Exploring IT-Enabled Sustainability-Oriented Innovation: A Case Study

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Completed Research Paper

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Abstract

An increasing number of organizations are developing sustainability-oriented innovations (innovations that aim to enhance organizational performance, SOI) to strategically address sustainability challenges. Previous studies recognize that IT can significantly enable the development of SOI. However, their coverage of SOI is limited, and most of them lack an in-depth understanding of the link between IT and SOI. Thus, this study explores how IT can enable SOI development and capture the fundamental relationship between IT and SOI by adopting affordance theory. Based on a case study, we develop an IT-enabled SOI model and propose that a) organizational sustainability orientation significantly impacts IT affordances for SOI, b) all components of IT capability are critical for the formation of IT affordances for SOI, c) there are five IT affordances that support SOI development, and d) IT affordances are not completely independent of each other.

Keywords: IT/IS, sustainability, innovation, affordance

Introduction

Over the last few years, the public’s concerns about sustainability have increased due to the COVID-19 pandemic, climate change, and frequent natural disasters. Consequently, organizations are expected to address sustainability issues by promoting sustainable development in their businesses. Sustainable development requires organizations to simultaneously consider their environmental, social and economic (collectively known as the triple bottom line, TBL) impacts (Elkington 1994) and thus brings many challenges. Innovations provide strategic ways to overcome those sustainability challenges (Maletić et al. 2016; Silva et al. 2019). In this paper, innovations that aim to improve environmental, social, and economic performance are referred to as sustainability-oriented innovation (SOI) (Bengtsson and Ågerfalk 2011). As with any innovation, SOI may involve new businesses or significant improvements in organizations’ existing businesses (OECD and Eurostat 2005).

Previous literature has revealed that information technology (IT) as an organizational capability plays a critical role in enabling sustainable development (Chen et al. 2008). In particular, IT can provide innovative solutions to sustainability issues (Epelbaum and Martinez 2014; Nascimento et al. 2019) or facilitate existing non-IT SOI (Hanelt et al. 2017), leading to IT-enabled SOI. While existing literature has investigated the role of IT in SOI development (e.g., Bengtsson and Ågerfalk (2011), Srivastava and...
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Shainesh (2015), Hanelt et al. (2017), and El-Kassar and Singh (2019)), they lack a comprehensive view of IT-enabled SOI (i.e., limited coverage of sustainability, innovation, or IT), and most of them lack an in-depth analysis of the link between IT and SOI. These limitations would impact organizations’ understanding of how IT can enable SOI development.

Our literature analysis further shows that various theoretical lenses have been adopted to analyze IT’s role in sustainability, including resource-based view (RBV) theory (El-Kassar and Singh 2019; Epelbaum and Martínez 2014), competitive dynamics (Hu et al. 2016), actor-network theory (Bengtsson and Ågerfalk 2011), institutional theory (Hu et al. 2016; Maret et al. 2013), etc. However, they mainly focus on the merits of IT (resources or capability) and its impact on organizational competitiveness and/or sustainability performance. To help organizations leverage IT for SOI, it is important to understand how IT can be used for SOI. Hence, affordance theory (Hanelt et al. 2017; Seidel et al. 2013), arguably, provides the most appropriate lens to understand the role of IT (Chatterjee et al. 2020). Affordances represent what an organization can do by utilizing technical objects to achieve its goal (Markus and Silver 2008; Seidel et al. 2013). IT affordances incorporate both IT capability and the use of IT capability for achieving specific organizational goals such as enhancing sustainability performance through SOI (Chatterjee et al. 2015). Thus, focusing on IT affordances for SOI enables in-depth investigation into the relationship between IT and SOI.

Nevertheless, there is still a lack of studies that comprehensively analyze IT affordances for SOI. Existing literature on IT affordances is limited and focuses on either IT-enabled innovation (Chatterjee et al. 2020; Lehrer et al. 2018) or IT-enabled sustainability practices (Seidel et al. 2013) and capabilities (Eitiveni et al. 2018). Hanelt et al. (2017) explore IT-enabled SOI but merely focus on environmental sustainability, innovation performance, and supporting IT (IT that only supports the innovation rather than is an inherent part of the innovation). Therefore, this study aims to address the gap between these two research realms by systematically exploring the role of IT in SOI development from an affordance perspective. The research question of this study is:

RQ: How can IT enable the development of sustainability-oriented innovations in an organization?

To address the research question, we first review the related literature. Then, we conduct an exploratory case study to investigate the role of IT in enabling SOI development. Based on the case study findings, we develop an IT-enabled SOI model and propose four propositions that guide future studies: a) organizational sustainability orientation significantly impacts IT affordances for SOI, b) All components of IT capability are critical for the formation of IT affordances for SOI, c) There are five IT affordances that support SOI development, and d) IT affordances are not completely independent of each other.

The remainder of this paper is organized as follows. First, we provide a brief theoretical background on sustainability-oriented innovations, IT capability, and affordances. Then, the case study methodology is explained, followed by the case study findings and discussion. Finally, we conclude the paper, highlight our study limitations, and propose future studies.

Literature Review

Key Concepts and Definitions

Sustainability

Organizations address sustainability issues by promoting sustainable development. A well-known definition of sustainable development was proposed by the World Commission on Environment and Development in 1987: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED 1987, p. 43) Derived from the core principle of this definition, the concept of the triple bottom line (TBL) has emerged, which emphasizes that sustainable development compromise three dimensions, namely, environmental, social, and economic dimensions (Elkington 1994). Thus, organizations should simultaneously consider their environmental, social, and economic impacts to promote sustainable development.

Promoting sustainable development within an organization is typically started with establishing sustainability orientation (Tim et al. 2018), defined as an organization’s attitude and commitment to
enhancing sustainability performance (Hanelt et al. 2017). Therefore, the development of SOI is usually driven by the sustainability orientation of organizations. Specifically, organizations’ top managers should first perceive the importance of sustainability and then decide to address sustainability issues and promote sustainable development. Thus, sustainability orientation greatly influences organizations’ decisions on SOI development. (Hanelt et al. 2017). Though sustainability orientation plays such a critical role, existing studies seldom formally investigate and acknowledge its importance (e.g., (Cheng 2020)).

Innovation

Innovation has long been recognized as a key factor in strengthening organizations’ sustainability performance (Adams et al. 2016; Hansen et al. 2009; Maletić et al. 2016; Silva et al. 2019). There are different terms used in the literature to describe innovations for improving sustainability performance, such as sustainable/sustainability innovation, innovation for sustainability, and sustainability-oriented/-driven innovation. Sometimes these terms are used synonymously. In this study, we use the term “sustainability-oriented innovation” (SOI) and define it as new or significantly improved products, services, or processes that enhance organizational environmental and/or social performance in addition to economic performance (Kusi-Sarpong et al. 2019; Rogers 2003). The development of SOI may involve just a business unit in an organization, the entire organization, or other organizations across a supply chain to achieve broader sustainability performance (Adams et al. 2016). The improvement of the sustainability performance can be achieved by either reducing negative impacts (e.g., waste reduction) or making positive impacts (e.g., financial support for disadvantaged groups).

It should be noted that technology is not an essential part of innovation (Blok and Lemmens 2015). For example, technology is not necessarily required for transforming existing products into sustainable products by dealing with suppliers with high sustainability performance.

IT Capability

IT has been viewed as an organizational capability, and thus IT and IT capability are sometimes used interchangeably. In the context of SOI, we define IT capability as the ability of an organization to manage its IT resources to allow the development of innovations that improve sustainability performance (Bharadwaj 2000; Melville 2010). Based on previous literature, we identify four components of IT capability, namely, IT strategy and governance, IT process management, IT people and knowledge, and IT infrastructure. Specifically, the first component, IT strategy and governance, consists of the strategy and corresponding governance that align IT function with business and ensure the synergy with other organizational functions, which leads to risk and responsibility shared by IT and business (Curry and Donnellan 2012; Rahim et al. 2014; Ross et al. 1996). IT process management includes analyzing, defining, implementing, monitoring and optimizing the activities and processes that enable the IT service provision, and establishing corresponding measuring and reporting mechanisms (Curry and Donnellan 2012; Rahim et al. 2014; Ross et al. 1996). The third component, IT people and knowledge, includes human resources with technical and managerial skills to provide and manage IT services to support the organization (Bharadwaj 2000; Curry and Donnellan 2012; Rahim et al. 2014; Ross et al. 1996). IT infrastructure refers to technical platforms, databases, systems, and applications, which form a shared information delivery base for business (Bharadwaj 2000; Curry and Donnellan 2012; Li and Chan 2019; Rahim et al. 2014). IT process management, IT people and knowledge, and IT infrastructure are guided by IT strategy and governance. It is vital for organizations to systematically understand and manage these components to realize the value of its IT capability (Bharadwaj 2000; Curry and Donnellan 2012; Rahim et al. 2014; Ross et al. 1996).

While the role of IT capability in enabling SOI development has been investigated in previous studies (e.g., Hanelt et al. (2017)), the four components of IT, to the best of the authors' knowledge, are not explored in detail and systematically. Some of the studies mainly focus on the infrastructure component (e.g., Bengtsson and Ågerfalk (2011)).

Affordance Theory

The concept of affordance was first introduced by James J. Gibson in the ecological psychology discipline. Gibson (1979, p. 127) explained that “the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill.” This concept was later applied to other fields of research,
including IT. IT affordances are defined as “the possibilities for goal-oriented action afforded to specified user groups by technical objects.” (Markus and Silver 2008, p. 622) They reflect what a goal-oriented user, who has specific capabilities, would be able to do with a given technical object (Markus and Silver 2008). The existence of IT affordances depends on the technology’s features and the organization’s capabilities and goals rather than the organization’s perception of action possibilities (McGrenere and Ho 2000; Pozzi et al. 2014). Hence, IT affordances cover an organization’s IT capability and the use of IT capability for organizations’ goals (Chatterjee et al. 2015).

Based on the nature of affordance theory, it can be seen that affordances are useful for explaining how IT can be utilized for SOI in-depth and thus capture the fundamental relationship between IT and SOI. Therefore, we believe affordance theory is the most appropriate theory to help us investigate in detail how IT can be used to enable SOI development.

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Since this research is multidiscipline in nature, we searched related papers published in leading IT/IS, sustainability and innovations journals such as MIS Quarterly, Journal of cleaner production, and Academy of Management Journal. Our literature analysis indicates that there are currently only a few studies investigating how IT enables SOI. Table 1 summarizes the key related studies on IT-enabled SOI.

These studies have different study focuses on IT-enabled SOI and thus have various main findings. Bengtsson and Ågerfalk (2011) acknowledged the critical role of IT in the implementation of sustainability innovations. Srivastava and Shainesh (2015) investigated how to promote IT-enabled service innovation by managing related resources and enablers. Hanelt et al. (2017) analyzed how supporting IT (IT that only supports the innovation rather than is an inherent part of the innovation) can influence the performance of eco-innovations in an organization. El-Kassar and Singh (2019) found that Big Data Analytics technologies help facilitate SOI practices and positively impact organizational competitive advantage. None of these studies comprehensively analyzed the role of IT as an organizational capability in enabling SOI development.

These studies adopt limited coverage of SOI. Bengtsson and Ågerfalk (2011) considered all the dimensions of sustainability but analyzed a report and analysis system rather than organizational IT capability. Though Srivastava and Shainesh (2015) took organizational IT capability into account, they merely focused on the social aspect. Hanelt et al. (2017) gained an in-depth understanding of the relationship between IT and SOI through an affordance perspective. However, they only considered supporting IT and focused on the adoption of innovations that enhance environmental performance (eco-innovations). El-Kassar and Singh (2019) only focused on Big Data Analytics technologies and environmental performance. Hence, there is a lack of comprehensive studies exploring how IT enables the development of SOI, which hinders organizations from developing SOI by utilizing IT.

While most of the studies use case study research method, they adopt different theoretical lenses. By applying actor-network theory, Bengtsson and Ågerfalk (2011) view IT as an actant to address that IT can actively participate in the adoption of SOI. This theory acknowledges the role of IT in SOI adoption but does not provide an in-depth investigation of the relationship between IT and SOI. Service-dominant logic and service science theories adopted by Srivastava and Shainesh (2015) focus on service provision and value creation rather than emphasize the role of IT. Besides, these two theories are only suitable for sustainability-oriented service innovations but not applicable for other kinds of SOI, such as process innovations. Hanelt et al. (2017) investigate the role of supporting IT in promoting SOI performance through an affordance perspective. This perspective not only recognizes the role of IT but also reveals the use of IT for SOI. In terms of resource-based view (RBV) theory adopted by El-Kassar and Singh (2019), it focuses on the merits of IT resources and their impact on organizational competitiveness. However, similar to actor-network theory, RBV theory does not investigate the fundamental relationship between IT and SOI. Overall, affordance theory is more appropriate for exploring the role of IT in enabling SOI since it helps understand the link between IT and SOI (Chatterjee et al. 2020), as shown in Hanelt et al.’s (2017) study. Related IT affordance studies are discussed in the next section.
<table>
<thead>
<tr>
<th>Source</th>
<th>Study focus</th>
<th>Main findings</th>
<th>Methodology</th>
<th>Theoretical lens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bengtsson and Ågerfalk (2011)</td>
<td>Journal of Strategic Information Systems</td>
<td>Role of IT in SOI implementation</td>
<td>A case study</td>
<td>Actor-network theory</td>
</tr>
<tr>
<td>Srivastava and Shainesh (2015)</td>
<td>MIS Quarterly</td>
<td>Resources and drivers of IT-enabled service innovation</td>
<td>A multiple case study</td>
<td>Service-dominant logic, service science</td>
</tr>
<tr>
<td>Hanelt et al. (2017)</td>
<td>Information Systems Journal</td>
<td>Role of supporting IT in SOI performance</td>
<td>A multiple case study</td>
<td>Affordance theory</td>
</tr>
<tr>
<td>El-Kassar and Singh (2019)</td>
<td>Technological Forecasting and Social Change</td>
<td>Impacts of IT on SOI</td>
<td>Survey</td>
<td>Resource-based view (RBV) theory</td>
</tr>
</tbody>
</table>

Table 1. Summary of Key Related Studies on IT-Enabled SOI

**IT Affordances**

Table 2 compares previous studies that have proposed different IT affordances, including Seidel et al. (2013), Hanelt et al. (2017), Eitiveni et al. (2018), and Chatterjee et al. (2020). Seidel et al. (2013), Hanelt et al. (2017), and Chatterjee et al. (2020) investigate the IT affordances in the context of an organization, while Eitiveni et al. (2018) adopt a supply chain perspective. Seidel et al. (2013) and Eitiveni et al. (2018) focus on sustainability but do not focus on innovation. On the contrary, Chatterjee et al. (2020) focus on innovation but do not consider sustainability. Hanelt et al. (2017) focus on both innovation and sustainability. However, unlike Chatterjee et al. (2020), who adopt a comprehensive view of innovation development, and Eitiveni et al. (2018), who take all the sustainability dimensions into account, Hanelt et al. (2017) merely investigate the performance of eco-innovations, which are the innovations that lead to improved environmental performance. Besides, Hanelt et al. (2017) merely consider supporting IT, which is not an inherent part of innovation. Overall, all these studies do not provide a comprehensive view of SOI.
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--- | --- | --- | ---
Context | Organization | Organization | Supply chain | Organization
Sustainability dimension | Environmental | Environmental | All | None
Innovation focus | None | Innovation performance | None | Innovation development
Technology | IT | Supporting IT | IT | IT
Affordances | • Reflective disclosure | • Seidel et al.'s (2013) IS affordances | • Recordability and monitorability | • Organizational memory
  • Information democratization | • Technological flexibility | • Information democratization | • Collaboration
  • Output management | • Digital eco-innovation | • Benchmarking | • Process management
  • Delocalization | | • Persuasive | |

Table 2. Comparison of Different IT Affordances Studies

Research Methodology

We conducted an exploratory case study to investigate how IT enables SOI development in an organization. Case study research method is appropriate because a) the research question requires an in-depth investigation of IT-enabled SOI, which is a contemporary social phenomenon, b) this study acknowledges that the real-life context is highly relevant, and c) no control is required on the studied phenomenon (Schoch 2020; Yin 2018). The case organization was carefully selected according to (Yin 2015) to ensure that it is suitable for a single case study. Specifically, the case organization should a) have adequate sustainability-related reports, announcements, posts, etc. available and b) have successfully implemented a number of SOI with the support of IT. A Chinese logistics company was identified as an appropriate case organization because it has successfully developed several sustainability-oriented innovations and has relied on its IT capability to develop various innovations that have produced significant economic, environmental, and social benefits.

Data Collection and Analysis

The major data source is published documentation. According to Yin (2018), the use of secondary data is common in case studies and can support almost all case study designs (e.g., Bengtsson and Ågerfalk (2011), Wiener et al. (2020), Neutzling et al. (2018), and Klimmek et al. (2021)). Any documentary information related to CN-Logistics' sustainability, innovation, and IT capability was collected. Specifically, published organizational documents (such as sustainability reports, annual reports, and IT strategy reports), public releases (such as announcements, news, and social media posts), and published cases were manually searched and reviewed. We browsed over 300 documents and eventually identified and thoroughly read five organizational reports published in the recent three years, 157 public releases, and two cases that are relevant to our study. We mainly focused on CN-Logistics’ sustainability orientation, SOI development and implementation, technologies used, its management of IT, and sustainability performance.

In terms of data analysis, we conducted a content analysis which is defined as “a research technique for making replicable and valid inferences from texts ... to the contexts of their use.” (Krippendorff 2018, p. 24) Content analysis is a useful tool that helps us gain new insights into a studied phenomenon (Krippendorff 2018), i.e., IT-enabled SOI. The analysis of collected data is non-linear (Yin 2015) and aims to “improve understanding, expand theory, and advance knowledge” by identifying patterns and relationships (Neuman
2013, p. 477). We used deductive coding method (Miles and Huberman 1994), and our “start list” of codes comes from the key concepts of this study (e.g., sustainability orientation, IT capability, IT affordances). Data analysis is assisted by qualitative data analysis software NVivo, which is used to facilitate analysis including pattern matching and emerging pattern identification (Yin 2015; Yin 2018).

**Establishing Rigor**

The research rigor of this study is established by following the criteria proposed by Yin (2018). Specifically, three tests are addressed as follows.

*Construct validity test* requires that the measures used in the study accurately reflect the investigated concepts (Yin 2018). To ensure construct validity, a literature review was conducted to identify appropriate definitions for IT-enabled SOI concepts, such as SOI, IT capability, and IT affordances. Based on the definitions, a set of operational measures for the concepts were determined. Moreover, construct validity is further enhanced by collecting data from multiple sources and maintaining an evidence chain, as Yin (2018) recommended.

*External validity test* is concerned with “the extent to which the findings from a case study can be analytically generalized to other situations that were not part of the original study” (Yin 2018, p. 287). To ensure external validity, this study carefully selected a case organization by following established selection criteria to increase the generalizability of the findings. Besides, the use of affordance theory to guide the identification of IT affordances is another tactic to increase analytical generalizability (Yin 2018).

*Reliability test* deals with “the consistency and repeatability of producing a case study’s findings.” (Yin 2018, p. 288) To ensure reliability, this study developed a case study repository and established a chain of evidence, as suggested by Yin (2018).

**Case Study Findings**

The case organization CN-Logistics (pseudonym) was founded in 2013 in China. Rather than competing with other logistics companies, CN-Logistics established a partnership with them and combined their capabilities to create a logistics ecosystem. Having about 100 logistics partners worldwide, CN-Logistics aims to establish a global smart logistics network through innovation and harnessing of advanced technologies (e.g., Big Data Analytics, Artificial Intelligence (AI), Cloud, Internet of Things (IoT), etc.). The smart logistics network significantly improves the efficiency within and among the logistics companies, and parcels within the network can therefore flow smoothly from end to end.

**SOI Implemented in CN-Logistics**

To address sustainability issues, CN-Logistics has developed various innovations to improve its environmental and social performance in addition to economic performance, i.e., SOI. Table 3 summarizes the major SOI successfully implemented in CN-Logistics. Those SOI cover CN-Logistics’ logistics businesses, such as packaging, shipping, delivering, etc., as well as its office operations, such as office energy consumption control. Besides, those SOI are significantly enabled by CN-Logistics’ IT capability. All the SOI are technology-enabled, and many modern technologies (e.g., AI, Big Data Analytics, and IoT) are utilized. Various systems are also established to support the SOI.

**CN-Logistics’ Sustainability Orientation**

The development of the above IT-enabled SOI is greatly driven by CN-Logistics’ sustainability orientation. We found that CN-Logistics has a strong sustainability orientation, and thus it is devoted to promoting sustainability in its businesses.

It redesigned its business logo to show its commitment to sustainability. Also, CN-Logistics has published a sustainability plan for its Carbon Neutral goal for 2030. It sets the target for each year from 2021 to 2030.

“We are aligned with China’s landmark strategic commitment for carbon neutrality, and therefore hope to realize carbon neutrality for [our organization’s] own operations before 2030.″ (Carbon Neutrality Action Report)
<table>
<thead>
<tr>
<th>SOI</th>
<th>Technology-Enabled</th>
<th>Technology Used</th>
<th>Related System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic shipping (E-shipping) label</td>
<td>Yes</td>
<td>Electronic printer and Cloud</td>
<td>Parcel management system</td>
</tr>
<tr>
<td>Electric autonomous vehicles</td>
<td>Yes</td>
<td>AI, autonomous vehicle, and electrification</td>
<td>Smart route optimization and planning system</td>
</tr>
<tr>
<td>Route optimization and planning</td>
<td>Yes</td>
<td>AI and Big Data Analytics</td>
<td>Smart route optimization and planning system</td>
</tr>
<tr>
<td>Packaging optimization</td>
<td>Yes</td>
<td>AI and Big Data Analytics</td>
<td>Smart packaging optimization system</td>
</tr>
<tr>
<td>Green packaging material trading platform</td>
<td>Yes</td>
<td>Online trading technologies</td>
<td>Green packaging material trading platform</td>
</tr>
<tr>
<td>Interactive online sustainability</td>
<td>Yes</td>
<td>Social media, mobile application</td>
<td>Parcel management system</td>
</tr>
<tr>
<td>promotion activities and campaigns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smart energy control</td>
<td>Yes</td>
<td>Sensors and Internet of Things (IoT)</td>
<td>Smart energy control system</td>
</tr>
<tr>
<td>forecasting</td>
<td>Yes</td>
<td>Machine learning</td>
<td>Intelligent demand forecasting system</td>
</tr>
</tbody>
</table>

Table 3. Summary of SOI Implemented in CN-Logistics

The organization involves not only logistics partners but also customers (both senders and recipients) in its sustainability initiatives. Environmentally, CN-Logistics reduces, reuses, and recycles (i.e., 3R’s) packaging materials. Over 100 million cartons are reused every year, and 86 million meters of plastic tape were saved during the 2020 November Shopping Festival (also known as the Double 11 Festival). Furthermore, CN-Logistics introduced e-shipping labels and reduced the size of the labels, which cut 450 thousand tons of carbon emissions in a single year in 2020. Partnering with non-profit organizations, CN-Logistics launched a coastal plastics clean-up campaign with more than 500 thousand participants. In terms of social sustainability, CN-Logistics plays an active role, for example, in promoting the development of agriculture e-commerce in rural areas. The sales of agricultural products in those areas have grown remarkably. For a typical area, agriculture product shipments have increased 10 thousand times in 10 years. We recognize that CN-Logistics’ sustainability orientation plays a major role in driving the development of SOI, which is greatly enabled by its IT capability.

**CN-Logistics’ IT Capability**

The development of the IT-enabled SOI relies on CN-Logistics’ IT capability. As a tech organization, CN-Logistics was established with an innate belief in IT to enable innovation. Therefore, the organization utilizes its IT capability extensively to support the development of SOI. In fact, CN-Logistics’ IT capability is leading in the logistics industry. Each component of CN-Logistics’ IT capability is discussed below.

In terms of **IT strategy and governance**, many of the senior managers of CN-Logistics are IT-related managers and have IT-related backgrounds. Consequently, IT strategy is aligned with organizational overall business strategy. Managers from both the IT and business sides have a common understanding of organizational strategic goals (e.g., Carbon Neutral goal for 2023). They also agree on what SOI are needed and how those SOI should be developed. Guided by the strategy, the governance of IT ensures that there is a good synergy between IT function and other organizational functions. Regarding **IT process management**, CN-Logistics has a robust management mechanism to ensure the IT services are properly and timely delivered. IT processes and activities are continuously assessed, monitored, and regularly reported to senior...
managers. IT people and knowledge are also well-managed in CN-Logistics, and IT people have actively participated in SOI development. At the top management level, many senior managers from the IT side are involved in SOI-related decision-making. Besides, a research center is established for IT people to utilize advanced technologies to invent innovations, including SOI, and manage related knowledge. CN-Logistics also has a well-established IT infrastructure. Its IT functions are mostly based on self-owned Cloud service. The organization also develops various systems by itself. The self-owned Cloud service as well as many self-build systems are massively used for SOI development.

**IT Affordances for SOI in CN-Logistics**

We identify five IT affordances for SOI in the case organization. In this section, we present how sustainability orientation and IT capability lead to the emergence of IT affordances for SOI and how each IT affordance supports the development of SOI above in the case organization.

**IT Sustainability Opportunity Sensing Affordance**

Driven by its strong sustainability orientation, CN-Logistics keeps exploring opportunities for innovations that improve its sustainability performance by leveraging its IT capability, which gives rise to IT sustainability opportunity sensing affordance.

One of the most significant sustainability opportunities found by CN-Logistics through IT is electronic shipping (i.e., e-shipping) labels. Through digitalization, the upgraded shipping label can pack more information while using less paper (a conventional shipping label has five sheets, each of which is for different purposes). Moreover, a parcel management system will detect any redundancy shipping data, and if the redundant shipping label is printed, it will recycle it automatically.

In addition to reducing resources consumptions, IT offers opportunities in improving efficiency. Compared to conventional handwriting shipping labels, e-shipping labels can be better managed through IT. For example, e-shipping labels require less time to fill and can effectively avoid unrecognizable handwriting and typos, ensuring the recognizability and accuracy of shipping data. Also, E-shipping labels store all the data in a unified format. By scanning the barcode or QR code on the label, IT can process those structured data directly without human intervention. Therefore, the processing time has been greatly reduced, and the status of parcels can be easily monitored and tracked at each shipping stage.

IT also help find opportunities in social sustainability such as information security and traceability. The security of shipping information is enhanced as all the data are securely stored in the Cloud-based parcel management system – only necessary information will be shown on the label. It also promotes responsible shipping management by providing a transparent and traceable logistics system.

More recently, CN-Logistics has been seeking IT-enabled SOI opportunities in multi-disciplines, including artificial intelligence (AI), autonomous vehicle, and electrification. Electric autonomous vehicles are released to promote energy efficiency and reduce carbon emissions. Hundreds of those autonomous vehicles are deployed for last-mile deliveries. In addition, CN-Logistics is inventing a larger electrical autonomous vehicle for longer delivery distance. Hence, the advancement of information technologies brings about considerable innovation opportunities for enhancing sustainability, which, in turn, strengthens CN-Logistics’ faith in SOI.

“… we are exploring the development of smart transportation systems with autonomous vehicles. The combination of artificial intelligence (AI) and electrification can improve transportation efficiency, thereby reducing attendant carbon emission. … We are also developing an autonomous truck … which targets urban distribution scenarios” (Carbon Neutrality Action Report 2021)

**IT Sustainability Knowledge Management Affordance**

CN-Logistics’ dedication to sustainability makes SOI-related knowledge a valuable asset to the organization. IT enables CN-Logistics to create, store, transform, mobilize, etc. knowledge that contributes to SOI development, which leads to IT sustainability knowledge management affordance.
A self-developed software system is used by employees to communicate. The system is built on self-owned Cloud services, and it can be accessed via an application on mobile devices such as smartphones, tablets, and laptops. Hence, employees can easily communicate, share and access SOI information through the system at any time and from anywhere (as long as they have the authority to do so). Moreover, since their Cloud provider provides the underlying IT infrastructure services (i.e., infrastructure as a service, IaaS), it stores all the data or knowledge that input into, collected, or created by the system. That is, all the SOI knowledge is managed from a central location and totally controlled by CN-Logistics and other authorized companies/users. SOI knowledge is securely stored and can be shared within CN-Logistics and other trusted partners. To further promote information and knowledge sharing, especially with foreign partners, CN-Logistics has built eight electronic centers (eCenters) worldwide. Those eCenters form a global logistics data network and enable SOI knowledge sharing worldwide.

In addition, CN-Logistics deploys AI and Big Data Analytics technologies to create SOI knowledge. Based on logistics data such as transportation conditions, vehicle conditions, weather conditions, and customer demand patterns, CN-Logistics utilizes AI and Big Data Analytics to provide logistics management predictions and suggestions for route optimization and planning. Combining with Cloud services, those predictions and suggestions can be delivered and displayed in real time. It makes the logistics network more efficient, which leads to less energy consumption and carbon emissions. AI and Big Data Analytics are also employed for gaining insights into packaging optimization. Specifically, AI algorithms provide CN-Logistics with the best solution for postal box cutting and packaging. Big Data helps design the postal box for various goods so that conventional boxes, which are fixed-sized and cannot perfectly match all the goods, can be avoided. Consequently, goods are better packed in suitable boxes and safely delivered with less packaging material, and spaces are more efficiently used.

"[CN-Logistics] developed an intelligent system based on big data and artificial intelligence to offer packaging solutions to deal with the problem of packing different kinds of goods with different shapes." (A published case study)

**IT Sustainability Collaboration Affordance**

Driven by the high sustainability orientation, CN-Logistics also make use of IT to facilitate effective and efficient collaboration within the organization and with partner organizations, which reflects **IT sustainability collaboration affordance**. This IT-enabled collaboration, in turn, provides an opportunity to develop and implement SOI promptly.

Within the company, CN-Logistics deploys centralized Cloud-based systems to facilitate collaboration within and among the departments. Rather than using desk phones, CN-Logistics employees use mobile devices to send messages, make phone calls, share files, etc. Timely, efficient, and reliable communications help facilitate SOI implementation, such as real-time route optimization planning, which requires quick responses and adjustments.

IT also helps enhance collaboration among CN-Logistics’ partners in several ways. As mentioned above, CN-Logistics built several eCenters around the world, which forms a high-efficient data and knowledge sharing network. Through those eCenters, the partners’ systems can freely “communicate” with each other when implementing SOI.

"Essentially, [eCenters] provide warehousing and distribution center services within the platform. These are smart warehouses that leverage technology such as Internet of Things (IoT), robots and AI to digitalize operations." (CN-Logistics’ official blog)

Besides, acting as a coordinator in the network, CN-Logistics collects logistics data from its partners via the systems. Then, with the help of AI, CN-Logistics provides data-driven services to the partners and coordinates them. SOI can therefore be implemented smoothly within the smart logistics network. Moreover, CN-Logistics established a green packaging material trading platform to link sustainability-focused high-tech companies with logistics partners. Thus, the logistics companies have direct access to advanced green packaging materials. To further promote sustainability among the partners, CN-Logistics offers a Cloud-based software (software as a service, SaaS) that helps manage carbon emissions within a company. By using the software, the partners are able to know where they could improve to reduce carbon...
emissions. Hence, they will have a better understanding about the value of SOI and be more actively implementing SOI.

Customers also play a critical role in promoting SOI. Therefore, CN-Logistics launches interactive online activities and campaigns to increase customers’ awareness of sustainability and encourage them to promote sustainability practices. Customers will be rewarded once they participate in sustainability initiatives, such as reducing, reusing, and recycling packaging materials. Those virtual rewards will be accumulated and eventually turn into physical sustainability practices, for example, planting trees and protecting nature reserves.

**IT Sustainability Process Management Affordance**

With a solid commitment to sustainability, CN-Logistics is expected to have robust management for SOI processes. Specifically, CN-Logistics uses IT to design, visualize, and monitor its SOI and allocate and manage SOI development resources. This is where *IT sustainability process management affordance* is identified.

CN-Logistics mainly uses self-built Cloud-based systems to manage its SOI processes. The case organization has implemented a smart energy control system to manage its energy consumption in the offices. A large scale of sensors and IoT equipment are installed in the offices to monitor and report the real-time energy consumption status, which is visualized in an energy control center. The energy control system will automatically adjust the usage of equipment (e.g., lights, air conditioners, projectors, etc.) according to the surrounding conditions, such as weather, temperature, and population in the offices. Therefore, IT enables the smart energy control management by providing and managing the underlying processes.

> "Through environmental sensors and smart IoT equipment, energy use in our offices is actively monitored. Energy intensive equipment such as projection screens, lights, and air conditioners are automatically controlled in an adaptive way with the surroundings. In addition, real time energy consumption can be continuously displayed and managed in [the organization]'s smart center.” (Carbon Neutrality Action Report 2021)

CN-Logistics also has an integrated logistics management system to manage the processes of logistics-related SOI. The e-shipping labels described earlier enable CN-Logistics to track and control the shipment of the parcels through the parcel management system, which is part of the integrated logistics management system. Moreover, CN-Logistics has introduced an intelligent demand forecasting system, which is identified as a SOI. Supported by machine learning, the demand forecasting system generates recommended inventory and shipping capabilities. CN-Logistics access the forecasting data through the integrated logistics management system and adapt its inventory and shipping capabilities accordingly. The smart route optimization and planning system mentioned above is also part of the integrated logistics management system. Overall, CN-Logistics has all the access to the SOI management systems through the centralized and integrated logistics management system.

**IT Sustainability Performance Management Affordance**

To meet the Carbon Neutral goal for 2030, CN-Logistics uses IT to measure and benchmark its SOI performance as well as overall organizational sustainability performance, which reflects *IT sustainability performance management affordance*.

A corporate social responsibility (CSR) management system is used to fetch sustainability-related data and manage its sustainability performance. Specifically, the CSR management system is able to monitor the offices’ sustainability performance through the smart energy control system, which is supported by sensors and IoT technologies. With the help of AI and Big Data Analytics technologies, the CSR management system can monitor and manage CN-Logistics’ packaging, shipping, and delivery sustainability performance. The sustainability-performance-related data will be collected by the sub-systems (e.g., parcel management system, smart packaging optimization system, packaging optimization system, smart energy control system, etc.) and regularly analyzed and reported through the CSR management system. Thus, through the various management systems, CN-logistics effectively monitors, assesses, and controls its SOI performance as well as its overall sustainability performance.
Summary of Findings

Overall, it can be seen that CN-Logistics’ sustainability orientation greatly impacts how the organization would utilize its IT capability for SOI development and, therefore, influences the existence of IT affordance in the organization. Besides, with strong IT capability, CN-Logistics realized all the proposed IT affordances (Table 2). We also noticed that an IT affordance could impact other IT affordance(s). For example, route optimization and planning SOI are enabled by both knowledge management affordance and collaboration affordance. In this case, IT sustainability collaboration affordance is supported by the knowledge management affordance to perform the optimized shipping route. Moreover, sustainability performance management affordance is supported by knowledge management affordance and collaboration affordance to obtain sustainability performance-related data.

Discussion

Addressing the Research Question

RQ: How can IT enable the development of sustainability-oriented innovations in an organization?

A model is developed (Figure 1) to illustrate how SOI can be enabled by IT through affordances in an organization. According to affordance theory, the emergence of IT affordances depends on an organization’s goal and IT capability (McGrenere and Ho 2000; Pozzi et al. 2014). In the context of SOI development, the model shows that SOI-related IT affordances are influenced by both organizational IT capability and sustainability orientation. IT affordances are derived from IT capability and represent how IT is used for a specific goal (Markus and Silver 2008), which, in this study, is to develop SOI. Sustainability orientation is a crucial driver of IT-enabled SOI development. It not only drives organizations to develop SOI but also influences how IT is used to enable SOI development (i.e., IT affordances for SOI). With a strong sustainability orientation, an organization is expected to utilize all its resources and capabilities, including IT, to develop SOI and boost its sustainability performance. Thus, sustainability orientation significantly impacts what IT affordances are generated for SOI. Those SOI-related IT affordances, in turn, enable organizations to develop innovations that yield economic, environmental, and social benefits, i.e., SOI. Several key insights that can be examined in further research are discussed below.

Figure 1. IT-Enabled Sustainability-Oriented Innovation

Sustainability orientation is found to greatly influence how organizational IT capability is utilized for SOI development, i.e., IT affordances for SOI. In the case study, CN-Logistics has a formalized commitment to sustainability. It changed its logo, set short-term and long-term sustainability goals, established a CSR management system, etc. All these efforts impact each of the IT affordances. Specifically, the organization’s sustainability commitment makes it continuously seek opportunities for sustainability-oriented innovation, which gives rise to the IT sustainability opportunity sensing affordance. Besides, with a strong sustainability
orientation, the organization understands the value of sustainability-related knowledge. Therefore, IT sustainability knowledge management affordance emerged to enable the management of sustainability-related knowledge and help the organization gain its value. Sustainability orientation also impacts sustainability collaboration within the organization and with partners. The stronger the sustainability orientation is, the better collaboration is required. As a result, IT sustainability collaboration affordance is needed to promote the collaboration for SOI. Moreover, IT sustainability process management affordance is also influenced by the organization’s commitment to sustainability. This affordance can enable the organization to establish robust process management for SOI development. Also, IT sustainability performance management affordance is needed to reflect on the outcome of the organization’s sustainability orientation. A strong sustainability orientation brings higher expectations of the organization’s SOI performance. Therefore, we propose that:

**Proposition 1:** Organizational sustainability orientation significantly impacts IT affordances for SOI.

The case study also provides a closer view of the relationship between IT affordances and IT capability. As reflected in the case study, CN-Logistics has industry-leading IT capability, and the use of IT is aligned with organizational sustainability strategic goals. IT governance and process management are well-established since the systems and modern technologies are evidently utilized properly without any integration issues. Also, all the SOI implemented in the case organization are technology supported, which implies that the IT people have a good understanding of the SOI needed by the organization and actively participate in the SOI development. In terms of IT infrastructure, CN-Logistics has a self-developed Cloud, self-developed systems, and advanced technologies (e.g., AI, Big Data analytics, IoT, etc.). Overall, all these IT components play a vital role in the formation of the IT affordances for the SOI development. Without robust IT capability, those IT affordances can hardly be realized in CN-Logistics. Hence, we propose the following:

**Proposition 2:** All components of IT capability (i.e., IT strategy and governance, IT process management, IT people and knowledge, and IT infrastructure) are critical for the formation of IT affordances for SOI.

Based on the case study, five IT affordances for SOI are proposed, including sustainability opportunity sensing, sustainability knowledge management, sustainability collaboration, sustainability process management, and sustainability performance management. These affordances support and extend previous studies. The definitions of the five IT affordances and how they are related to previous studies are shown in Table 4.

In the case organization, IT sustainability opportunity sensing affordance help explore and identify new innovations that lead to better sustainability performance, such as electric autonomous vehicles. IT knowledge management affordance reveals that IT can enable SOI development by creating, managing, applying, exploiting, etc. organizational SOI-related knowledge (e.g., route optimization and planning). The SOI development can be facilitated by promoting cooperation within the organization and with partners, which can be enabled by IT through sustainability collaboration affordance (e.g., green packaging material trading platform). Besides, through sustainability process management affordance, IT enables the organization to design, visualize and monitor its SOI processes and to distribute resources for SOI (e.g., smart energy control). The last affordance, i.e., sustainability performance management affordance, represents that IT is used to measure and benchmark the organization’s SOI performance. Therefore, we formulate the following proposition:

**Proposition 3:** There are five IT affordances (i.e., sustainability opportunity sensing, sustainability knowledge management, sustainability collaboration, sustainability process management, and sustainability performance management) that support SOI development.

Additionally, we found that IT affordance can be interrelated. For example, IT sustainability opportunity sensing affordance can contribute to sustainability knowledge management affordance as the former affordance may bring new sustainability knowledge to the organization when seeking sustainability opportunities. Furthermore, IT sustainability knowledge management affordance can support sustainability collaboration affordance because sustainability collaboration requires shared knowledge among the participants. Sustainability collaboration affordance can also influence sustainability knowledge management affordance. With a better collaborative relationship with partners, it should be easier for the organization to obtain and manage sustainability knowledge from the partners. Besides, IT process management can be impacted by the opportunity sensing affordance. For example, e-shipping labels, which
were sensed by the IT, have changed CN-Logistics' parcel management process. Regarding IT sustainability performance management affordance, it could be supported by knowledge management affordance and collaboration affordance to obtain and analyze sustainability performance-related data. This case study only serves as an initial exploration of the relationship among the IT affordances for SOI. Therefore, more investigations are needed to sort out the relationship among IT affordances for SOI. Hence, the following proposition is suggested:

**Proposition 4:** IT affordances are not completely independent of each other.

<table>
<thead>
<tr>
<th>Affordances</th>
<th>Definition</th>
<th>References</th>
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<tbody>
<tr>
<td>Sustainability opportunity sensing</td>
<td>This IT affordance enables an organization to (internally or externally) explore innovation opportunities for enhancing sustainability and to form the belief in sustainability-oriented innovation.</td>
<td>Reflective disclosure (Seidel et al. 2013) Persuasive (Eitiveni et al. 2018)</td>
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<tr>
<td>Sustainability knowledge management</td>
<td>This IT affordance enables an organization to “create, store, transform, refine, access, mobilize, apply, and exploit organizational knowledge” (Chatterjee et al. 2020, p. 6) for sustainability-oriented innovation.</td>
<td>Information democratization (Seidel et al. 2013) Information democratization, and risk analysis (Eitiveni et al. 2018) Organizational memory (Chatterjee et al. 2020)</td>
</tr>
<tr>
<td>Sustainability collaboration</td>
<td>This IT affordance enables an organization to promote cooperation within the organization and with its partners, “both in a collocated and distributed/virtual setting, on a one-to-one or many-to-many basis” (Chatterjee et al. 2020, p. 6) for sustainability-oriented innovation.</td>
<td>Information democratization (Seidel et al. 2013) Information democratization, collaborative (Eitiveni et al. 2018) Collaboration (Chatterjee et al. 2020)</td>
</tr>
<tr>
<td>Sustainability process management</td>
<td>This IT affordance enables an organization to “design, visualize, prioritize, and monitor” (Chatterjee et al. 2020, p. 6) sustainability-oriented innovation and “allocate and manage appropriate resources” (Chatterjee et al. 2020, p. 6) for sustainability-oriented practices and decision-making.</td>
<td>Delocalization (Seidel et al. 2013) Technological flexibility and digital eco-innovation (Hanelt et al. 2017) Recordability and monitorability, and process &amp; output management, and delocalization (Eitiveni et al. 2018) Process management (Chatterjee et al. 2020)</td>
</tr>
<tr>
<td>Sustainability performance management</td>
<td>This IT affordance enables an organization to measure and benchmark its sustainability-oriented innovation performance and reflect on the outcomes.</td>
<td>Output management (Seidel et al. 2013) Recordability and monitorability, benchmarking, and process &amp; output management (Eitiveni et al. 2018)</td>
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Table 4. SOI-Related IT Affordances

**Implications**

This case study contributes to the current literature on IT-enabled SOI in the following ways. First, it adopts an affordance perspective to gain insights into the relationship between IT and SOI and addresses the research gap by comprehensively analyzing IT affordances for SOI. Five IT affordances are proposed especially for the development of SOI, namely, sustainability opportunity sensing affordance, sustainability knowledge management affordance, sustainability collaboration affordance, sustainability process management affordance, and sustainability performance management affordance.
In addition, we develop an IT-enabled SOI model to capture the relationship among sustainability orientation, IT capability, IT affordances, and sustainability-oriented innovation. Four propositions are proposed regarding organizational sustainability orientation, the relationships between IT capability and IT affordances and between IT affordances and SOI, and the relationship among the proposed affordances, which provide insights into IT-enabled SOI. Specifically, though the role of sustainability orientation is acknowledged in the previous study (Tim et al. 2018), empirical validation is lacking. In this study, we provide empirical evidence of the significance of sustainability orientation for IT-enabled SOI through a case study. We also offer a closer view of the relationship between IT capability and IT affordances and explain how the IT affordances support SOI development. Besides, we find that IT affordances can be interrelated. Though the model and propositions are based on an initial exploratory case study, they can guide future empirical studies to further refine or extend the IT-enabled SOI model.

In terms of practical implications, this study helps facilitate organizations’ understanding of IT-enabled SOI. By referring to the IT affordances for SOI, organizations are expected to realize the value of IT, evaluate and assess their IT capability, and explore the potential of their IT capability. Policy guidelines may also consider these IT affordances to help organizations utilize IT appropriately and efficiently.

Besides, this study addresses the importance of organizational sustainability orientation for the development of IT-enabled SOI. In the case study, the case organization’s sustainability orientation has a substantial impact on IT affordances for SOI and forms a strong support for IT-enabled SOI development. Therefore, organizations are highly recommended to establish a formal commitment to sustainability to facilitate the development of IT-enabled SOI.

**Conclusion**

This study explores IT-enabled sustainability-oriented innovation (SOI) from an affordance perspective. Based on a case study, five IT affordances for SOI and an IT-enabled SOI model are proposed to illustrate how IT enables SOI development through affordances in an organization. The case study findings also lead to four propositions which can be further examined in future studies.

There are several limitations of this study. The case study is an exploratory study, which means the investigation is just initial, and more studies are needed to further explore this field and validate the findings of this study. Moreover, the proposed model only captures high-level relationships among the constructs rather than providing a detailed view of the realization of IT affordances for SOI. For example, the relationships among IT affordances are still underexplored. Additionally, the generalizability of the findings may be challenged since we only conducted a single case study.

To further explore IT-enabled SOI, future research could conduct multiple case studies with organizations from different industries so that the IT-enabled SOI model can be evaluated, refined, and extended. Future research could also examine the relationships among the IT affordances to complement this study. Overall, this study lays the foundation for future research to explore how IT enables the development of SOI in an organization.

**Acknowledgments**

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**References**


