

SUSTAINABILITY - A NEW DIMENSION IN INFORMATION SYSTEMS EVALUATION

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Abstract

The paper introduces new dimensions of Information System evaluation. Sustainability issues have increasing importance and their influence is compared with the Internet revolution. Customers, policymakers and business partners increasingly require the monitoring and reporting of the impact of an organisation on sustainability. However, traditional IS evaluation approaches are not able to capture the impact of IT/IS on sustainability, especially in relation to social and environmental dimensions. In order to stimulate discussion and research, the authors propose a framework that was originally developed to focus on supply chain issues. The framework is built upon three dimensions: economic, social and environmental, which are divided further into three sub-dimensions. It was created to evaluate supply chain practices, but it can be used as a starting point to develop a framework for sustainability-oriented IS evaluation. In the paper the sustainability drivers are presented, and the problems related to IT/IS evaluation are discussed using selected examples from IT/IS applications in supply chain management. IT/IS solutions used in supply chains are perceived as having both positive and negative effects on sustainability. Moreover some business models supported by IT/IS that are perceived as positive for the supply chain processes, could be considered negative after taking into consideration their external effects on sustainability. For example Just-In-Time reduces inventory and costs, but it increases road transport and the associated CO₂ emission, as well as potentially increasing road congestion and accidents.

Sustainability and its new dimensions create new challenges for Information Systems evaluation. Companies require frameworks and tools that can help to measure and evaluate the organisational impact on sustainability, to create a sustainability-oriented IS evaluation.

Keywords: supply chain, logistics, IS evaluation, sustainability, best practice, BestLog project

1 INTRODUCTION

This paper discusses the emerging issue of Information Systems evaluation with respect to sustainability. Sustainable development is a new agenda 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.* 2007). However, the current level of knowledge relating to the environmental impact of e-business and ICT is limited (Yi, *et al.* 2007), while Information Technology is perceived as having both negative and positive influences on the environment (EC 2006c). Sustainability, according to the definition of the European Commission, includes not only economic, but also social and environmental aspects (EC 2007). This paper is using IT/IS applications dedicated to the supply chain (SC) as a basis to discuss the emerging trend of sustainability-oriented Information Systems evaluation. 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. From individuals, organisations, and recently from

governments, through regulations, there is pressure 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 CO₂ emissions, organisations implement various solutions, including IT/IS applications. This situation creates a new dimension in IT/IS investments evaluation. This evaluation is going to be extended and will incorporate other impact categories than traditionally related to business aspects. There are already some recommendations for policy makers to extend ICT evaluation into environmental factors (Hambreaeus-Bjorling 2006, Pamlin, *et al.* 2004) and the academic community need to respond to the needs of stakeholders to provide IT/IS evaluation frameworks that consider sustainability. This paper provides a framework for the analysis of supply chain and logistics practices that is proposed as a starting point for the development of sustainability-oriented IS evaluation. In the paper, current drivers of sustainability are presented. The role of IT/IS in SC 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. Shortages of current IS evaluation approaches are identified and future research directions proposed.

2 METHODOLOGY

The paper aims to discuss sustainability issues within an Information Systems evaluation concept. The framework proposed in the paper was built as part of the EU financed BestLog project. To create the framework, a literature review, analysis of existing case studies, as well as the results of 32 case studies were used. Even though the framework was built to assess supply chain initiatives it can also be used as a starting point for the evaluation of IT/IS-related practices. The framework aims to be generic and applied in various supply chain areas, it also covers an analysis of practices related to IT/IS. The authors believe that this paper will stimulate research related to sustainability-oriented IS evaluation answering emerging needs of policy makers, customers and businesses. The proposed framework could be further developed and adjusted to evaluate IT/IS investments and their impact on sustainability. To illustrate the need for sustainability-oriented IS evaluation latest articles and company documents were reviewed, some examples selected and these are presented in the paper. The limitation of the approach presented is that the framework was originally developed to evaluate a wide range of supply chain practices, not exclusively IT/IS implementations.

3 SUSTAINABILITY DRIVERS AND SUSTAINABLE SUPPLY CHAINS

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 (see also review of sustainability terms (Glavic, *et al.* 2007)). Customers and policy makers require actions from businesses to include sustainability into their overall business agenda, despite 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*” (EC 2007), clearly identifying the social, economic and environmental dimensions, which also relate to transport and logistics (EC 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 CO₂ emission, and participating in the “greening” of transport. Customers and business partners alike may demand such information. 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 (EC 2006a, b). This new situation creates new problems concerning the evaluation of supply chain activities, including IT/IS solutions. A lack of commonly accepted definition of sustainability and existing standards makes 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. As a result sustainability measurement is perceived as a difficult task (IEE 2003), while the impact of ICT on environment is not well understood (Pedersen, *et al.* 2005). A sustainability-oriented IS evaluation is likely to emerge from the implementation of IT/IS in supply chains, due to the importance of information systems and their usage in supply chain, but it is likely that this will eventually be extended to all IT/IS investments.

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 (IEE 2003). The largest part of the energy used through IT products lifecycle is during its usage (Hambreaeus-Bjorling 2006, Pedersen, *et al.* 2005). To produce a desktop computer with a 17inch monitor the equivalent of 260kg of fossil fuel is required and it uses 1.3 time more energy per year than a fridge (Williams 2004), and when disposed, electronic equipment damages the environment. Such costs should also be considered in any assessment of IT/IS investments.

Some companies from the IT/IS sector have already started to respond to new demand for sustainable business and have decided to be proactive in tackling sustainability issues. It is possible to see that this represents a major change in companies' approaches, as the IT industry was perceived to be not greatly aware of sustainability needs just a few years ago (Pamlin, *et al.* 2004).

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. This section does not aim provide a comprehensive and structured review, but gives some illustrations of this increasing trend showing that IT/IS leaders incorporated sustainability aspects into their business. Some of introduced initiatives have been voluntary, including using sustainability for marketing purposes, while other changes have been compulsorily driven by government policy and regulations. For example, environmental aspects relating to hardware recycling are regulated by the WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment) directives and impact all electronic good manufacturers and distributors operating within the European Union. The EC have defined 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 also joined the Climate Savers Computing Initiative, defining a minimum percentage efficiency and "Energy Star" requirements for new computers. The initiative aims to reduce the CO₂ emission from computers by 2010, at the same time as reducing energy costs, through a 50% reduction in annual computer power consumption (Climate Savers 2007). Apart from joining this Initiative, organisations such as Intel have also 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 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 regulations (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 supply chain (Byrd, et al. 2003). IT in supply chain covers six main areas: strategic planning, virtual enterprise, e-commerce, infrastructure, knowledge, IT management and finally the implementation of IT in Supply Chain Management (Gunasekaran, et al. 2004a). (Vickery, et al. 2003) categorised integrative information technologies into three groups:

- Computerized productions systems (MRP, MRPII, ERP) – that integrate manufacturing activities, especially through joint production planning, tracking, scheduling and ordering from suppliers.
- Integrated information systems – that provide the ability to transmit and share information within the organisation, both horizontally and vertically.
- Integrated electronic data interchange (EDI) – that allows automating 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: Supply Chain Management (SCM) that increases efficiency by applying ICT, teleshopping, virtual goods, Intelligent Transport Systems and production process management. Relationships between ICT and transport and their links with sustainability are complex (Black, *et al.* 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, *et al.* 2006), so ICT might have a net negative effect on freight transport volumes (Erdmann, *et al.* 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 presented in this section was developed as part of the BestLog - Best Practices in Logistics project (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. Work Packages 4-6 concentrate on the creation of a framework for logistic practices evaluation in accordance with EU policy. As well as the framework that includes social, economic and environmental criteria, a methodology was also developed to evaluate supply chain 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 existing case studies and two-stage fieldwork completed across Europe, covering various industries and supply chain areas (32 case studies was completed). The framework was designed to be as generic as possible in order to apply to a wide range of SC areas and industries. Presented framework was not developed to evaluate exclusively IS implementation, however among initiatives analysed were some related to IT/IS. The framework is built upon three main dimensions – social, economic and environmental. Every dimension is divided further into three additional sub-dimensions (figure 1).

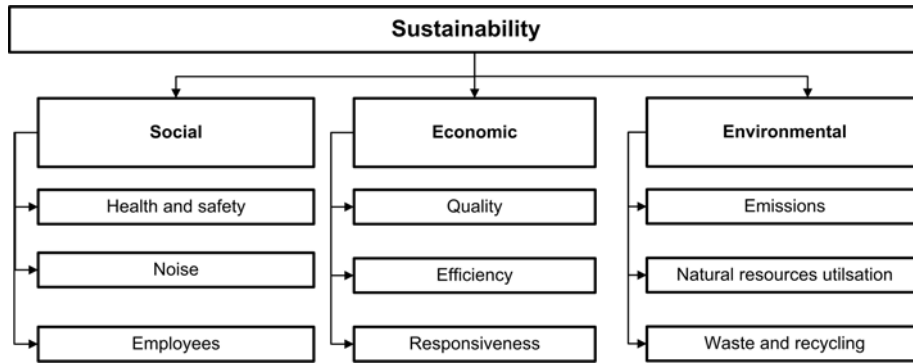


Figure 1. Sustainability dimensions and sub-dimensions

To create a generic and flexible framework, within each dimension various metrics categories can be used to confirm 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 1).

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 emission Other pollutants emissions
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	Responsive ness	Response to customer needs Response to market changes Flexibility	Waste and recycling	Waste reduction % of materials. products recycled Bio-degradable materials used

Table 1. Metrics for assessing supply chain practice impact on sustainability

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

In evaluating the SC practices, the authors propose to look beyond economic measures that are grouped into three sub-categories – quality, efficiency and responsiveness. The economic benefits evaluation is already well developed so it will not be explored further in this paper.

The second dimension of evaluation is related to social aspects. How the practice, such as IT/IS impacts social issues. The social dimension includes three sub-dimensions: health and safety, employees and noise. 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, 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 increases the risk of road accidents and congestion. In relation to employment, IT/IS might reduce number of staff required, but

could also provide new skills to employees. Some IT/IS (such as e-procurement) might make it more difficult for SME's 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 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 CO₂ emitted. When in use, IT/IS require energy, which in case of energy from the fossil fuels will result in further CO₂ emission. As with the social dimension, the indirect impacts can be both negative and positive. Better scheduling systems reduce distances vehicles are required to travel, so fuel consumption can be reduced. Centralised automated warehouses might increase transport distance and associated CO₂ emission. Automated warehousing, 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. Monitoring of CO₂ 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

7 CONCLUSION – SHORTCOMINGS OF CURRENT IS EVALUATION APPROACHES AND RESEARCH AGENDA

Although IS evaluation is already a complex issue (Irani 2002), sustainability adds even more complexity. Current IS evaluation approaches concentrate mainly on economic impacts. However, a truly sustainable evaluation must include an assessment of the social and environmental impacts. This is further complicated for the IT/IS industry by the distinction between direct and indirect effects. For example, the employment of information systems generally has a negative impact on sustainability due to its necessary use of resources, but the impact on those systems on another industry, such as case of supply chain, may have a beneficial effect on sustainability by saving resources. While the IT/IS sector might promote energy efficient hardware and software solutions, the greater environmental and social impacts may lie in the application of these solutions – whether positive or negative overall. 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 the IT/IS industry, but it will develop and may significantly change the perception of IT/IS solutions among stakeholders groups.

In detail, through IT/IS implementation new social and environmental, as well as economic, costs should be recognised. For example, addition of costs related to equipment disposal and transport to "de-manufacturing" facilities is required. Also the inclusion of environmental and social costs in the total implementation costs might be calculated in order to determine the external costs of IT/IS implementation, as there is currently a lack of integration between IT/IS usage and its impact on the environment. Even where environmental benefits occur, they are not generally recognised. While some authors, such as (Yi, *et al.* 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 dimensions: social, economic and environmental. 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 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 inclusion of sustainability issues within pre-investment IT/IS planning.
- The design of applications to monitor sustainability performance.
- The impact of IT/IS on the supply chain, and other industries, and the implications for sustainability.
- Analysis of IT/IS supported business models and their impact on sustainability
- Cooperation between business managers and policy makers regarding the requirements for assessing the social, environmental and economic impacts of IT/IS.
- 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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