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Environmental Sustainability 2.0: Empirical Analysis of Environmental ERP Implementation

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Abstract
We examined the implementation of a new and rapidly emerging class of enterprise software system for managing environmental resources such as energy and carbon emissions. Analysis of the implementation of an environmental enterprise resource planning (ERP) system at a leading global software and technology services company, SunGard Data Systems Inc., yielded three primary findings. First, we found that adoption of environmental ERP supported implementation of the corporate environmental sustainability strategy, and at the same time, may transform that very strategy. Second, we uncovered unique data sharing hurdles originating in the upstream energy information value chain. Finally, we identified the role of private equity as one important stakeholder that influences environmental ERP adoption. Overall, our analysis revealed that well-established IS phenomena have unique underlying mechanisms in the environmental sustainability context, inform understanding of cause and effect, and may ultimately enhance managerial practice and inform theoretical understanding.

Index Terms: carbon emissions, corporate sustainability report, eERP, energy informatics, energy management, environmental enterprise resource planning system, environmental ERP, environmental sustainability, ERP, green IS, green IT, greenhouse gas emissions, implementation, private equity.

[1] We thank SunGard Data Systems and Hara for generously granting us access during data gathering phases.

Going forward, when a CEO is asked, "well didn't you know that your company has this big of a carbon footprint or this much waste," I think CEOs will be expected to know that. The answer "we don't measure it, we don't know," that's just not going to be acceptable anymore.[2]

1. INTRODUCTION

Business leaders are adopting environmental sustainability strategies to mitigate risk and develop new sources of value, spurred by investors, customers, and supply chain partners. For example, Coca-Cola Enterprises set a target of a 15% reduction in its carbon footprint by the year 2020 [68], while Owens Corning set an energy-intensity reduction goal of 25% against its 2002 baseline [7]. Environmental sustainability is strategic and receives board-level attention in many firms, such as Clorox: "Sustainability is a business imperative that helps us identify product improvements, cost-saving initiatives and innovation opportunities…We also include it in our corporate scorecard, which is reported to senior management and the board of directors." [81, p. 1]. Such attention appears fiscally prudent, given a near 100% projected increase in the real price of oil by 2021 [11], and U.S. energy efficiency potential valued in excess of $1.2 trillion [29].

Accurate and reliable data are a necessary foundation of effective corporate sustainability initiatives and valid corporate sustainability reports [32]. However, spreadsheets – with inherent limitations of workflow management, data integration, data sharing, and auditing – are still widely used as environmental information systems of record for managing electricity, carbon emissions, water, and other environmental resource data [5]. As a recent Ernst & Young report described regarding the state of sustainability information systems: "Based on our survey responses, those tools remain rudimentary, even primitive, compared with those used for reporting on financial measures." [70, p. 10]

[2] Quote is from SG_VP interview (see Table 3).

The absence of effective information systems (IS) for managing increasingly costly and strategic environmental resources represents a misalignment between environmental strategy and IS strategy [57]. Misalignment inhibits achievement of sustainability objectives, negatively impacting costs and thwarting value generation opportunities, as the right information is not available to the right people at the right time [33]. As Ernst & Young concluded, poor systems lead to challenges "to find the right data, assess its credibility and determine which data [are] material for reporting purposes." [70, p. 10] From a financial perspective, inadequate environmental IS suggests that an organization "could have potentially hundreds of millions of dollars in energy spend, but they don't really even know why that is, or where it is being spent."[3]

A new class of information system has emerged to address these issues: environmental enterprise resource planning (eERP) systems. Environmental ERP systems are being rapidly adopted by firms [44] and represent a growing market that is projected to reach $5.7 billion by 2017 [59]. They are part of a broader trend toward Environmental Sustainability 2.0, which refers to digitalizing environmental sustainability processes and practices, such as online social media for employee engagement around green issues, wireless sensors for real-time energy monitoring, mobile applications for carbon footprinting, and telematics for optimizing transport [34, 48].

In some ways, the emergence of environmental ERP systems mirrors that of conventional ERP decades earlier – large firms adopting expensive software promising to enhance efficiency and effectiveness throughout the organization. The earlier wave of ERP software rollouts turned out to be much more complex and challenging to implement than anticipated, leading to notorious failures and high overall failure rates [54]. For example, Nike spent $400 million for enterprise software to upgrade its supply chain, only to see significant profit losses due to

[3] Quote is from HA_VP interview (see Table 3).

subsequent inventory problems [54]. Some of the reasons cited for high ERP failure rates include a lack of attention to business processes, insufficient executive sponsorship, poor project management, user issues, excessive customization, lack of business input, and poor attention to data reliability and accuracy [26].

In addition to these challenges, environmental ERP adds new dimensions of complexity, including new data types, new sources of data, and new stakeholders. Thus, it seems possible that environmental ERP could be equally or more challenging to implement successfully than conventional ERP. The result could be similar failure rates, which would hinder the achievement of greenhouse gas reductions, create financial losses, and hamper attempts to address climate change. As emphasized in prior research, IS scholars have a responsibility to examine questions that help to mitigate such problems: "In the area of IS, academic social responsibility means developing a stream of research on how IS can reduce emissions and increase resource usage efficiency" [77, p. 35]. We thus ask the following research question: *What phenomena shape successful implementation of environmental ERP and the attainment of corporate sustainability objectives?*

Given the lack of prior research, we conduct a revelatory case study of environmental ERP implementation at SunGard Data Systems, a leading *Fortune 500* software and technology services company. We focus on the IT services industry as this industry, more than any other, drives the digital age, and in so doing uses a significant amount of energy to power data centers. We also expect that as an IT services firm, SunGard is likely to have well-developed capabilities to implement new types of information systems internally, thereby providing insights into leading-edge practices. Finally, focusing on a single organization enables us to explore underlying patterns and causal mechanisms within the emergent domain of Sustainability 2.0. To

emphasize, our objective is not to develop and test hypotheses, rather, to identify new phenomena, develop new insights, and suggest new causal mechanisms to enhance management practice and support future theorizing.

Our study makes three primary contributions to the literature. First, examining SunGard's implementation of environmental ERP revealed several underlying phenomena that shape successful implementation and corporate sustainability performance, including the role of environmental ERP as an enabler of sustainability strategy and its potential to transform that very strategy; the presence of unique data challenges in the upstream energy information value chain; and the role of external stakeholders such as private equity firms in acting as sustainability knowledge networks and in so doing influencing and enhancing environmental ERP adoption. These insights have important implications for senior executive decision making, environmental data standards setting, and public policy. For example, environmental ERP may play an important role in self-regulation in the presence of asymmetric information and externalities [37]. Second, identification of new causal mechanisms, such as the role of environmental ERP in shaping organizational sustainability culture, provides rich opportunities for future theorizing and empirical analysis, thereby informing IS scholarship. Third, our analysis provides new insights into well-established IS phenomena (automation to transformation, framing folly of IS as tool, collaborative innovation) within the environmental sustainability context, thereby building on what we know. This is not "old wine in new bottles," as we demonstrate below.

The plan of the paper is as follows. In the next section we provide background to the research objective, including relevant literature on environmental sustainability and enterprise resource planning systems. We then describe our research methodology, including the research setting, research approach, data collection, and data analysis. Next we discuss our three research findings.

We end with a synthesis of the implications of our research study for management practice, limitations of our analysis, suggestions for future research, and concluding thoughts.

2. BACKGROUND

2.1. Information Systems and Environmental Sustainability

There is a rich tradition of research examining issues at the nexus of business and the natural environment [8], and IS scholars have begun to build on this tradition. Early IS research examined the role of information systems used in specific application contexts, such as how interorganizational information systems enhance life-cycle analysis and improve environmental performance within transportation supply chains [66, 67]. More recently, researchers have begun to synthesize what is known, develop integrative frameworks, and craft research propositions to guide future studies [22, 24, 36, 50], such as in the area of energy informatics [77]. The salience of environmental ERP has also been noted [14]. Researchers have also begun to conduct empirical analyses examining the role of information systems in reducing energy intensity [15, 17]. In summary, the research is emergent (Appendix A), and our systematic review of the literature revealed no scholarly studies of environmental ERP system implementation on which to build [cf. 44]. We thus turn to the literature on conventional ERP to understand what is known for this related system type.

2.2 Conventional Enterprise Resource Planning (ERP) Systems

ERP systems have been defined as "large, complex software packages that provide an integrated real-time environment based on an enterprise-wide data model with a set of software applications that allow processing of the core transactional data of the organization" [69, p. 213]. ERP systems have been widely adopted by large organizations, for example, to enable systematic

management of accounts payable and receivable and real-time cost data. Environmental ERP systems share key characteristics of conventional ERP systems, notably, in providing a single system of record combining and standardizing environmental data for analysis and report generation, such as energy usage, water consumption, and recycling tonnage.

Reviews of the ERP scholarly research indicate that researchers have focused on different research topics, including selection and adoption, implementation, assimilation, and markets for ERP (Table 1). In the area of implementation, which is the focus of our analysis and which has been widely studied, researchers have examined critical success factors, change management issues, stages of implementation, the role of national culture, selection criteria, risks, and business strategy.

Table 1: Reviews of the ERP Literature

	Identified Research Topics	**Implementation Sub-topics**
Addo-Tenkorang and Helo [2]	**Implementation**, exploration, extension, value, trends, education.	• Change management • Critical success factors • Cultural issues across nations • Focused stage
Aloini et al. [3]	Selection, **implementation**, risk management, IT/ERP project.	• Critical success factors • Design of structured implementation procedures and techniques • Resolving actions of a particular critical success factors
Moon [52]	**Implementation**, using ERP, extension, value, trends and perspectives, education.	• Change management • Critical success factors • Focused stages • General • National cultural issues
Schlichter and Kraemmergaard [63]	**Implementation**, optimization, management and ERP issues, the ERP tool, ERP and supply chain management, studying ERP, ERP and education, the ERP market and industry, other.	• Business process reengineering and ERP • Challenges at different phases • Critical success factors • Fit of ERP with business strategy • Selection criteria • Type of implementation approach
Xu et al. [79]	Selection and adoption, **implementation**, post-implementation, integration, other.	• Challenges and obstacles • Cross-functional teams • Deep understanding of key issues • Previous organizational experience • Public, SME, multinational culture • Risks: top-down, consultant driven, IT department driven • Role of business strategy, software configuration, technical platform, and management execution

It is not clear how findings about conventional ERP might apply to environmental ERP. For example, an organizational culture emphasizing environmental sustainability may shape the adoption and assimilation of environmental ERP – a different mechanism compared with conventional ERP. Though culture has been studied in conventional ERP, the focus has been on national culture rather than organizational culture [52]. Moreover, there may be new phenomena present in the new context. For example, data used for conventional ERP typically derive from internal sources, whereas environmental ERP requires data from external sources such as utilities, government agencies, and building owners. Another example is imitative forces, which may have new underlying causal mechanisms in environmental ERP due to the potential for greenwashing. For example, firms may imitate other firms that appear to be sustainability leaders in environmental ERP adoption to gain perceived value from key stakeholders. In this case, the actual usage of the system matters far less to the firm than the mere fact that it has adopted environmental software used by environmental leaders, which extends prior research examining institutional adoption factors [1]. Other areas that may give rise to new phenomena include the role of the chief information officer and the role of regulation, neither of which have been widely studied for conventional ERP, but which are likely to be important in the environmental ERP context.

In summary, it is not clear whether existing knowledge on conventional ERP apply to environmental ERP, given their inherent differences. Moreover, it is not clear what new phenomena may exist for environmental ERP systems, given the distinctive nature of environmental sustainability. This latter point is particularly important, given that we are interested in examining new organizational phenomena arising from the introduction and use of an environmental ERP. As Lee [42, p. vii] emphasizes, our focus is on: "the lessons that emerge

in the interactive system effects between the technological and the organizational, where these lessons pertain to the management of information technology and the uses of information technology for managerial and organizational purposes." The lessons for environmental ERP may be different than those for conventional ERP, and exploring this question is a key motivator for this study.

3. RESEARCH METHODOLOGY

3.1 Case Study

We chose the case study method as it enabled us to explore our research objective, which seeks to address questions of *what, how,* and *why*, focuses on a contemporary phenomenon, and does not require control of behavioral events [80]. The case study is also appropriate when few prior studies have been carried out [10]. Similar to prior IS research employing a single-case study [45, 46, 58, 75], we chose a revelatory case [62] that enabled us to explore phenomena previously inaccessible to researchers and extract insights that lay a foundation for future theory development and potentially advance management practice.

3.2 Research Setting

We used five selection criteria for our research setting, all of which were satisfied by SunGard. First, we sought to examine a firm that has developed strong capabilities in effectively managing information systems for value generation, thereby raising the chances that we will observe revelatory phenomena. Second, we sought to examine an industry in which significant energy is used for both information technology (e.g., data centers) and other business purposes. Third, we sought to examine a firm with an established culture of sustainability, given that many prior studies in environmental management and strategy have examined environmental strategy formation. Fourth, we sought a firm that is in the process of implementing an environmental ERP

system. Last, the firm must be willing to share internal data, make key personnel available for interviews, and facilitate vendor interviews.

SunGard Data Systems is one of the world's leading software and technology services companies, providing software and technology services for financial services, education, and public sector organizations, as well as disaster recovery services, managed services, information availability consulting services, and business continuity management software. In 2011, the company operated over 250 offices in 35 countries, with employees numbering 17,000 and revenues of roughly $4.5 billion (Table 2). SunGard implemented an environmental ERP system in 2011 from a leading vendor (Hara), making it an ideal research setting.

Table 2: Background on SunGard Data Systems

Lines of Business	Availability Services: IT availability and business continuity services. Financial Systems: provides mission-critical software and services to virtually every type of financial services institution. K-12: software and technology services designed to help school districts improve the efficiency of their operations and support student achievement. Public sector: help government agencies and non-profits provide more effective services to citizens and communities.
Revenue	$4.5 billion
F500 Rank	434
Employees	17,000
Customers	70+ countries, approximately 25,000 customers

All data are for fiscal year 2011.

3.3 Data Collection

Data collection was driven by a developed case protocol that included our research objective, areas of inquiry, data types, and telephone interview questions [80]. We collected data in various forms. First, we conducted two waves of in-depth interviews in 2011: one in March-May and one in October-November (Table 3). The early wave captured the early phases of implementation (organizational mapping, data integration, vendor relationship, etc.), while the latter captured later phases as the project began to shift from startup to ongoing phases. As we focused on

implementation rather than impacts, our data collection matched our research objective (no quantitative data on impacts were collected). Semi-structured interviews were conducted by the authors with various members of SunGard and the system vendor Hara, for a total of more than 50 pages of transcribed data (Table 3). Questions were open-ended and focused on three key areas: motivation for adoption, implementation issues, and impacts (Appendix B). We encouraged respondents to discuss other issues they considered relevant. Second, we collected internal documents from SunGard and Hara, such as documentation related to the vendor vetting process. Third, we collected archival data from various sources.

Table 3: Data Collection

Source	Code	WAVE 1 (March-May 2011)	WAVE 2 (October-November 2011)
SunGard Director of Sustainability	SG_DS	48 minutes – 10.5 pages	50 minutes – 12 pages
SunGard Internal IT Consultant	SG_IT	49 minutes – 6 pages	
SunGard VP Communications	SG_VP		25 minutes – 6.5 pages
SunGard Sustainability Coordinator	SG_SC		35 minutes – 9 pages
Hara VP Marketing	HA_VP	27 minutes – 7.5 pages	
Hara Professional Services	HA_PS		40 minutes – 9 pages
Non-Interview Data Collection	NID	SunGard internal documents, SunGard public interviews, Hara public documents, other stakeholder documents such as from private equity firm KKR, and white papers and other material obtained from consultants and other environmental ERP vendors.	

Note: Audio recording times rounded to nearest minute; pages are single-spaced audio transcriptions. See Appendix B for semi-structured interview questions (distributed to interviewees in advance of data collection).

3.4 Data Analysis

Our data analysis method was developed to address our research question, following an inductive approach [19, 80]. First, the lead author conducted a careful reading of all interview transcripts, interviewer notes, and other documents. This provided a high-level understanding of potential patterns and themes present in the data. Second, interview transcripts were read again carefully and coded based on emergent themes according to an inductive process. Third, text for each instance of a theme or pattern was collated and placed into a table. At the end of this process,

themes or patterns that were related were combined, and themes themselves were further refined. We used the guidelines of Maxwell [47] to minimize threats to validity including giving study participants a chance to confirm, validate, and refute study data; collecting multiple sources of data; and electronically recording interviews verbatim and having them transcribed and validated against the recording.

4. FINDINGS

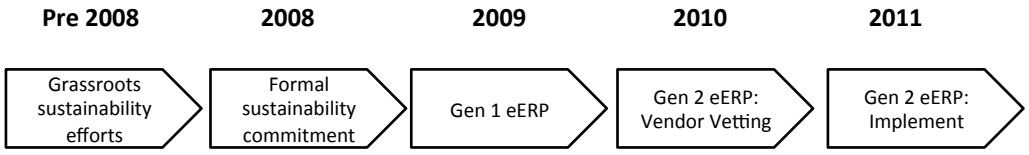
Our data collection focused on key stakeholders in the implementation process, including the Director of Sustainability, who led the implementation team; an internal IT consultant, who worked at the interface of the Hara system and SunGard's internal systems; a sustainability coordinator, who supported the Director; and the VP of Communications, to which the Director of Sustainability reported. From Hara, key stakeholders included a VP of Marketing and an IT Professional Services expert who led the implementation for Hara. Our perusal of the professional literature suggested that SunGard's environmental ERP implementation structure, driven and led by sustainability not IT, is not uncommon.

Analysis of collected qualitative data yielded insights into several socio-technical phenomena that were not expected at the outset of the case, nor are they typically included in analyses of enterprise resource planning systems: 1) environmental ERP was driven by corporate sustainability strategy and may subsequently shape that very strategy; 2) data complexities and challenges emerged from the upstream energy information value chain; and 3) private equity owners influenced sustainability knowledge development and environmental ERP system adoption. We now describe these findings in detail.

4.1 Environmental ERP as Outcome and Driver of Corporate Sustainability Strategy

A timeline of key events related to environmental sustainability and environmental ERP at SunGard is provided in Figure 1.

Figure 1: Environmental Sustainability and Environmental ERP at SunGard



Senior management recognized early on the importance of corporate environmental sustainability in the context of an energy-intensive IT services firm. As described by the SG_VP:

> *We were pretty early in the game in terms of embracing sustainability. I think we have a fairly progressive leadership team at our CEO level and also with our Chief Marketing Officer at the time. They both recognized early on that as a technology company we needed to get to the forefront of this. We knew we had a large carbon footprint with the number of servers that we host to provide client services, particularly in our Availability Services business. We have huge data centers all over the world and so we knew that was an issue, we knew there was some risk, we knew there were opportunities in terms of doing a better job with reducing waste … We looked at it from a three-pronged approach: risk, opportunity, and also doing right for the environment and the communities that we are a part of.*

Grassroots sustainability efforts in the mid-2000s eventually resulted in a formal sustainability commitment in 2008, encapsulated in the following mission statement [72, p. 1]:

> *For SunGard, sustainability is a matter of values. It is also a matter of competitiveness. Our customers and stakeholders are increasingly affected by sustainability issues such as climate change, energy efficiency and other resource constraints. We are dedicated to sustainable development as an integral part of the way we conduct business.*

The company published its first sustainability report the same year and has published annual reports since then. These grew nearly fourfold in length from 4 pages in 2008 and 2009 to 36 pages in 2010 in concert with enhanced information systems used to support environmental sustainability. Early sustainability efforts resulted in the mitigation of 20,700 metric tons of

greenhouse gasses, equivalent to $3.8 million in energy cost in 2008 and 2009 [38]. In 2008-2009, SunGard moved from spreadsheets to an early generation environmental ERP system. As SG_IT put it:

> *SunGard is a performance driven, data driven organization, hence the need for a tool to keep track of emissions which we could leverage for sustainability reporting.*

Given its growing requirements from internal and external stakeholders, as well as rapid advances in market offerings, the company subsequently chose to adopt a second generation environmental ERP with significantly expanded functionality, conducting vendor vetting and implementation in 2010-2011. SunGard chose Hara, which met its extensive selection criteria. The implementation process, as described by HA_PS, began with a mapping of the organizational structure:

> *Organizational structure is basically I think the foundation of the application. This is how we determined all the various business units, regions, buildings, offices… how are we going to track that, what is the structure looking like. Is the lowest level of granularity a facility out of Georgia for example?... So we sort of start sketching all that out because that really impacts how the data is uploaded into the system and to what level of granularity our customers can get the data out of the system.*

This phase of implementation provides a systematic process by which organizations can determine which emission sources are material – e.g., energy usage in office buildings – rather than following an ad hoc "institutional logic" [40]. Following the structural mapping process, an implementation plan was developed and then implemented by a multi-functional team comprising SunGard sustainability and information technology personnel as well as vendor support personnel.

In summary, the corporate environmental strategy at SunGard developed over a period of many years. As the strategy was refined, the need for better information and management thereof became clearer. This prompted use of an early generation environmental management system

(Gen 1), which ultimately gave way to the current environmental ERP implementation (Gen 2 – Hara). Environmental ERP adoption can thus be seen as a response to environmental strategy, i.e., the system is required for the strategy to be implemented.

Our analysis also suggests that environmental ERP can drive a feedback loop that informs and possibly reshapes strategy by enabling various environmental programs and actions that in turn open up new and potentially transformational environmental strategies. The SG_VP suggested that environmental ERP shaped environmental initiatives:

> *We need to know what we have [in terms of energy use] and that informs us as to the kind of targets that we would be able to set and the reduction programs that we would be able to launch.*

The role of environmental ERP in driving environmental initiatives was also suggested by the HA_VP:

> *Some organizations come in and they say: hey we've already established a target, either an energy reduction or sometimes a GHG reduction target that they already have and they're leveraging a solution to enable them to meet or exceed that. There are other cases where they establish a system of record and use the solution that we provide to be able to go and say OK what are the low hanging fruit that make the most sense?*

Over time, attacking the "low hanging fruit" influences organizational culture. The idea that better information shifts conversations as a prelude to changing beliefs and values of the organization was mentioned by SG_DS [9]:

> *Part of the value of sustainability is the process that you go through in implementing an enterprise-wide management system. It's the conversations that you have internally, where you're realigning processes. For us, we could highlight—with different stakeholders within the company— the importance of tracking our energy usage and having an understanding of our carbon emissions.*

One form of environmental initiative is the use of employee engagement programs, which leverage data contained in the environmental ERP system to enable dashboards, idea generation systems, communities of interest, and so forth. This vision was described by the SG_SC:

> *We've been initiating a number of programs that will help our company to gain employee engagement in sustainability. We've developed action teams and we're trying to create a*

central hub for them on our intranet and they'll be able to use social media to connect with each other, share ideas, all within the scope of what we're calling the "sustainability action network." So essentially we're in the pilot phase right now… Hara's information could help them to understand this is where my office stands, this is how I compare to other offices and hopefully motivate them to compete against each other in completing the energy efficiency project.

Once the system is implemented, new programs are put into place, which in turn may shape environmental strategy by opening up new strategic possibilities. As the SG_DS noted with regards to how the Hara system supports the strategy:

Setting a foundation for continuing to promote a culture at SunGard that understands the value and the impact of sustainability on the business was one of the goals that we articulated [for the Hara system].

Table 4: Result #1 – eERP as Outcome and Potential Driver of Sustainability Strategy

Evidence
Formal sustainability commitment – "We are dedicated to sustainable development as an integral part of the way we conduct business" – preceded first generation of eERP.
Early recognition of the need for action on sustainability before considering information systems: "We were pretty early in the game in terms of embracing sustainability."
Being a data-driven company, the sustainability emphasis led to the recognition that better information management was needed: "SunGard is a performance driven, data driven organization, hence the need for a tool to keep track of emissions which we could leverage for sustainability reporting."
Information and knowledge provided by environmental ERP informs the setting of targets and development of environmental initiatives: "We need to know what we have [in terms of energy use] and that is also informing the kind of targets that we would be able to set and the reduction programs that we would be able to launch."
Some organizations adopt Hara system to drive identification of low-cost initiatives and shape sustainability culture: "There are other cases where they establish a system of record and use the solution that we provide to be able to go and say OK what are the low hanging fruit that make the most sense?"
Environmental ERP enables employee engagement, which may shift culture and values over time: "We've developed action teams and we're trying to create a central hub for them on our intranet and they'll be able to use social media to connect with each other, share ideas, all within the scope of what we're calling the "sustainability action network."

In sum, our analysis revealed strong interconnections between environmental strategy and environmental ERP. Our data illustrated how development of a formal corporate environmental strategy at SunGard necessitated an environmental ERP system to enable that strategy. Moreover, our data suggested that in the future, initiatives enabled by the Hara system are likely to inform SunGard's environmental strategy by shaping beliefs, shifting culture, and enabling new

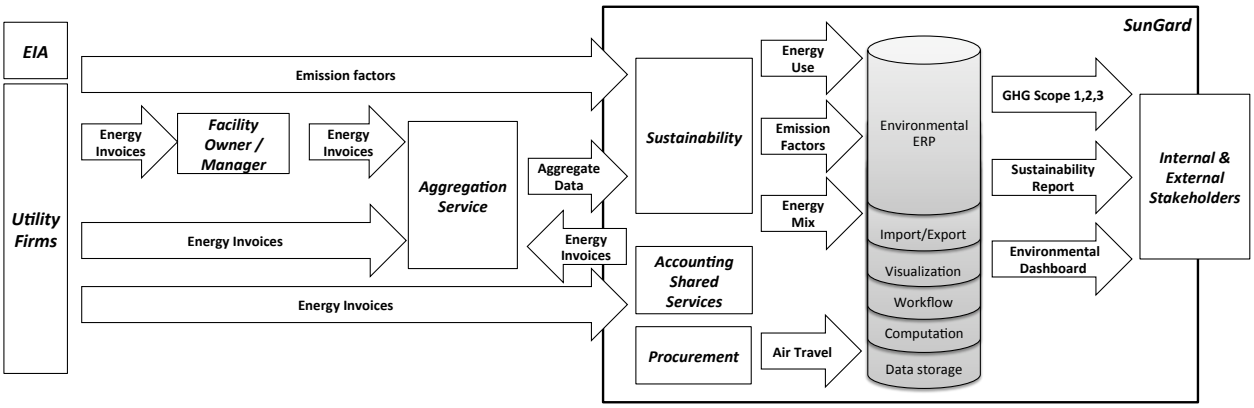
objectives. This holistic view has not been described in prior research to our knowledge concerning conventional ERP.

4.2 Unique Data Challenges in Upstream Energy Supply Chain

It was a lot harder to get the data right than I had anticipated (SG_DS).

Researchers have identified a host of implementation challenges for conventional ERP systems, such as organizational fit, skill mix, management structure and strategy, software system design, user involvement and training, and technology planning and integration [3, 71, 79]. Regarding integration, data from throughout the firm residing in various systems must be ported into a single ERP system. However, the data – e.g., employee names, addresses, and so forth as needed for a human resources module – are typically already present somewhere *within* the organization. For example, a PeopleSoft HR module may need to integrate with a legacy internal payroll application. This is not the case for environmental ERP systems (Figure 2).

Figure 2: Environmental ERP at SunGard



Energy data reside within numerous external firms, including utility companies, facility owners and managers in the case of leased space, and government agencies such as the U.S. Energy Information Administration (EIA). Utility data includes energy use for buildings and data

centers, such as electricity in kilowatt hours (kWh). Electricity generation methods vary with location (coal-fired power plant versus nuclear plant) and time (renewables such as wind and solar may be provided on a dynamic basis). Emission factors (e.g., kg CO_2 emitted per kWh of electricity consumed) may be calculated and provided by government agencies such as the U.S. Energy Information Administration[4]. They may also be calculated directly based on the specific energy mix (breakdown of fuel types such as coal, natural gas, oil, biomass, etc., used to generate electricity) employed by a particular plant.

Once the data are contained within the environmental ERP, software algorithms process it into usable information, such as greenhouse gas emissions specified by standards such as the Global Reporting Initiative (GRI). In Figure 2, GHG scope 1, 2, and 3 refer to greenhouse gas scope 1 (stationary and mobile combustion), scope 2 (purchased energy), and scope 3 (supply chain, employee travel, etc.). For example, greenhouse gas scope 2 might be computed as the product of activity data (kWh of consumed electricity), emission factor (kg CO_2 emitted per kWh of electricity consumed), and global warming potential (weighting factor to convert to baseline unit of $C0_2$).[5] For SunGard, scope 2 emissions are much larger than scope 1, and derive overwhelmingly from its Availability Services business line (Figure 3).

Gathering the required data types (activity data, emission factors, energy mix, etc.) is non-trivial, as described by the SG_DS:

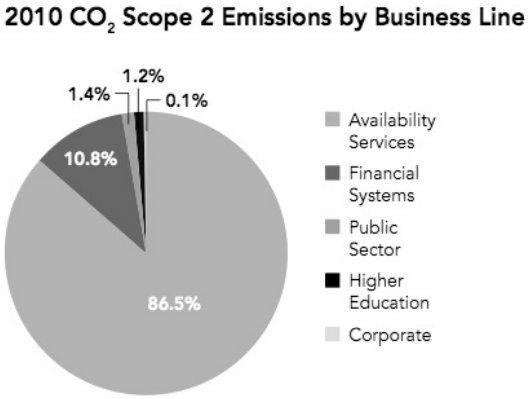
> *It is not as easy as just getting the [utility] reports and uploading them into the system. It [the system] is very particular about the data formats and there are a lot of things that are mapped together. You have the location, then the energy supplier, and then the emission factor for the supplier.*

This comment was echoed by SG_IT, who noted regarding the implementation of the Hara system that:

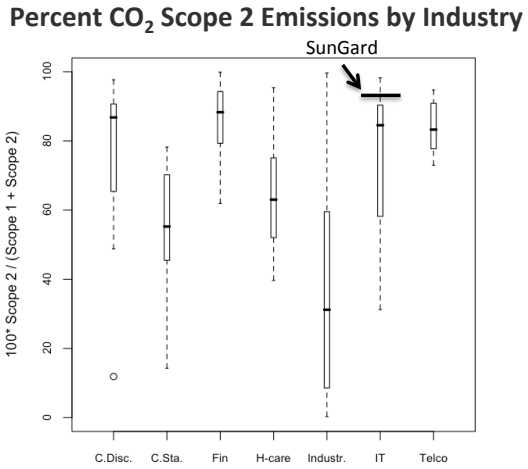
[4] See http://www.eia.gov/oiaf/1605/emission_factors.html for emission factors.
[5] See http://www.ghgprotocol.org/ for details.

The hardest thing is to get [utility companies] to provide the data.

Figure 3: SunGard Greenhouse Gas Emissions - Purchased Energy is Paramount



Note: From SunGard 2010 Sustainability Report (page 10). Figures are based on measured CO2 of 554,810 tons. Total CO2e —which includes GHG emissions other than CO2 —is 554,812.9 tons. The difference of less than 0.01 percent is *de minimis* because the vast majority of SunGard's emissions come from purchased energy and electricity.



Note: Data are from 2009 Carbon Disclosure Project respondents (excludes energy, utilities, and materials industries). See http://www.cdproject.net for details.

The challenges of global energy data collection, in particular, regarding emission factors, were further elucidated by the SG_SC:

> *In reality we have to separately enter all the data on our own and find it on our own, and Hara's been really helpful. They sent over different supplier lists with emission factors that they had from other companies. But again it's not going to cover all the suppliers that we have for all of our different facilities. Who knows, maybe that's something they can develop in the future?*

An additional challenge that global firms such as SunGard must contend with is that owners of leased spaces may not provide sufficient data visibility, as described by the SG_DS:

> *We have a [large percentage] of leased space. Typically, you don't have any visibility into your water or waste in leased spaces. This gives me another thing to go work on with my real estate team, to talk to my landlord and say look, we need to start gathering this data.*

Further complexities include the need to capture enormous volumes of data from sub-metering systems, and variation in emission factors by time of year, time of month, or even time of day. In addition, there may be poor or inconsistent data provided by utilities in global geographies. On this latter point, utility firms may provide only a hard copy in certain global localities, may provide a monthly proprietary data format without emission factors, may provide annual averages, and so forth. One implication is that large firms may receive hundreds of paper bills monthly [6]. According to the U.S. EPA [53], only 50 percent of utilities provide business customers with online bill presentment and payment, and even if they do, manual processes may still be needed to translate online information to a usable format for internal systems. Moreover, historical data prior to the current period may be unavailable. The inefficiencies of hard copies were noted by SG_DS in reference to an early approach used by SunGard to enter the data:

> *Originally SunGard rolled out a system that would have all of the facility managers enter… look at their paper copy of the invoice and enter the [kilowatt hours] and the cost. Not reliable… didn't work.*

As a software company, SunGard realized the inefficiencies inherent to manual data collection. However, many companies maintain reliance on highly manual processes: "surprising numbers of people are involved across the organization and beyond at different stages of the [carbon emission data collection] process." [35]. The monthly billing cycle may not align with a calendar month, requiring estimations to align energy use with accounting cycles. Noting the evolution from hard copies, SG_DS commented:

> *We moved to a model where it is kind of a two tier system, where we have a service that takes all the utility invoices, aggregates it all, and puts it into a database. I get a report that they generate, then we upload into Hara. So it's still two-steps, it's still manual, but it automates things way beyond where it was before. But even within this system we have in some cases the invoices actually get forwarded directly from the utility to the [aggregation] service…other parts of the business it goes to our accounting shared*

services first and then they send it on. It's taken some persistence between all these different channels just to make sure, looking back and saying OK we're four months behind where's this invoice. So just getting the data and the whole process behind that has been actually one of the biggest tasks of this whole implementation.

The utility data situation is worse in many emerging economies in which SunGard does business. For example, the challenge of global emission factors was emphasized by SG_DS:

We're getting data from our offices in Asia…While I'm able to get the name of the supplier there there's not a whole lot of data sources for what the emission factors are for the utility suppliers in India. It isn't in a library in Hara so there's legwork that has to be done there too.

In summary, the unique data challenges associated with environmental ERP relative to conventional ERP arise from the nature of the required data itself. Data are generated primarily from outside the firm, are unsystematic and often still provided in hard copy form, and vary significantly across global geographies in quality and availability. The result is a gap between expectation and reality, which may slow implementation, degrade project budgeting, and diminish information reliability and accuracy.

Table 5: Result #2 – Unique Data Challenges in Upstream Energy Supply Chain

Evidence
According to the SunGard Director of Sustainability: "It was a lot harder to get the data right than I had anticipated."
Regarding external data gathering: "The hardest thing is to get [utility companies] to provide the data."
Challenges of leased space were emphasized: "We have a [large percentage] of leased space. Typically, you don't have any visibility into your water or waste in leased spaces. This gives me another thing to go work on with my real estate team, to talk to my landlord and say look, we need to start gathering this data."
Difficulty of gathering required data from about global operations for use in GHG emission calculations: "We're getting data from our offices in Asia…While I'm able to get the name of the supplier there there's not a whole lot of data sources for what the emission factors are for the utility suppliers in India."
Challenges of highly manual process: "Originally SunGard rolled out a system that would have all of the facility managers enter… look at their paper copy of the invoice and enter the [kilowatt hours] and the cost. Not reliable… didn't work."
Overall challenge of gathering data: "So just getting the data and the whole process behind that has been actually one of the biggest tasks of this whole implementation."

4.3 Role of Private Equity in Influencing System Adoption

> *Around 2008, sustainability became a formal priority for our company. It had been a grassroots effort for a while, and one of the things that drove this was through increasing interest within some of our private equity owners. [SG_DS]*

The ERP literature has examined institutional factors such as imitation of competitors in driving system adoption. These external factors are focused on industry organizations and competitors, i.e., horizontal stakeholders. At SunGard, we observed that in addition to internal factors such as the need for improved efficiencies, the role of vertical stakeholders, in particular, private equity, was a significant driver of sustainability and environmental ERP. This extends knowledge about the external drivers of both conventional and environmental ERP.

We observed a chain of influence from private equity to environmental sustainability commitment to environmental ERP evolution. In 2008, private equity firm KKR formed a team to manage sustainability issues, which included sustainability initiatives in current investments such as SunGard [38]. The goals of the team were to prepare for regulatory changes, identify opportunities, and partner with key stakeholders. KKR's Green Portfolio Program, developed in conjunction with the Environmental Defense Fund (EDF), also emerged to advance environmental management practices at participating companies, including SunGard. The program included identification of key environmental performance areas, establishment of metrics and baselines, development of goals and action plans, and measurement and reporting of results. Collaboration, knowledge sharing, and learning among Green Portfolio Program companies provided a key impetus to SunGard's sustainability initiatives and to the adoption of environmental ERP. IT issues were initiated in 2009 with the launch of the Green Technology series (attended by IT executives across portfolio companies), which included initiatives targeting energy savings from making data centers more efficient. SunGard also participated in

the Green IT Working Group, which facilitated knowledge sharing of best practices among portfolio companies [72, p. 2]:

> *We also share best practices in energy efficiency and data center design with other companies in a Green IT Working Group facilitated by one of our private equity investors, Kohlberg Kravis Roberts & Company (KKR). In 2009, our Financial Systems business initiated a project to consolidate 25 datacenters into just five data centers, which we anticipate will result in net savings of $5 million over 5 years and a reduction in GHG emissions of nearly 1,000 metric tons yearly.*

Regarding the role of private equity at SunGard, the SG_VP described the process as follows:

> *The value that the private equity sponsors provide is that they sort of push their portfolio companies to step back and say 'hey, look, there may be some opportunities that you're not looking at and you know, here are some things that we have identified that you should look at … you may see that there may be some opportunities to reduce costs, reduce waste or to do things in the long run that will have some pretty significant return.'*

The close collaboration among portfolio companies and private equity is a key benefit, as emphasized by the SG_VP:

> *One of the things that private equity firms do well is that they facilitate a lot of knowledge transfer and best practices. I think they are uniquely positioned to do that with their portfolio companies. Again especially SunGard where we have a consortium of private equity firms that own us. Even amongst themselves they are starting to influence each other in terms of what they start to expect form portfolio companies.*

The case of KKR's Green Portfolio Program is not isolated. Other private equity firms, such as Carlyle, have launched their own green programs [25]. These firms perceive value generation and risk mitigation potential, and in so doing, develop and share best practice sustainability initiatives, including data centers and environmental ERP systems. In contrast to the situation at publicly traded firms, "Private equity is particularly well placed to act on the ESG [environmental, social, governance] agenda because of the short lines of accountability." [39, p. 1] Another reason that private equity firms may take more of an interest in sustainability issues may be less focus on quarterly returns, and more attention to a longer view of competitive

performance. KKR focuses on environmental and social governance to "minimize risk and maximize long-term value and sustainability of companies." [39, p. 2]

Beyond private equity, customers and employees are also important stakeholders in shaping the sustainability culture and driving the need for a system of record such as Hara at SunGard. This was emphasized by the SG_VP, who noted that:

> *It is really not just about having a job anymore, where your work defines you as well. So that's sort of the employee perspective. From the customer perspective we're starting to see similar things … when we pitched our customers our solutions and products they do ask us in part of the procurement process: What is your sustainability policy? What are you doing? Are you a sustainable provider? And in many cases they're going further and they are asking for actual data points and proof points that you are doing what you say you are committed to and that's why things like Hara are sort of preemptive for us in that as the trend continues we'll need to be able to, in a convincing way, demonstrate that we're doing the things that we say we are committed to doing.*

In summary, we observed that private equity exerted significant influence on corporate sustainability, and indirectly, on environmental ERP, which has not been observed in prior research of conventional ERP adoption. Private equity firms such as KKR are guiding their portfolio companies and providing knowledge sharing to further long-term financial and sustainability objectives. This was an unexpected finding and suggests potential differences in corporate sustainability practices and environmental IS adoption at privately held versus publicly held firms, as we discuss below.

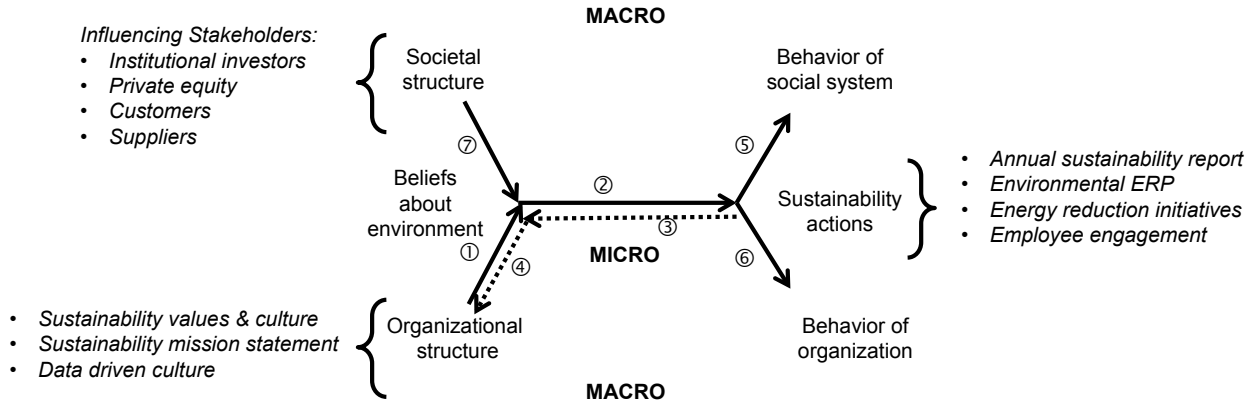
Table 6: Result #3 – Role of Private Equity in Influencing System Adoption

Evidence
Nudge provided by private equity in going from grassroots efforts to formalized mission statement: "Around 2008, sustainability became a formal priority for our company. It had been a grassroots effort for a while, and one of the things that drove this was through increasing interest within some of our private equity owners."
How private equity shapes values and actions of portfolio companies: "The value that the private equity sponsors provide is that they sort of push their portfolio companies to step back and say hey look there may be some opportunities that you're not looking at and you know, here are some things that we have identified that you should look at … you may see that there may be some opportunities to reduce costs, reduce waste or to do things in the long run that will have some pretty significant return."
Role in facilitating knowledge transfer: "One of the things that private equity firms do well is that they facilitate a lot of knowledge transfer and best practices. I think they are uniquely positioned to do that with their portfolio companies"
Green IT practices (data center efficiency) facilitated by private equity: "In 2009, our Financial Systems business initiated a project to consolidate 25 datacenters into just five data centers, which we anticipate will result in net savings of $5 million over 5 years and a reduction in GHG emissions of nearly 1,000 metric tons yearly."

5. SYNTHESIS

Our research objective was to shed light on the following research question: *What phenomena shape successful implementation of environmental ERP and the attainment of corporate sustainability objectives?* In this section we synthesize our three key findings and provide further interpretation by identifying and reframing them into three underlying mechanisms: automation to transformation, framing folly of IS as tool, and collaborative innovation. We use the belief-action-outcome (BAO) framework as a lens through which to view our findings concerning environmental ERP [50] (Figure 4).

Figure 4: Belief Action Outcome (BAO) Framework Applied to Environmental ERP



(Note: Adapted from [50])

According to the BAO framework, societal structure (cultural or normative patterns that define expectations of individuals about each other's behavior) and organizational structure (ways in which an organization divides labor into tasks and achieves coordination, including values, hierarchy, culture, etc.) shape individual beliefs about the environment. These beliefs may translate into sustainability actions, such as adoption of an environmental ERP system or social media for coordinating employee engagement programs around sustainability. Finally,

actions may translate to the behavior of the social system (functioning of society and the natural environment) and the organization (achievement of sustainability goals, financial performance, etc.). As we describe below, our case study results illustrate existing linkages in the BAO framework and introduce new linkages, thereby refining and extending its usefulness.

5.1 Automation to Transformation

Our first result sheds light on how environmental ERP systems can both result from environmental strategies (automation), and, may inform and ultimately transform them. Similar to SunGard, many firms have publicized formal environmental sustainability strategies with commitments to triple-bottom line principles (people, profits, planet)[23]. Realizing the greatly increased information requirements necessitated by these strategies, executives are rapidly adopting environmental ERP systems. If implemented and assimilated effectively, these systems will act as an enabler of environmental strategies. Providing data and information to support key performance metrics will enable validation of expected goals versus actual performance, identification of patterns, and development of insights, as done for decades in the realm of financial management. This flow is indicated by the ①➔② path in Figure 4 connecting organizational structure to beliefs about sustainability to sustainability actions.

However, these systems also have the potential to transform these very strategies by making new information available to key decision makers. Use of social media by firms to market products and services provides a useful analogy. In the early years, social media was used for external messaging about new product rollouts and other public relations activities. As social media data exploded, firms began to mine the rich treasure trove of insights using various analytic techniques such as latent semantic analysis. This transformed the very nature of "customer intimacy" by allowing social media listening systems to provide valid insights about

what consumers are thinking, saying, and feeling about their products [27]. This was previously unthinkable except in the realm of science fiction.

Analogously, as environmental ERP systems begin to process and present new forms of environmental data such as daily recycling tonnage or monthly carbon emissions due to business travel, it is not difficult to envision how innovative uses of this data might transform individual beliefs about environmental sustainability, and in the aggregate, organizational culture, such as via the use of competitions and other forms of employee engagement (Figure 4, path ③➔④). The message to organizations is that environmental ERP implementation and assimilation might be thought of in stages, beginning with efficiency of data collection and presentation processes, moving to "informatization" of natural resource data by sharing it in creative ways throughout the firm, and ending with transformation of what is possible in the realm of environmental strategy [48, 82].

The basic logic is that once firms realize what is possible (new targets, new processes, new ways of doing business), a process of transformation will occur in which environmental strategy itself will be reshaped and reformulated based on what is newly possible. This is analogous to what has happened in other industries such as retail and music. For example, digital music standards not only made music cheaper to replicate (early days of MP3 players), but ultimately transformed core business models of the industry (e.g., Apple iTunes platform). The theoretical basis can be found in Zuboff's [82] "informate," automate, transform framework (Table 6). We summarize and generalize this finding in our first proposition:

> *P1: Enterprise information systems targeted at enhancing corporate sustainability performance will proceed through stages of automation (efficiency), informatization (data sharing), and transformation (altering what is possible and creating new business models).*

Table 7: Synthesis of Results and Managerial Implications

From Automation to Transformation	Environmental ERP systems will likely progress through a common pattern followed by other information systems: automate, informate, transform [82]. Automation (current stage) is typically initiated to enable environmental strategy. However, as digitalization progresses, shared real-time environmental information used for new and creative purposes and ultimately transformation will feed back to re-shape what is possible and inform environmental strategy. Awareness of the transformative potential of environmental ERP can inform long-range planning around what is possible in the realm of energy cost savings and greenhouse gas emission reductions.
Framing Folly of IS as Tool	Unanticipated outcomes (positive and negative) abound, consistent with proper framing of environmental ERP as system not tool. One of these revolves around the need to obtain, clean, and input environmental data on energy use, water use, etc. Scenario analysis might be conducted to determine the specific challenges for a given organization (which scopes, which energy inputs, etc.). This analysis can then be used as part of the environmental ERP vendor scoping to ensure that the system is a fit for current and future information requirements.
Collaborative Innovation	Private equity firms such as KKR enable collaborative innovation by applying their developed capabilities to diffuse best practices across portfolio companies in realm of environmental sustainability. Institutional investors are also demanding better information about sustainability initiatives, processes, structures, and governance, which require advanced information systems. Both offer best practices, white papers, workshops, and other forms of knowledge sharing. Executives might determine how best to use such external sources to scale learning curves more effectively and mitigate implementation risks.

5.2 Framing Folly of IS as Tool

While transformation is possible with environmental ERP, we identified two moderating forces – one negative and one positive – that influence the extent to which firms may realize this transformative potential. First, we identified unique data challenges at the interface of utility companies and organizations. While executives may think that adopting an environmental ERP is no more difficult than any other type of IT "tool," they would be falling prey to the "framing folly of system as tool." Information systems are complex, nonlinear, dynamic systems with feedback loops; in contrast, tools exhibit linear cause-effect relationships [4, 56]. Mistaking the former for the latter has contributed to notorious IT project failures [54], and there is little evidence in the extant literature that the same mistakes will not occur again in the realm of environmental information systems. One systemic challenge is that utility companies have not uniformly advanced their information systems to provide data in standard, electronic formats to

industrial customers. The problem is compounded by variation in how and to what extent basic energy metrics are provided to utility customers across regions and nations, as well as by the problems of obtaining energy data from leased office spaces.

From a technical perspective, while adopting a cloud-based environmental ERP system may be as easy as signing up for an email account and assigning roles and responsibilities to different employees, gathering all required data inputs from external and internal sources and developing a process to automate this data gathering on a regular basis (monthly, quarterly, etc.) is complex and may require new organizational capabilities. Firms are cautioned against viewing environmental ERP as a "tool," as an unanticipated outcome may be timelines that are not met (due to unanticipated difficulty of data gathering), poor system application in the long term (due to ineffective automation and costly manual processes), and unrealized environmental sustainability objectives and energy cost savings (Figure 4, paths ⑤ and ⑥). Even SunGard, a leading software and technology services provider with well-developed data management capabilities, was not aware *ex ante* of the full scope of data gathering complexities. Scenario analysis might be employed to determine the specific challenges for a given organization, such as which greenhouse gas scopes are material, which business units have the most emissions, the sources of energy inputs, the current level of digitalization in the upstream energy supply chain, and so forth. Such an analysis might yield more accurate environmental ERP implementation plans and could also inform vendor scoping to ensure that a particular offering is a fit for current and future information requirements. We summarize and generalize this finding in our second proposition:

> *P2: Enterprise information systems targeted at enhancing corporate sustainability require new types of data, some of which remain significantly non-digitalized. This creates unique data challenges that impact the probability of success, especially when an IS is inappropriately framed as a "tool."*

5.3 Collaborative Innovation

Finally, we also identified a positive moderating factor in environmental ERP adoption and implementation. Private equity firms such as KKR are applying their developed capabilities to diffuse best practices across their portfolio companies in the realm of environmental sustainability. With formal and informal programs, these large and active investors are nudging firms to develop initiatives to reduce energy and greenhouse gas emissions and measure the impacts – both of which are difficult or impossible without the right systems in place (Figure 4, path ⑦). Beyond private equity, institutional investors are also demanding better information about sustainability initiatives, processes, structures, and governance, which again require advanced information systems to document, communicate, and validate associated information. For example, an analysis of Carbon Disclosure Project data concluded that "shareholder pressure can have an impact on disclosure." [40, p. 733]. We view these external pressures in a positive light as both private equity and large institutional investors offer best practices, white papers, workshops, and other forms of knowledge sharing. SunGard, a global IT firm with well-developed information systems capabilities, benefited from these sorts of nudges and associated knowledge sharing. Executives might determine how best to use such external sources to scale learning curves more effectively, mitigate implementation risks, and facilitate achievement of sustainability objectives. We summarize and generalize this finding in our third proposition:

> *P3: Adoption decisions about enterprise information systems targeted at enhancing corporate sustainability are influenced more than other types of IS by external stakeholders such as private equity, institutional investors, customers, and suppliers.*

6. LIMITATIONS AND EXTENSIONS

Our analysis is exploratory and revelatory rather than confirmatory. Nonetheless, the extent to which identified insights are meaningful beyond the particular situation of SunGard is a

function of our methodological choices. First, the issue of data complexity is likely to be faced by all adopters of environmental ERP, though to a lesser or greater extent depending on situational specifics. Future research might explore questions of interorganizational energy data sharing, perhaps with case studies or quantitative empirical analyses. For example, primary survey data might be used to determine the extent of data standardization, use of online bill presentment and payment, and other data issues, as well as how these issues might vary with geography, utility provider, etc. Prior research on standard setting in the PC industry [78] provides one example on which to build. Moreover, the role of recently introduced energy standards (ISO 50001) might also be explored in the context of environmental ERP. Other standards, such as extensible business reporting language (XBRL), may play a key role in integrating the energy information value chain [49]. Another potentially fruitful area of future research is the role that reporting standards such as the Carbon Disclosure Project and the Global Reporting Initiative play in fostering data standardization and hence reducing costs for adopters. Will such standards accelerate adoption of environmental ERP? It is also possible that environmental ERP will enhance reporting in terms of data quality and reliability [40]. Finally, self-regulation has been studied widely in environmental economics [37], and environmental ERP may enable new forms of mitigating asymmetric information by enabling open, standardized data formats. These and related questions are fruitful areas of future research.

Another approach would be to examine the energy value chain from the perspective of value networks, as has been done for financial and transactional data shared between vehicle rental trading partners [60]. Here, the value of industry collaboration might benefit all industry participants, rather than a single vendor acting as a repository of information such as emission factors. All of these approaches can inform the information systems dimension of an energy

informatics framework, which connects sensor networks, flow networks, and sensitized objects in an integrated system [76].

Regarding the role of environmental ERP in feeding back to influence and possibly transform strategy, exploration of innovation paths might identify whether certain standard modes may arise (e.g., ERP follows sustainability strategy), or whether firms may pursue different approaches depending on their own particular circumstances, i.e., mindful innovation [73]. One possibility is a dynamic path by which environmental ERP follows an inaugural sustainability policy. Over time, in a situated change model [55], the evolved use of ERP may inform and transform what is possible and lead to a new sustainability strategy. Another perspective would be to use environmental ERP as a lens through which to examine the types of green IT strategies employed by firms, including image oriented, eco-efficiency, eco-equity, and eco-effectiveness [36].

The ability of environmental ERP to influence organizational culture is another interesting area of possible future research. Research at the nexus of IT and culture demonstrates that IT can indeed influence culture. For example, implementation of a workflow management system enhanced a culture of customer intimacy [21]. Another example is the use of electronic communication within a joint venture project team, which narrowed cultural differences over time [12]. A review of the literature concludes that: "IT has the potential for use in organizational culture reengineering efforts. This may be particularly true with such large-scale IT projects as ERP systems that impose their own logic on organizational structures and business processes." [43, p. 370]. Given the salience of environmental sustainability initiatives, analysis of the role of environmental ERP in transforming sustainability strategy, perhaps in conjunction with collaborative information systems such as social media, is a fruitful area of future research.

New modes of collaborative innovation around environmental sustainability might be explored with respect to our third finding concerning the role of private equity. For example, how is the tension between collaboration versus competition resolved among groups of organizations in the realm of sustainability? KKR's Green Portfolio has made a significant impact on how SunGard views sustainability, how they learn about what works and what doesn't, and how they are able to set meaningful objectives. In the aggregate, this raises questions about the environmental sustainability performance of publicly traded versus privately traded firms. On the one hand, there is some evidence that publicly traded firms do better. In a study of environmental management systems (management processes and policies for reducing environmental impacts) researchers found that publicly traded facilities enjoyed lower adoption costs relative to privately owned enterprises and government facilities, suggesting that differences in capabilities might play a role [18]. By contrast, our case data suggest that privately owned enterprises might enjoy lower costs of implementing environmental ERP (and higher benefits), given the knowledge sharing role played by private equity. This is an empirical question that is a fruitful area of future research.

Finally, though the present analysis focused on implementation, future studies might focus on different phenomena represented in the BAO framework (Figure 4). For example, new adoption antecedents may be present, such as managerial incentives or environmental regulations. Future research may examine these issues, for example, by examining eERP adoption across different regulatory regimes. Another area would be examining the value implications of environmental ERP adoption, from either a financial or sustainability perspective (or both). The concept of ethical information systems might be expanded to include environmental goals. Prior research

emphasizes the importance of "fundamental human issues" in the development of information systems [13]. Might ecological sustainability be placed alongside such concepts as fairness and justice as ultimate goals of all information systems? Theory perspectives that may shed further light on issues related to environmental ERP include institutional theory [20], the natural resource-based view of the firm [30], organizing visions [74], and evolutionary economics [28].

7. CONCLUSION

Automation and transformation of financial markets in the 1970s and 1980s produced sweeping changes that heralded a new era of financial market innovation. IS scholars documented these changes, such as the London Stock Exchange Big Bang on October 27, 1986 [16], which formed the foundation of a rich literature bridging finance and information systems. A similar wave of innovation is now occurring in the realm of natural resources, which we refer to as Sustainability 2.0. As before, IS scholars are paving the way. However, we now have decades of knowledge on which to build. If the changes in environmental sustainability are anything like those that occurred in previous decades in finance – and they are likely to be even more transformational – the future will look very different than the past. We as IS scholars have a responsibility to collaborate with other disciplines and adapt accumulated knowledge in our field to the new context for the betterment of society, organizations, individuals, and the natural environment. The present analysis represents a small first step towards this objective. We need much more research to yield practical *and* theory-informing insights concerning phenomena that bridge information systems, business, and the natural environment.

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Appendix A: Prior Research on IS & Environmental Sustainability

	TITLE	TOPIC	DESCRIPTION
Early Studies			
Heng and de Moor [31] *Information Systems Journal*	From Habermas's Communicative Theory to Practice on the Internet	Genetically modified food	Analyzes web-based electronic forum for online debate about genetically modified food.
Laitner [41] *Journal of Industrial Ecology*	Information Technology and U.S. Energy Consumption	Energy consumption	Technological change and growing substitution toward information likely to reduce energy intensity.
Schlumpf et al. [64] *Climatic Change*	An Information Tool for Citizens to Assess Impacts of Climate Change from a Regional Perspective	Integrated assessment	Examines a designed information system to support participatory integrated assessment.
Sen et al. [65] *Decision Support Systems*	An Organizational Decision Support System for Managing the DOE Hazardous Waste Cleanup Program	Hazardous waste	Examines a decision support system developed to support the US Department of Energy.
Shaft et al. [66] *Journal of Industrial Ecology*	A Framework for Information Systems in Life-Cycle-Oriented Environmental Management	Life cycle management	Develops a framework for the types of information systems needed to support life-cycle oriented management.
Romm [61] *Resources, Conservation, and Recycling*	The Internet and the New Energy Economy	Energy intensity, GHG	Reviews data illustrating reduced U.S. energy intensity coinciding with Internet emergence in the late 1990s.
Recent Studies			
Collard et al. [17] *Energy Economics*	Electricity Consumption and ICT in the French Service Sector	Electricity consumption	Empirical analysis suggests that impact of IT on electricity intensity depends on the type of IT.
Chen et al. [14] *Journal of Systems and Information Technology*	Information Systems and Ecological sustainability	Ecological sustainability	Conceptual model for role of IS on eco-effective practices, mediated by institutional pressure.
Cho et al. [15] *Energy Policy*	The Impact of ICT Investment and Energy Price on Industrial Electricity Demand	Electricity consumption	Empirical analysis suggests that ICT is associated with increased electricity consumption in service and most manufacturing sectors.
Elliott [24] *MIS Quarterly*	Transdisciplinary Perspectives on Environmental Sustainability	Environmental Sustainability	Conceptual model of intended impact of changed human behavior on natural environment.
El-Gayar and Fritz [22] *Communications of AIS*	Environmental Management Information Systems (EMIS) for Sustainable Development	EMIS	Framework for environmental management information systems (EMIS).
Jenkin et al. [36] *Information and Organization*	An Agenda for 'Green' Information Technology and Systems Research	Green IT	Multilevel research framework to guide future research, drawing on green information technology and systems literature, and broader management literature.
Melville [50] *MIS Quarterly*	Information Systems Innovation for Environmental Sustainability	Environmental Sustainability	Develops belief-action-outcome model (BAO) for role of IS innovation in environmental sustainability.
Molla [51] *PACIS*	Organizational Motivations for Green IT: Exploring Green IT Matrix and Motivation Models	Green IT	Proposes and explores a Green IT Matrix and Motivation classification. Tests propositions regarding institutional forces and organizational motivations for adopting Green IT.
Watson et al. [76] *MIS Quarterly Executive*	Telematics at UPS: En Route to Energy Informatics	Energy Informatics	Illustration of energy informatics framework at UPS.
Watson et al. [77] *MIS Quarterly*	Information Systems and Environmentally Sustainable Development	Energy Informatics	Develops framework for energy informatics.

Note: Table is illustrative and not intended to be comprehensive.

Appendix B: Case Data Collection Protocol

INTERVIEW WAVE 1

1. Adoption motivation

a) Describe your understanding of the motivations behind the decision to adopt and implement the system?
b) How did the decision come about? Were alternatives discussed?

2. Project planning and budgeting

a) Was there a planning process and how did it work? What were the original goals and targets (timing, benefits, costs, etc.)?
b) How was budgeting allocated?

3. Implementation

a) Who was the project lead?
b) How did current work practices change or stay the same?
c) In what ways is this innovative, i.e., is this just like other system implementations, or are there differences?

4. Impacts

a) Any surprises?
b) Appears to be meeting its objectives so far?

INTERVIEW WAVE 2

1. Implementation

a) What's the roadmap for how you expect the system to evolve over the next 18 months (and longer term)?
b) Has there been a focus on any one particular area, such as a particular GHG scope?
c) Any unexpected challenges in rollout (technical, people, process, etc.)?
d) How would you characterize the vendor relationship?
e) Who are the important stakeholders that impact the success of the rollout?
f) User feedback? Does it vary by type of user?

2. Outcomes

a) What's the impact on the system on your company's ability to:

- develop new products and services for customers
- enhance process efficiencies
- generate intangible value such as branding, employee morale, competitive differentiation, mitigate risk, culture shift, energy ISO quality certification, etc.
- improve its environmental performance, such as energy or carbon intensity (CO2/revenue).
- mobilize options to enable future value generation such as the ability to mine energy data to make better resource allocation decisions or locate facilities

b) Any unexpected outcomes (positive or negative)?
c) From a technical standpoint, how well does the system integrate with other corporate systems, for example, can data be easily moved across systems?
d) Most valuable feature(s) of the system?
e) Have any privacy or security issues arisen with the system?
f) Overall, would you say that the system is meeting expectations thus far?

3. Looking ahead

a) In hindsight, would you do anything differently regarding vendor selection, rollout, etc.
b) Any advice for other organizations who are considering adopting an energy and carbon management system?