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Sustainability – a new dimension in information systems evaluation

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Received 1 February 2008
Revised 31 March 2008,
12 January 2009
Accepted 17 January 2009

Abstract

Purpose – The purpose of this paper is to introduce sustainability as a new dimension of information systems (IS) evaluation. Customers, policymakers and business partners increasingly require the monitoring and reporting of the organisational impact on sustainability. However, traditional IS evaluation approaches are not able to capture the impact of information technology (IT)/IS on sustainability, especially in relation to social and environmental dimensions, so the authors want to stimulate discussion and research related to this area.

Design/methodology/approach – This paper is conceptual. However, it is based on the results of an existing related research project focussed on supply chain evaluation.

Findings – In order to stimulate discussion and research, the authors propose a framework that was originally developed to evaluate supply chain practices, in which IS often play a major role. The framework is built on three dimensions – economic, social and environmental – which are divided further into three sub-dimensions. It can be used as a starting point to develop a framework for sustainability-oriented IS evaluation.

Research limitations/implications – The framework was originally developed for supply chain evaluation; however, it has generic features that can be adjusted or modified in order to be applied to a whole range of IT/IS initiatives

Practical implications – Sustainability and its new dimensions create new challenges for information systems evaluation. Companies require frameworks and tools that can help them to measure and evaluate the impact of IS on sustainability. The researcher's role is to answer such needs and focus on this emerging research topic; this paper aims to stimulate such research.

Originality/value – Sustainability is a new dimension in IT/IS evaluation. Current approaches do not include all sustainability dimensions (environmental aspects are excluded, evaluation of the social impact is limited).

Keywords Benchmarking, Information systems, Supply chain management

Paper type Conceptual paper

1. Introduction

This paper discusses the emerging issue of information systems (IS) evaluation with respect to sustainability. Although the results of this paper are derived from practical examples of supply chain (SC) IS, this paper is largely theoretical and conceptual; it aims to stimulate discussion and define a research agenda for the extended information technology (IT)/IS evaluation. Thus the paper does not aim on building or testing theory; its goal is rather to initiate research in this emerging field of IT/IS evaluation. Sustainable development is a new area that has started to be incorporated into mainstream operations management, logistics and information systems. Research related to sustainability is still at an early stage but is increasing rapidly (Linton *et al.*,

This paper is based on the paper submitted by the authors for the European and Mediterranean Conference on Information Systems EMCIS 2008, 25-26 May, Al Bostan Rotana, Dubai (ISVN 978-1-902316-58-1). For more details about EMCIS, please visit at www.emcis.org

Journal of Enterprise Information Management
Vol. 22 No. 5, 2009
pp. 492-503

1741-0398
DOI 10.1108/17410390910993509

2007). However, the current level of knowledge relating to the environmental impact of e-business and information and communication technologies (ICT) is limited (Yi and Thomas, 2007). While information technology is perceived as having both negative and positive influences on the environment (European Commission, 2006c), to date there has been no need for IT/IS evaluation approaches to consider sustainability, but this is going to change. Sustainability, according to the definition of the European Commission, includes not only economic, but also social and environmental aspects (European Commission, 2007), so these issues need to be reflected when decisions on IT/IS investments are being made.

This paper uses examples of IT/IS applications dedicated to SC as a basis to discuss the emerging trend of sustainability-oriented information systems evaluation, which extends traditional IT/IS evaluation, as current methods and tools lack some sustainability dimensions – in particular the environmental impact of IT/IS is usually ignored.

One of the major focuses of sustainability is on supply chains, as transport results in negative social and environmental impacts, such as congestion, road accidents and pollution. There is pressure from individuals, organisations, and recently from governments, through regulation, to reduce the negative impact of transport. One of the enablers that could improve supply chains is IT/IS. To fulfil promises given to customers, that a company will "green" its supply chain, as well as to achieve national and EU targets to reduce CO_2 emissions, organisations implement various solutions, including IT/IS applications. This situation creates a new dimension in IT/IS investments evaluation. Such evaluations will be extended and will incorporate other impact categories beyond the traditional commercial aspects. In some countries there are already some recommendations for policy makers at the national level to extend ICT evaluation into environmental factors (Hambreaeus-Bjorling, 2006; Pamlin and Thorslund, 2004). And the academic community needs to respond to the requirements of stakeholders to provide IT/IS evaluation frameworks that consider sustainability dimensions. This paper presents an original framework for the analysis of supply chain and logistics practices. The framework is proposed as a starting point for the further development of sustainability-oriented IT/IS evaluation. In the paper, current drivers of sustainability are presented. The role of IT/IS in the supply chain and their relationships to sustainability are overviewed, followed by a presentation of the framework for SC practices evaluation that was developed during the BestLog project (BestLog, 2007). Finally, deficiencies in the current IS evaluation approaches are identified and future research directions proposed.

2. Methodology

This theoretical paper aims to discuss sustainability issues within an information systems evaluation concept. The paper does not aim to review the interdisciplinary literature related to sustainability, nor to develop or test theories. The authors want to initiate discussion on sustainability-oriented IS evaluation and overview the current trends and directions in relation to IT/IS in a supply chain context. While the paper is largely conceptual, it makes use of the results of empirical work and personal experience from the EU-financed Best Practices in Logistics (BestLog) project, in which the authors have participated since 2006. The project resulted in the creation of a generic framework for evaluating sustainable practices in supply chains. This

framework illustrates the concept of sustainability and its evaluation dimensions, which can then be assessed in terms of their relevance to IT/IS evaluation. A literature review (BestLog, 2007), analysis of published case studies (Cuthbertson and Piotrowicz, 2008), as well as the results of primary case studies were used to create the framework. Even though the framework was originally built to assess a whole range of supply chain initiatives, it can also be used as a starting point for the evaluation of IT/IS-related practices due to its generic and flexible approach. The authors believe that this paper will stimulate research related to sustainability-oriented IS evaluation answering the emerging needs of policy makers, customers and businesses. The proposed framework can be tested, further developed and adjusted to evaluate IT/IS investments and system applications to determine their overall impact on sustainability. To illustrate the emerging need for sustainability-oriented IS evaluation, the latest practitioner-oriented articles and company documents (including marketing publications) were reviewed. Some examples are presented in this paper. The limitation of the approach presented is that the paper is primarily conceptual at this stage, as the presented framework was originally developed to evaluate a wide range of SC practices, not exclusively IT/IS implementations. Thus, the framework needs further development and testing in different contexts, beyond supply chain developments.

3. Sustainability drivers and sustainable supply chain

Sustainability is one of the latest "buzzwords" among politicians and businesses. Sustainability is sometimes compared with the internet revolution, given its wide-ranging impact on businesses. Sustainability is in many cases, but not correctly, associated with the environmental aspects only, while corporate social responsibility is more often perceived as primarily social-oriented. Additional confusion is created by the various social and environmental-focused initiatives related to climate change or fair trade. For a detailed review of sustainability terms, see Glavic and Lukman (2007). Customers and policy makers require actions from businesses to include sustainability in their overall business agenda, despite a lack of common understanding on what sustainability really means. The European Union defines sustainable development as "progress that integrates immediate and longer-term needs, local and global needs, and regards social, economic and environmental needs as inseparable and interdependent components of human progress" (European Commission, 2007), clearly identifying the social, economic and environmental dimensions, which also relate to transport and logistics (European Commission, 2006a, b). To fulfil the needs of policy makers and customers, companies are trying to respond. However, it is not enough just to talk about being sustainable: companies must provide evidence, such as confirmation that they are reducing CO_2 emissions, and are participating in the "greening" of business, at the same time as being socially responsible as well as profitable. Shareholders, customers and business partners alike may demand such confirmation. Transport is one of the main areas where improvements are expected. There is a variety of potential solutions, such as car-free zones, through bio-diesels, to co-modal transport solutions. IT/IS is perceived as a vital element that will improve information sharing and coordination, and so result in supply chain improvement. At the European level, working documents list ICT as an enabler that could improve transport efficiency and effectiveness (European

Commission, 2006a, b). This new situation creates new problems concerning the evaluation of SC activities, including IT/IS solutions. A lack of commonly accepted definitions of sustainability and existing standards make it problematic to design or modify evaluation approaches to reflect the sustainability aspects. Sustainability issues cannot be captured by traditional performance measurement and evaluation methods that are focussed on organisational and economic performance (BestLog, 2007). As a result, sustainability measurement is perceived as a difficult task (Institution of Electrical Engineers, 2003), while the impact of ICT on the environment is not well understood (Pedersen *et al.*, 2005). A sustainability-oriented IS evaluation could emerge from the implementation of IT/IS in supply chains, due to the importance of information systems and their usage in supply chain, and could eventually be extended to other IT/IS investment-related decision-making processes.

Apart from the impact of implementing information systems, there is also the direct impact of IT/IS on sustainability relating to the materials used to build the hardware, energy use, toxic substances, product durability, use of renewable resources and hardware recycling (Institution of Electrical Engineers, 2003). The largest part of the energy used through an IT product's lifecycle is during its usage (Hambreaeus-Bjorling, 2006; Pedersen *et al.*, 2005). To produce a desktop computer with a 17-inch monitor, the equivalent of 260 kg of fossil fuel is required, and it uses 1.3 times more energy per year than a fridge (Williams, 2004). Moreover, when disposed into landfill, electronic equipment damages the environment. Such external environmental costs should also be considered in any assessment of IT/IS investments.

4. Sustainability and responses from the IT/IS industry

Some organisations, including major players in the IT/IS industry, have started to seriously consider sustainability issues. It is possible to see that this represents a major change in companies' approaches, as the IT industry was not perceived to be greatly aware of sustainability needs just a few years ago (Pamlin and Thorslund, 2004). This section does not aim to provide a comprehensive and structured review, but gives some selective illustrations of this increasing trend, showing that IT/IS leaders have incorporated sustainability aspects into their business. Motivations to introduce sustainability into IT/IS vary. Some initiatives have been voluntary, including using sustainability for marketing and public relations purposes, while other changes have been driven by government policy and regulations, or as a result of customer requirements. For example, environmental aspects relating to hardware recycling are regulated by the Waste Electrical and Electronic Equipment (WEEE), and Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directives, which have an impact on all electronic goods manufacturers and distributors operating within the European Union. The European Commission has defined the level of electronic goods that should be recycled (e-waste recycling). This has resulted in the creation of reverse supply chains in which computers and other hardware are collected and "de-manufactured". Hardware manufacturers have also joined the Climate Savers Computing Initiative, defining minimum percentage efficiency and "Energy Star" requirements for new computers. The initiative aims to reduce the CO_2 emission from computers by 2010, at the same time as reducing energy costs, through a 50 per cent reduction in annual computer power consumption (Climate Savers, 2007). Apart from joining this initiative, organisations such as Intel have reduced their own carbon

footprint (Intel, 2007) through other voluntary programmes. Sun promotes its solutions using a sustainable computing concept that aims to be more sustainable when compared to current client/server models (Sun, 2007). A major software provider, SAP, has introduced applications that support emission management, via emission monitoring, measurement, modelling and comparison with regulation benchmarks (SAP, 2006). Another software solution is dedicated to support environment, health and safety compliance (SAP, 2007). All these initiatives show that the sustainability agenda is moving to all businesses, including the IT/IS industry.

5. IT/IS and sustainability in supply chains

Information technology is perceived as an integral part of a supply chain (Byrd and Davidson, 2003). IT in the SC covers six main areas:

(1) strategic planning;
(2) the virtual enterprise;
(3) e-commerce;
(4) infrastructure;
(5) knowledge; and
(6) IT management and the implementation of IT in supply chain management (SCM) (Gunasekaran and Ngai, 2004a).

Vickery *et al.* (2003) categorised integrative information technologies into three groups:

(1) computerized productions systems (MRP, MRPII, ERP) that integrate manufacturing activities, especially through joint production planning, tracking, scheduling and ordering from suppliers;
(2) integrated information systems that provide the ability to transmit and share information within the organisation, both horizontally and vertically; and
(3) integrated electronic data interchange (EDI) that enables the automation of electronic documents to flow within and between organisations: these links with customers and suppliers create vertical integration.

Hilty *et al.* (2006) identified five key areas related to environmental sustainability in freight transport:

(1) SCM, which increases efficiency by applying ICT;
(2) teleshopping;
(3) virtual goods;
(4) intelligent transport systems; and
(5) production process management.

Relationships between ICT and transport and their links with sustainability are complex (Black and van Geenhuizen, 2006). There are some conclusions that ICT in isolation has a limited impact on transport. Other factors, such as energy prices and policies, could stabilise transport growth using current ICT, according to most modelling scenarios, by increasing transport intensity (Hilty *et al.*, 2006). However, other authors claim that ICT has a large potential in reducing the negative

environmental impact of transport (Pedersen *et al.*, 2005) and ICT is perceived as a tool that could change transport, by increasing its efficiency (Hambreaeus-Bjorling, 2006). Some business strategies (such as just-in-time) supported by IT/IS increase delivery distance, frequency and smaller loads (Black and van Geenhuizen, 2006), so ICT might have a net negative effect on freight transport volumes (Erdmann and Wurtenberger, 2003). On the other hand, the use of internet freight exchanges could improve vehicle fill and backloads (Davies *et al.*, 2007). These mixed arguments suggest that IT technologies used to support supply chain management can have different impacts on sustainability depending on the context and content of the IT/IS system employed, so further analysis of IT/IS impact on supply chain, and finally on sustainability, is required. In the following section, a framework that could help to assess the IT/IS impact on sustainability in supply chains is proposed as a starting point to develop sustainability-oriented IS evaluation.

6. Framework for evaluating supply chain practices

The framework, selected to illustrate the sustainability concept, is presented in this section. It was developed as part of the BestLog project (see www.bestlog.org). BestLog was initiated by the European Commission and aims to improve logistics/supply chain practice and education, as well as to reduce differences across Europe. The framework includes social, economic and environmental dimensions for evaluation. In addition to the framework a methodology was also developed to assess SC practices. The framework was created based on a review of the literature from operations management, operational research and logistics disciplines and existing literature related to supply chain measurement and evaluation (BestLog, 2007), supported by an analysis of published case studies (Cuthbertson and Piotrowicz, 2008) and two-stage fieldwork completed across Europe, covering various industries and SC areas. (Individual case studies are available on the project webpage.) The framework was designed to be as generic as possible in order to apply to a wide range of SC areas and industries. The framework is built upon three main dimensions:

(1) social;

(2) economic; and

(3) environmental.

Every dimension is divided further into three additional sub-dimensions (Figure 1).

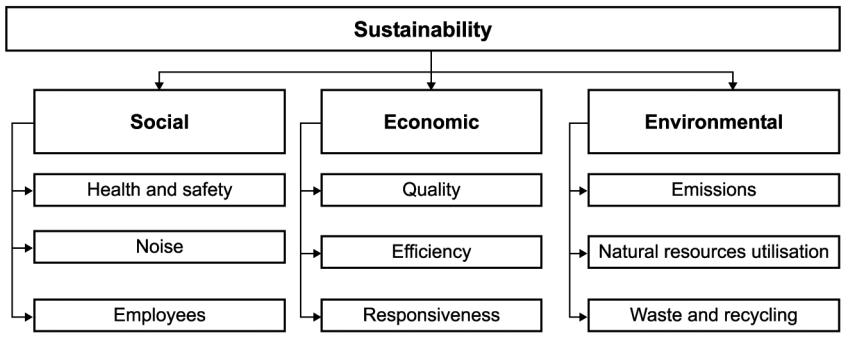

Figure 1.
Sustainability dimensions and sub-dimensions

To create a generic and flexible framework, within each dimension various metrics categories can be used to confirm the impact. As there are differences between companies located within various supply chain points and industries, the metrics used are also different. An organisation could use a variety of metrics to confirm their impacts on the dimensions and sub-dimensions (Table I).

Examples of the impacts, and their related metrics, are a combination of qualitative/quantitative (Chan *et al.*, 2003. Shepherd and Gunter, 2006) and financial/non-financial measures (Gunasekaran *et al.*, 2001, 2004b). In supply chains, the most commonly used metrics are economic, while social and environmental issues are largely ignored in SC performance measurement (Cuthbertson and Piotrowicz, 2008) and require further development and standardisation.

Any sustainability evaluation is further complicated for the IT/IS industry by the distinction between direct and indirect effects. For example, while the IT/IS sector might promote energy-efficient hardware and software solutions, the greater economic, environmental and social impacts may lie in the application of these solutions – whether positive or negative overall.

In evaluating sustainable SC practices, the authors propose to look beyond economic measures, which are grouped into three sub-categories:

(1) quality;

(2) efficiency; and

(3) responsiveness.

Social		Economic		Environmental	
Sub-dimension	Impacts (examples)	Sub-dimension	Impacts (examples)	Sub-dimension	Impacts (examples)
Health and safety	Toxic, hazardous emissions Accidents Working conditions	Quality	Quality of products and services Customer service level Availability	Emissions	CO_2 emissions Emissions of other pollutants
Employees	Employment Training Job security	Efficiency	Utilisation Productivity Cost reduction	Natural resources utilisation	Fuel consumption Water consumption Land use Energy consumption
Noise	Volume Timing and location	Responsiveness	Response to customer needs Response to market changes Flexibility	Waste and recycling	Waste reduction Percentage of materials and products recycled Bio-degradable materials used

Table I.
Examples of metrics for assessing supply chain practice impact on sustainability (BestLog Project)

The economic benefits evaluation is already well developed, so it is not explored further in this paper. The two remaining dimensions – i.e. social and environmental – are briefly discussed, focusing on IT/IS impacts.

The second dimension of evaluation relates to social aspects. This considers how the practice, such as IT/IS, impacts social issues. The social dimension includes three sub-dimensions:

(1) health and safety;

(2) employees; and

(3) noise emission.

At first glance, the relation of IT/IS systems in SC to these dimensions appears slight. However, with respect to health and safety, new automated warehouses could reduce the risk of accidents, fleet monitoring systems could increase safe driving, and the monitoring of dangerous cargo transport might reduce the rate of major incidents. On the other hand, there are emissions from IT hardware that might have a negative impact on health, or the application of some IT solutions may increase transport frequency and distance travelled by vehicles and so increase the risk of road accidents and congestion. In relation to employment, IT/IS might reduce the number of staff required, but could also provide new skills to employees, increasing their employability. Some IT/IS (such as e-procurement) might make it more difficult for SMEs to access buyers, but at the same time e-procurement increases supplier control and may help exclude companies that do not fulfil environmental or social requirements. In the case of noise emission, better delivery planning and scheduling systems might reduce noise emission when the delivery is in an urban area.

The environmental dimension is similar to the social dimension as there is the direct impact of using IT/IS, as well as the indirect effects of the IS/IT application. The direct effects include new IT hardware replacing old hardware that ends up as landfill, resulting in toxic emissions into the environment. To create and transport IT hardware, fossil fuel is used and CO_2 is emitted. When in use, IT/IS requires energy, which in the case of energy from fossil fuels will result in further CO_2 emissions. As with the social dimension, the indirect impacts can be both negative and positive. Better scheduling systems reduce the distances vehicles are required to travel, so fuel consumption can be reduced. Centralised automated warehouses might increase transport distance and associated CO_2 emissions. Automated warehousing and zero-inventory approaches, supported by IT/IS applications, could reduce requirements for land use, but also may result in the abandonment of existing warehouses that do not fulfil new technical parameters. The monitoring of CO_2 emission (and other greenhouse gases) is increasingly important as companies start to evaluate their "carbon footprint", so both the direct and indirect impacts of IT/IS should be measured. However, current IT/IS evaluation frameworks and approaches do not sufficiently cover sustainability issues, especially the environmental and social aspects. Current evaluation approaches also focus mainly on the impact within the organisation and its immediate surroundings, not on the extended external impact on society and the wider environment.

Thus, through IT/IS implementation, new social and environmental, as well as economic, impacts should be recognised. For example, additional costs related to equipment disposal and transport to "de-manufacturing" facilities might be

considered. Also, the inclusion of environmental and social costs in the total implementation might be estimated in order to determine the external cost of IT/IS implementation. There is currently a lack of integrated thinking between IT/IS usage and its impact on the environment. Even where environmental benefits occur they are not generally recognised, as current evaluation approaches were not designed to capture IT/IS impact on sustainability.

7. Conclusion: shortcomings of current IS evaluation approaches and research agenda

Although IS evaluation is already a complex issue (Irani, 2002) and companies have difficulties in determining the indirect costs of IT/IS implementation (Love *et al.*, 2006), sustainability adds even more complexity. It is possible to see from the few examples discussed in this paper that the evaluation of sustainability is not an easy task, especially in relation to IT/IS and its usage, but it may significantly change the perception of IT/IS solutions among stakeholder groups. Current IS evaluation approaches concentrate mainly on economic impacts, with some inclusion of social aspects, but mainly within the organisation. However, a truly sustainable evaluation must include an assessment of all the social and environmental impacts. While some authors, such as Yi and Thomas (2007) propose to identify e-business and ICT impacts on the environment, and related indicators, the authors stress the need for a sustainable approach that considers all three equally important dimensions: social, economic and environmental, as well as direct (within organisation) and indirect effects, beyond the boundaries of the firm (on business partners, society, and the environment). The proposed framework, developed during the BestLog project, provides a starting point to develop sustainability-oriented IT/IS evaluation that answers the needs of industry, society and policy makers. The framework was developed for supply chain evaluation rather than IT/IS evaluation, which creates shortcomings in its direct application to all scenarios. However, specific IT/IS metrics and measures to analyse their impact on sustainability should be developed during further research.

Due to the complex character of sustainability, there is a need for cooperation between IT/IS and other fields and disciplines to incorporate findings. The future IS research agenda related to sustainability should consider:

- the overall impacts of IT/IS on sustainability and how to measure this;
- the social and environmental external costs of IT/IS usage;
- the extension and modification of existing evaluation tools and methods to incorporate sustainability dimensions in IT/IS evaluation;
- the inclusion of sustainability issues within pre-investment IT/IS planning;
- the creation of guidelines and metrics that consider sustainability impact, for public procurement of IT/IS products and solutions at national, regional and global levels;
- the design of applications to monitor sustainability performance;
- the impact of IT/IS on the SC, and other industries, and the implications for sustainability;
- analysis of IT/IS infrastructure, applications design, and their usage in regards to their impact on sustainability;

- analysis of IT/IS driven business models and their impact on sustainability;
- impact of outsourcing and off shoring on sustainability;
- cooperation between business managers and policy makers regarding the requirements for assessing the social, environmental and economic impacts of IT/IS; and
- an analysis of responses to situations where existing applications currently accepted as beneficial might be perceived as negative when including sustainability issues, and the implications for business model redesign.

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