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Implementing Green Business Processes: The Importance of Functional Affordances of Information Systems

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Abstract

An environmentally sustainable and thus green business process is one that delivers organizational value whilst also exerting a minimal impact on the natural environment. Recent works from the field of Information Systems (IS) have argued that information systems can contribute to the design and implementation of sustainable business processes. While prior research has investigated how information systems can be used in order to support sustainable business practices, there is still a void as to the actual changes that business processes have to undergo in order to become environmentally sustainable, and the specific role that information systems play in enabling this change. In this paper, we provide a conceptualization of environmentally sustainable business processes, and discuss the role of functional affordances of information systems in enabling both incremental and radical changes in order to make processes environmentally sustainable. Our conceptualization is based on (a) a fundamental definition of the concept of environmental sustainability, grounded in two basic components: the environmental source and sink functions of any project or activity, and (b) the concept of functional affordances, which describe the potential uses originating in the material properties of information systems in relation to their use context. In order to illustrate the application of our framework and provide a first evaluation, we analyse two examples from prior research where information systems impacted on the sustainability of business processes.

Keywords

Green IS, functional affordances, business process management, sustainability, IT-enabled transformation

INTRODUCTION

Environmental sustainability describes stakeholder behavior impacting on the natural environment that meets the needs of the present without compromising the ability of future stakeholders to meet their own needs (Elliot 2011). Business organizations are a main contributor to the environmental sustainability challenge (Melville 2010) as their behavior, that is, their business processes can exert quite dramatic impact on the use and availability of natural resources for present and future generations.

Green information systems (IS) are being lauded as a key resource to assist organizations in transforming to more sustainable entities (Thibodeau 2007) by assisting the design and implementation of sustainable business processes (Melville 2010; Watson, Boudreau and Chen 2010). Environmentally sustainable business processes can be described as those business processes that deliver organizational value whilst exerting a minimal impact on the natural environment (e.g., through reduced waste production or energy consumption).

Recent research in the fields of computer science and information systems has investigated different information technologies for environmentally sustainable business practices (Bose and Luo 2011; DesAutels and Berthon 2011; Zhang, Liu and Li 2011). Still, there is a void as to as to the actual changes a business process has to undergo in order to become environmentally sustainable, and the role that IS may play in enabling this change.

Green IS can positively impact on organizational sustainability (Melville 2010). We define green IS innovation as the *use of information systems for the purposes of (re-) designing and implementing environmentally sustainable changes to business processes*. This, we believe, is in line with the thinking of Watson et al. (2011), who point to the *transformative power of IS* and also with the definition proposed by Blowfield and Visser (2007) who define sustainability innovation as “innovation explicitly directed at a sustainability goal.”

In this paper, we discuss the role of functional affordances of information systems in enabling green changes in organizational business processes. Functional affordances are potential uses of information systems based on users' interpretation of their material properties dependent on the use context (Markus and Silver 2008). That is, the material properties of information systems are interpreted in the light of sustainability related goals, for instance, the reduction of carbon emissions. Specifically, we are interested in whether functional affordances of IS allow for incremental or radical re-design of business processes. It is assumed that some processes need to be changed incrementally in order to become environmentally sustainable, while others need to be changed radically.

To that end, we first need to understand what characterizes a business process as environmentally sustainable. Correspondingly:

***RQ1:** What is an environmentally sustainable business process?*

In order to seek answers to this research question, we consult the literature on environmental sustainability, sustainability transformations, and business process management.

Second, we are interested in the role that IS can play in incremental and radical changes (Dewar and Dutton 1986) to business processes in order to make those processes environmentally sustainable. Incremental changes represent "an extension to the status quo, that is, adjustments or refinements in current products, practices, relationships, skills, and norms" (Orlikowski 1993, p. 331). They thus relate to "minor improvements or simple adjustments in current technology" (Dewar and Dutton 1986, p. 1423). Radical changes, in contrast, go "beyond augmenting the status quo, requiring a shift to fundamentally different products, practices, relationships, skills and norms" (Orlikowski 1993, p. 331). Specifically, we are interested in how functional affordances of information systems can contribute to such change:

***RQ2:** How do functional affordances of IS contribute to incremental and radical process change, in order to create sustainable business processes?*

In order to seek answers to this research question, in this paper, we develop a conceptual framework for IS-enabled sustainability process change that is grounded in a general definition of environmental sustainability and the concept of functional affordances. This enables us to discuss green business process change in relation to the role that information systems can have in such change efforts. We illustrate the application of the framework by applying it to examples from prior IS literature that show how business processes can become more environmentally sustainable through capitalizing on the functional affordances proffered by IS. We further suggest that the framework can guide future research (a) to enhance our understanding of how business processes can be changed in the light of environmental sustainability, (b) to understand how information systems can be used in the context of specific business processes in order to contribute to environmental sustainability, and (c) to identify what specific functional affordances can contribute to more sustainable business processes.

On this basis, the paper makes two main contributions. First, it proposes a conceptualization of sustainability in business processes. Second, it proposes a model for how the impact of information systems on green business process (Watson, Boudreau and Chen 2010) implementation can be understood and evaluated. To that end, the paper proposes a conceptualization about the power of information systems to contribute to sustainability efforts.

The remainder of this paper is structured as follows. We first present a conceptual framework that is grounded in prior literature. We then apply the framework to two cases where information systems were used to implement more sustainable business processes. Finally, we provide a conclusion and an outlook to future research

CONCEPTUAL FRAMEWORK DEVELOPMENT

Functional Affordances of Information Systems

The concept of functional affordances builds on the view that individuals do not interact with an object without perceiving what the object can be used for (Gibson 1986). For information systems, this view implies that technology artifacts possess material properties, but the way these are used depends on the relationship between artifact and user (Markus and Silver 2008).

Functional affordances, therefore, describe the action possibilities proffered by properties existent in information systems. Still, these functional affordances need to be perceived as such before they can be realized. The way functional affordances are perceived is dependent on the context in which information systems are used (Leonardi 2011). Consequently, the way functional affordances are perceived is dependent on the business process in which information systems are used.

The concept of functional affordances allows us to examine how individuals, in the light of new, sustainability-related targets, interpret material properties of information systems. That is, this concept allows us to speculate how information systems can contribute (through the functional affordances they create) to sustainability process change.

Based on the literature, we can identify three key properties of functional affordances that lead to important questions for how information systems can lead to the development of sustainable business processes:

1. Functional affordances depend on material properties of information systems (Leonardi and Bailey 2008; Markus and Silver 2008). We thus ask: *which material properties need to be provided by information systems in order to permit functional affordances that will be required in developing sustainable business processes?*
2. Functional affordances emerge when the material properties of information systems are interpreted as affording action possibilities within the context of their use (Markus and Silver 2008; Leonardi 2011). We thus ask: *when and how do individuals interpret information systems as providing functional affordances that allow for developing sustainable business processes?*
3. Functional affordances arise when individuals interpret information systems through their goals for action (Zammuto et al. 2007; Markus and Silver 2008; Leonardi 2011). Acting on the perceived functional affordances leads to new intentions about the use of the material properties of an information system, in turn enabling new business processes. We thus ask: *what are the interpretations of functional affordances that lead to new, sustainable business processes?*

Based on this understanding, we now need to examine how sustainable business processes can be characterized. We will turn to this issue below.

Characterization of Sustainable Business Processes

A business process is a set of the logical and temporal activities executed to transform inputs into outputs according to an organizational value function. In examining when business processes can be characterized as being environmentally sustainable, we identify two fundamental environmental services, the source and the sink function (Goodland 1995, p. 10). Consequently, environmental sustainability constitutes a set of constraints on the main activities that regulate the scale of the human economic subsystem: (a) the use of both renewable and non-renewable resources on the source side and (b) the assimilation of emissions and waste on the sink side (Goodland 1995).

We can use this understanding in order to define a sustainable business process. As any business processes requires inputs from the environment that are then transformed into outputs, the sustainability of a business process can be defined in terms of the renewable and non-renewable inputs as well as the type and environmental quality of the output—both intended and collateral—that result from that process.

Based on the output rule, input rule, and operational principles that were defined by Goodland (1995) with regards to sustainability, we can thus define three characteristics of a sustainable business process. We summarize them in Table 1.

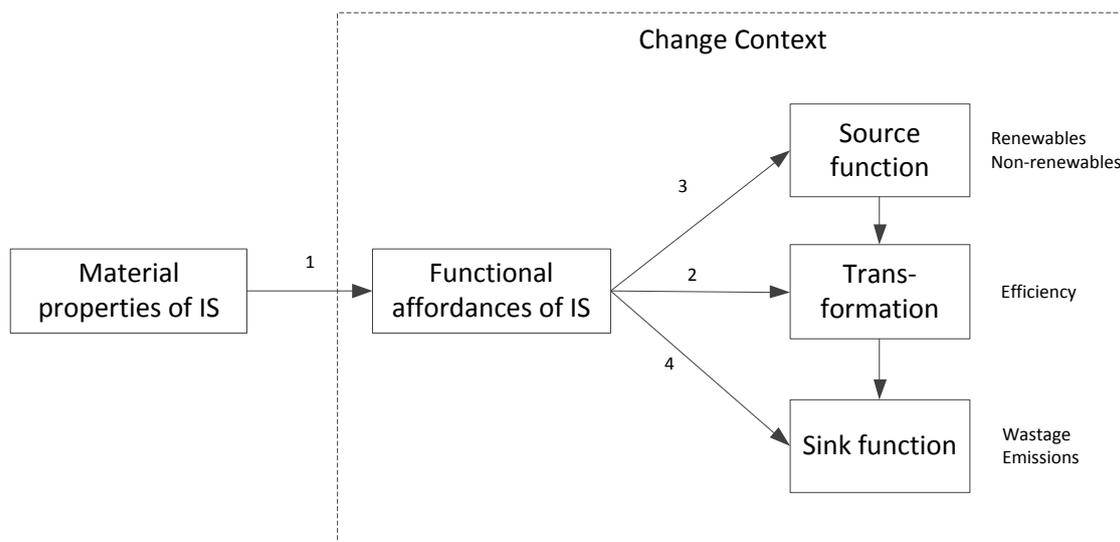
Table 1. Sustainable business processes and relevant change principles

Principle	Definition of environmental sustainability (Goodland 1995)	Characterization of environmentally sustainable business processes
Output rule	<i>“Waste emissions from a project or action being considered should be kept within the assimilative capacity of the local environment without unacceptable degradation of its future waste absorptive capacity or other important services.”</i>	<p>The extent of emissions that originate from a business process, which can be kept within the assimilative capacity of the environment within which the process is executed, should be maximized.</p> <p>The extent of emissions that originate from a business process, which exceed the assimilative capacity of the environment within which the process is executed, should be minimized.</p>
Input rule	<p><i>“(a) Renewables: harvest rates of renewable resource inputs should be within regenerative capacities of the natural system that generates them.”</i></p> <p><i>“(b) Non-renewables: depletion rates of non-renewable resource inputs should be set below the rate at which renewable substitutes are developed by human invention and investment according to the Serafian quasi sustainability rule (...). An easily calculable portion of the proceeds from liquidating non-renewables should be allocated to research in pursuit of sustainable substitutes”</i></p>	<p>The extent of renewable inputs of a business process, which are harvested within the regenerative capacities of the natural environment, should be maximized.</p> <p>The extent of non-renewable inputs of a business process should be minimized.</p>
Change principles	<p><i>(a) The scale (population x consumption per capita x technology) of the human economic subsystem should be limited to a level which, if not optimal, is at least within the carrying capacity and therefore sustainable.</i></p> <p><i>(b) Technological progress for sustainable development should be efficiency-increasing rather than throughput-increasing.</i></p> <p><i>(c) Renewable resources should be exploited on a profit-optimizing, sustained-yield, and fully sustainable basis.</i></p>	<p>The scale (number of instances x environmental impact) of a process should be limited to a level which, if not optimal, is at least within the carrying capacity of the local environment (including its related processes), and therefore sustainable.</p> <p>Processes need to be optimized with regard to their environmental efficiency as opposed to their throughputs; increased levels of environmental efficiency lower both inputs and outputs of a given process.</p> <p>Process change should attempt to maximize resource efficiency over throughput maximization.</p> <p>Process change should attempt to maximize the exploitation of renewable resources.</p>

Conceptual Model

Functional affordances of information systems depend on the use context (Leonardi 2011). Therefore, the material properties of information systems from which these affordances originate, must be considered in relation to the process they are used for. That is, the same material properties of information systems may offer different functional affordances in the context of different processes. Figure 1 visualizes our view of this model.

The model suggests that material properties of IS are interpreted in a specific change context (related to a process or a class of processes), thereby creating functional affordances. If these affordances are acted upon, the source function, transformation, and sink function of a process can be changed towards more environmental sustainability. The change context itself can be characterized by socio-technical factors relating to individual, structural, technological, and task elements (Bostrom and Heinen 1977).



- 1 Information systems provide functional affordances for a specific use context of sustainable change
- 2 Realization of affordance should reduce the use of renewables and non-renewables
- 3 Realization of affordance should increase process efficiency
- 4 Realization of affordance should reduce the production of wastage and emissions

Figure 1. Conceptual Model

On basis of this model, we develop the following set of propositions:

Proposition 1: *Material properties of information systems can provide functional affordances that allow incremental or radical changes towards more environmental sustainability, if interpreted in the light of a specific business process, or a class of business processes.*

Proposition 2: *In order to create environmentally sustainable processes, information systems must provide affordances which allow a transformation that exerts minimal impact on the natural environment.*

Proposition 3: *In order to change the process source function to minimize non-renewable resource consumption, information systems are required that provide affordances which allow accomplishing the same output, or an equivalent output, with lower resource consumption.*

Proposition 4: *In order to change the process sink function to minimize the output of waste and emissions, information systems are required that provide affordances which allow to accomplish the same output, or an equivalent output, with lower emissions.*

PRELIMINARY EXPLORATION OF THE PROPOSED FRAMEWORK

The above definition of a sustainable business process implies that any planned or actual transformation of a business process towards a more sustainable process must consider the input, transformation, and output functions of that process. While some processes may be changed incrementally in order to become environmentally sustainable, others will have to be changed radically. We are specifically interested in what functional affordances of IS can contribute to that effect, and to the making of a decision between incremental and radical process change for sustainability.

In a preliminary expository instantiation of our model, in this section, we provide one example of radical process change proffered by functional affordances from information systems from our study of an organizational sustainability transformation initiative (Seidel, Recker and vom Brocke 2013) and one example of another radical process change proffered by functional affordances from information systems from a case study (Bengtsson and Ågerfalk 2011, p. 107). We do this to examine and explore how (a) the material properties of information systems can be interpreted in the light of new, sustainability-related goals, and (b) how the material properties of IS impact on source function, transformation, and sink function of the affected business process.

Example 1: Technology-supported change of a sales process

In Seidel, Recker, and vom Brocke (2013), we investigated a case organization providing technology solutions and services, where sales processes have traditionally relied on resource movement to work; that is, on sales agents traveling to existing and potential clients to discuss requirements and solution offerings. Being a global service provider, the sales processes typically involve traveling using airplanes as part of the standard business process. In turn, the processes consume fossil fuel (nonrenewable stocks) whilst also producing large amounts of carbon emissions.

With new environmental objectives being defined at both a strategic (e.g., “reduce carbon emissions to their year-2000 level by 2020”) and operational level (“reduce corporate air travel for internal meetings in areas in the US and Australia”), two fundamental change proposals can be considered:

- 1) The process may retain its general design, but the means of travel become environmentally more sustainable. This could be achieved by choosing aircraft carriers with an improved carbon footprint or by leasing corporate cars fueled by hybrid or other eco-friendly technology. In our model, the changes to the process would manifest with regard to the source and the sink side. In our view, this change would be characterized by an incremental change, as the fundamentals of the process, that is, the transformation component (i.e., traveling to the customer), remains unchanged.
- 2) An alternative would be a radical change of the process by acting upon functional affordances of work virtualization (e.g., Bose and Luo 2011). These affordances originate in material properties of information systems that are intended to support group work, video conferencing, and file sharing. This radical change to the process, proffered by functional affordances of information systems, transforms the process in that it replaces face-to-face meetings with virtual communication. That is, the change results in a fundamentally different practice (Orlikowski 1993). As per our model, we see that as a consequence of this transformation, the source function is also transformed, as capitalizing on the functional affordances of information systems allows eliminating the use of fossil fuels by removing the physical movement of individuals and resources. The sink function, viz. the emissions caused by the consumption of fossil fuels, is altered accordingly. We also note how the new source and sink functions need to consider the resource consumption and emissions originating from the use of information systems. Table 2 summarizes our analysis of this change alternative on basis of our model.

Table 2. Radical change of sales process

Functional Affordance	Effect	Change		
		Impact on source function	Impact on transformation	Impact on sink function
Work virtualization [originating from material properties of information systems that support group work, video conferencing, file sharing]	Groupware tools offer functional affordances that allow for the virtualization of work. This enables a radical change of the sales process, as virtual meetings replace face-to-face meetings.	The elimination of travel leads to a reduction in the use of fossil fuels, that is, non-renewable resources. Inputs are now required for running an IT infrastructure.	Virtual meeting replaces face-to-face meeting.	The elimination of travel leads to a reduction of the emissions that result from burning fossil fuels. Emissions now result from IT use as opposed to, for instance, air travel.

Example 2: Change of Ordering Routines

Bengtsson and Agerfalk (2011) investigated the role of IT as a change actant in sustainability innovation at a Swedish municipality. Their study is of particular interest, as the underlying understanding of sustainability innovation (Blowfield, Visser and Livesey 2007) as “innovation explicitly directed at a sustainability goal” is congruent with our understanding of green IS innovation as the *use of information systems for the purposes of (re-) designing and implementing environmentally sustainable changes to business processes*.

Specifically, the authors investigated the role of information systems in addressing logistical issues (transport and ordering) from an environmental perspective. Prior to the sustainability initiative, there had been some agreement that logistic processes could be more efficient, both in economic and ecological terms. For instance, work-places reported that they could manage with one delivery per week, instead of multiple deliveries (which, for instance, naturally cause more carbon emissions). Besides, orders were often placed directly at the suppliers

and then directly delivered to the work-places—therefore triggering a large number of transport operations. In sum, there was little coordination of orders and a more centralized procurement was seen necessary.

The underlying rationale of the initiative was to change ordering behaviour (i.e., ordering processes), rather than logistics processes.

In order to improve the ordering processes, a centralized logistical function was implemented that was responsible for joint ordering and distribution for the different work-places. With regard to IT, (a) common ordering routines were put into place that allowed placing orders via a web-based system, phone, fax, as well as the supplier’s websites, and (b) a sustainability portal was implemented to allow for sustainability reporting and analysis, thereby supporting environmentally related decision-making. The study suggests that (1) the project led to increased awareness regarding the environmental impact of transportation, (2) that carbon emissions from internal transportation was significantly reduced (by more than 80%), and (3) that carbon emissions from external transportation was significantly decreased.

Taking the view of our model, we suggest that the above reductions of carbon emissions were due to changed operations which, in turn, were afforded by the action possibilities proffered by information systems. In line with the idea of changing ordering behaviour rather than logistics processes directly, “changes in logistics are therefore a consequence of new ordering behaviour” (Bengtsson and Ågerfalk 2011, p. 107). At least two classes of functional affordances were involved in the change: *decision support* and *joint ordering*. Table 3 provides an overview, also highlighting the impact of the change on source function, transformation, and sink function, as reported in the study.

Table 3. Incremental Change of Ordering Routines identified based on Bengtsson and Agerfalk (2011)

Functional Affordances	Effect	Change		
		Impact on source function	Impact on transformation	Impact on sink function
<p>Decision support [originating from the material properties of a sustainability portal]</p> <p>Joint ordering [originating from the material properties of a web-based ordering system and extensions to an existing ERP system]</p>	<p>Re-assessment and reflection of ordering behavior.</p> <p>Changes in ordering behavior, increased levels of communication with the central depot.</p>	<p>Not reported; however, the decrease in carbon emissions (sink function) is linked to lower levels of resource consumption on the source side.</p>	<p>Orders are handled by a centralized ordering system.</p> <p>Orders are always delivered to the municipal depot, instead of directly to individual workplaces.</p> <p>Regular reports on ordering activity based on sustainability indicators.</p>	<p>Decrease in carbon emissions from internal transportation by more than 80%.</p> <p>Decrease on carbon emission from external transportation by more than 30%.</p>

IMPLICATIONS

The exemplary application of our model has shown that the model allows the decomposition of environmental changes on a business process level with two objectives in mind, viz., *description* and *prescription*: First, the model allows the examination of a (proposed) environmental change solution with the view to characterize the extent of change (incremental or radical) and the locus of change (viz., source, transformation or sink function) to a business process. Second, the model also allows the consideration of change alternatives, for instance, by highlighting components of process change that remain unconsidered in a change proposal (such as the one in the incremental change solution proposed to the sales process above).

In summation, the two examples suggest that information systems provide action possibilities that, if enacted, lead to more sustainable business processes—in the first case a more sustainable sales process and in the second case changed ordering behaviour and changed logistics. In sum, the two cases lend some support for the propositions 1, 2, 3, and 4 in our model.

These initial explorations also suggest that our conceptualization of the transformative power of information systems in sustainability initiatives as affordances for sustainable action possibilities yields explanatory power. The identification of important functional affordances relevant to sustainability process changes (such as delocalization or decision support) will allow for the identification of sustainability-relevant classes of information systems that can provide the material properties from which such affordances emerge. Functional affordances originate from a design intention manifested in a technical object (Markus and Silver 2008). Further research will thus be necessary to investigate how relevant functional affordances can be deliberately considered in the

design of green information systems. A complementary approach could be to deliberately design information systems with specific affordances and then examine whether (a) the affordances emerge and (b) eco-positive ramifications ensue.

Our conceptualization of business process change as a composition of changes to source, transformation, and sink function also provides implications for considering IT-enabled change to business processes for reasons beyond sustainability objectives. For instance, the model allows to consider reported process changes on the basis of IT and to classify the exact locus and extent of IT-driven change. As such, this model can also be used to further theorize, analyse, as well as predict the impact of technology innovations on business processes in organizations.

LIMITATIONS

Aside from outlining the emergent model and its application potential, we also wish to draw attention to some of the limitations of this work at the time of writing. The paper describes our theorizing effort, at a stage where the theory development effort is neither fully completed nor fully evaluated. Guidelines on both theory development and evaluation (Weber 2012) were being considered in our work on this piece of research. We further look to engage in further case study research as a suitable inductive strategy for theory development.

Limitations of this paper especially include the lack of rigorous and comprehensive exploration of the emergent theory to new or existing cases on IS-enabled sustainability initiatives. One root cause for the lack of exploration is the current dearth of published cases that could form the basis of such explorations. Our own literature review of top IS journals over the period from 2008 to 2012 revealed a total of three published empirical works on green IS (and a further five conceptual papers describing frameworks and research agendas). Our strategy in overcoming this limitation was to rely on our own case research (Seidel, Recker and vom Brocke 2013). In the future, we will initiate further case study research to increase the sample of scenarios that could be analysed through our theoretical frame. We will also expand our literature review to other sources (e.g., management literature) and venues (e.g., conference proceedings).

CONCLUSIONS AND OUTLOOK

In this paper, we described our development of a conceptual framework to theorize about sustainable business process implementations. Grounded in prior work on business processes and environmental sustainability, the framework is intended to investigate how processes need to be changed in order to become environmentally sustainable, and to investigate the role of green IS innovations in this context. We grounded our definition of sustainable business processes in a general definition of environmental sustainability. This, we argue, enables us to relate the sustainability of business processes to the sustainability of the wider organizational and societal context.

The framework presented in this paper suggests that the material properties of information systems provide functional affordances for specific sustainability change contexts. At this, the emergence of the functional affordances not only depends on the material properties of information systems, but also on the characteristics of the process to be changed, including the involved individuals and organizational context. The model can thus assist in identifying how functional affordances contribute to the design of sustainable business processes. It therefore allows us to define the relationship between information systems and business process change in enabling environmental sustainability. The model allows examining different change paths and the extent of that change.

We have explored our model through applying it to two cases of IT-enabled sustainability process transformations. The results from this analysis suggest the viability of our model to describe change initiatives as well as to prescribe change alternatives based on the dimensions of change on the source, transformation, and sink function of a process.

Through the development of the framework, we have attempted to provide initial answers to the two research questions in this paper. First, our framework characterizes a sustainable business process as one that (a) consumes renewable resources within the regenerative capacity of the environment in which it is carried out and minimizes the consumption of non-renewable resources, and (b) keeps the extent of emissions and waste within the assimilative capacity of the environment in which it is carried out. Secondly, our framework suggests that green information systems can assist the creation of sustainable business processes by providing functional affordances that allow transforming business processes in a way that reduces the assimilation of emissions and waste as well as the consumption of renewable and non-renewable resources.

In moving forward, we look to apply our model in further case study research, in which we will look to review, revise, and extend the conceptualization. Selection of cases will be based on process change initiatives that involve an IT artefact and are driven by environmental objectives. On basis of these findings we will operational-

ize the model into a set of hypotheses and survey organizations that have successfully implemented sustainable business processes to gain more precise evidence about our hypotheses. Candidate organizations are, for example, those listed in sustainability indexes (<http://www.sustainability-index.com/>). On the basis of this mixed-method research, we hope to contribute substantially to theorizing around sustainability transformations and the role of information systems within these endeavours (Melville 2010; Watson, Boudreau and Chen 2010; Elliot 2011).

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