the role of IS-enabled sustainability practices in addressing the challenge of implementing an organizational sustainability strategy.

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Appendix

Variables, Items, and Scales

Variables and references guiding conceptualization	**Items**
Sustainability Strategy[1] (Engert & Baumgartner, 2016; Teh & Corbitt, 2015, Pre-Study Results)	*In my company…* …environmental and climate protection is a central strategic goal with concrete targets (e.g., climate neutrality, degree of utilization of renewable energies and resources). … there are individual incentives to work toward environmental and climate protection goals.

	… there is an organizational unit or committee that deals with sustainability (environmental, social and economic) and includes at least one member of top management? … projects and processes are stopped if they do not meet our sustainability targets. … there are data for calculating and analyzing our environmental and climate impacts collected continuously and systematically throughout the company.
IS-enabled Sustainability Practices[1] (Kirchherr et al., 2023)	*My company aims to achieve the following goals with digital technologies:* Reduce: Reduce energy and material consumption and waste in production. Reuse: To reuse products, materials, components, waste and by-products. Refurbish: Collection and reprocessing of products or materials that are no longer used in order to restore their original function. Recycle: to recycle and reprocess waste and by-products. Redesign: improve ecological design of products (e.g., ease of disassembly, increased durability and repairability).
Organizational Sustainability Performance[1] (Sambhanthan et al., 2017)	*My company consistently implements measures for more ecological …* … production of new products (e.g., less consumption of energy and resources). … procurement of preliminary products and services (e.g., sustainability checks and/or audits of suppliers, Supplier Code of Conduct). … logistics (e.g., sustainable transport routes, more environmentally friendly packaging, planning of warehouses according …recording and avoiding externalities arising in the production or use of own products (e.g., noise or air pollution, pollutant emission). … achievement our sustainability targets we have set ourselves.
Technology Intelligence Capability[1] (Nonaka et al., 2006)	*Please indicate the extent to which you agree with the following statements.* Our business departments are in constant exchange with internal and external experts to identify innovative applications of Industry 4.0 technologies. My company offers all employees comprehensive opportunities for further training to improve their Industry 4.0 skills.
Data Analysis Capability[2] (Mikalef & Gupta, 2021; Wittmann & Kranz, 2022)	*Please rate your company's capabilities compared to your direct competitors in terms of:* Staff skills and competencies for advanced data analysis methods (e.g., regarding data preparation, algorithms, APIs). Technical infrastructure for advanced data analytics (e.g., central data platform, analytics and visualization software, algorithm libraries). Production processes with partially and fully automated decisions (e.g., through artificial intelligence or machine learning). Systematic and continuous collection, processing, and analysis of data along the entire value chain.
Digital Twinning Capability[2]	*Please indicate below the implementation status your company has achieved.*

(Wurm et al., 2023)	We can locate all individual parts of our products as well as end products across the entire value chain (from inbound logistics to production, to customer service).
	Our plants and systems in production, warehousing and logistics are equipped with sensors to record and transmit environmental parameters and condition data.
	Our plants, devices and systems exchange automated and autonomous information in real time (machine-to-machine communication).

Table 6. Variables, Items, and Scales

Note. [1] The items were measured on a 7-point-likert scale ranging from "do not agree at all" (1) to "fully agree" (7) [2] The items were measured on a 5-point-likert scale ranging from "much worse" (1) to "much better" (5), and "not deployed" (1) to "fully deployed" (5)

Interview Partners Qualitative Pre-Study

Company	Company Description	Interviewee Role
TC1	Workforce: 110,600 (2020) Turnover: € 35.4 billion (2020)	I.1: Sustainability program manager with 8 years of experience.
TC2	Workforce: 135,000 (2019) Turnover: € 27.2 billion (2019)	I.2: Lead, Circular Economy Consulting Services with 5 years of experience. I.3: Sustainability – Business Development Manager with 2 years of experience.
TC3	Workforce: 28,000 (2019) Turnover: € 5.8 billion (2020)	I.4: Sustainability Director with 9 years of experience. I.5: Vice President R&D with 5 years of experience.
TC4	Workforce: 66,000 (2021) Turnover: € 14.46 billion (2020)	I.6: Senior Project Manager, Business Line Installed Base Development with 5 years of experience.
TC5	Workforce: 8,500 (2020) Turnover: € 7.32 billion (2020)	I.7: Senior Corporate Responsibility Manager with 2 years of experience.
CC1	Workforce: 117,628 (2019), Turnover: € 59.32 billion (2019)	I.8: Director Global Plastics Steering Committee with 20 years of experience.
CC2	Workforce: 33,106 (2020) Turnover: € 12.2 billion (2020)	I.9: Portfolio Development Manager – Circular Economy with 2 years of experience.
CC3	Workforce: 16,736 (2021) Turnover: € 12.23 billion (2020)	I.10: Global Sustainability Manager with 5 years of experience. I.11: Head of Global Circular Economy Program with 5 years of experience.
SC1	Workforce: 102,430 (2020) Turnover: € 27.55 billion (2019)	I.12: Sustainability Business Development Director with 2 years of experience. I.13: Advisor Digital Supply Chain with 4 years of experience.

Table 7. Interview Partners Qualitative Pre-Study

Note. TC = Technology Company, CC = Chemical Company, SC = Software Company