THE IMPACT OF GREEN INFORMATION SYSTEMS ON SUSTAINABLE SUPPLY CHAIN AND ORGANISATIONAL PERFORMANCE

Titilayo Ogunyemi, Brunel Business School, Brunel University, Uxbridge Middlesex, UK
Titilayo.Ogunyemi@brunel.ac.uk

Emel Aktas, Brunel Business School, Brunel University, Uxbridge Middlesex, UK
Emel.Aktas@brunel.ac.uk

Abstract

This paper reports about a research in progress focusing on the impact of green information systems on sustainable supply chain performance. Green information systems, supply chains and their relation to sustainability and performance measurement are explained. The preliminary literature review resulted in a draft conceptual framework where sustainable supply chain measures focusing on economic, environmental and social aspects are combined with traditional supply chain performance measures of cost, quality, dependability, flexibility and speed. The measures for the triple bottom line of sustainability are listed as internal and external indicators. The research challenges addressed in this preliminary work comprise of integration of sustainability performance with traditional performance objectives in the supply chain, measurement of the social performance of supply chain and establishment of the relationship amongst the sustainable supply chain and performance indicators using a green information system infrastructure.

Keywords: Green Information Systems, Sustainable Supply Chain, Performance Measurement.

1 INTRODUCTION

The world is changing and only forward looking companies will stay sustainable. Others will be engulfed by businesses that enter the market with new business models. Businesses are facing tough challenges to succeed in a globally competitive market. Customer demand is changing rapidly in terms of sophistication of the products and services demanded. As a result, companies need to become more responsive to customers and market needs, with a greater number of customer specific products and/or services, with processes that are more flexible, with coordinated suppliers and resources through a number of organisations along the supply chain, whilst reducing costs. In order to respond proactively to these challenges, management requires up-to-date and accurate performance information on its business. This performance information needs to be integrated, dynamic, accessible and visible to aid timely and robust decision-making to promote a pro-active management style that would lead to agility and responsiveness (Nudurupati et al., 2011).

Sustainability has become a huge buzzword, both in today's business world and within the broader facets of society (Carter and Easton, 2011). It is necessary to implement practices that not only promote company and overall supply chain efficiency, but also that focus on social, economic, and environmental concerns. Sustainable supply chain management requires consideration of economic performance, social performance, and environmental performance. According to Carter, there are four facilitators of sustainable supply chain management:

- *Strategy:* holistically and purposefully identifying individual SSCM initiatives which align with and support the organizations' overall sustainability,

- *Risk Management:* including contingency planning for both the upstream and downstream supply chain,
- *Organizational Culture:* which is deeply engrained and encompasses organizational citizenship, and which includes high ethical standards and expectations, and
- *Transparency*: in terms of proactively engaging and communicating with key stakeholders and having traceability and visibility in supply chain operations.

These facilitators make up the four corners of sustainability, and sustainability comes from the intersection of economic performance, environmental performance and social performance, i.e. the triple bottom line of sustainability (Carter and Easton, 2011).

Today companies are constantly experiencing domestic and foreign competition, and they are seeking for robust technologies that can enable them to achieve better control over their business performance and attain cost reduction. Supply chain models have predominantly utilised two different performance measures: cost and a combination of cost and customer responsiveness. Costs may include inventory costs and operating costs. Customer responsiveness measures include lead-time, stock-out probability, and fill rate (Bititci et al., 2012). The scope of SCM has to be broadened to include environmental, social and economic aspects in order to allow sustainable design of supply chains.

There are five sections in this paper. Following this introduction the next section is a review of previous research on GIS, GSCM and SSCM. The third section discusses the research methodology. Section four presents the findings. At the end of the paper, we draw some conclusions and identify potential issues and opportunities in the area of GIS and SSCM.

2 LITERATURE REVIEW

Some literature exists about various aspects and facets of Green information systems (GIS), Green Supply Chain Management (GSCM) and Sustainability. Related reviews can be summarised as follows: information systems innovation for environmental sustainability (Melville, 2010), GIS concepts and issues for information systems research (Dedrick, 2010; Meacham et al., 2013), synthesis of GIS framework for achieving strong environmental sustainability in organisations (Howard and Lubbe, 2012), influence of green and lean upstream SCM practices on business sustainability (Azevedo et al., 2012), and towards a theory of SC alignment enablers: a systematic literature review (Wong et al., 2012).

Reviews and earlier works are limited in focus and have narrow perspective. They do not cover adequately all the aspects and facets of GIS, GSCM and sustainability. For instance, Lai et al. (2012) focus only on green supply chain management systems in the textile industry. Meacham et al. (2013) focus on impact of information sharing and green IS in relation to environmental performance only. Our objective is to present an integrated view of the published literature on most aspects and facets of GIS, sustainable SCM and performance and to suggest propositions for further development of sustainable supply chain management theory and practice. In order to meet this objective, we define few relevant terms, which have been identified in the existing literature.

2.1 Green Information Systems (GIS) Defined

Green IS refers to the development and use of information systems to support or enable environmental sustainability initiatives and, thus, tends to have an indirect and positive impact. Examples include: collaborative group software and telepresence systems to enable remote meetings and reduce the negative environmental impacts associated with travel; environmental information systems to track and monitor environmental variables such as waste, emissions, toxicity, water consumption, and carbon footprints; and supply chain systems to optimize product routing

and transportation, thus reducing the amount of energy consumed moving products (Jenkin, Webster, and McShane 2011).

According to Dedrick (2010), Green IS refers to the use of information systems to achieve environmental objectives, while Green IT emphasizes reducing the environmental impacts of IT production and use. Green information systems provide the information needed for coordinating with customers in terms of eco-design, production, packaging, transportation, recycling, disposal, and scrap ratio. Information sharing, through the use of green information systems, is a key enabler for supply chain management in terms of integration and coordination (Chandra et al., 2007).

Piotrowicz & Cuthbertson (2008) posits that current IS evaluation approaches concentrate mainly on economic impacts and there is a need to consider social and environmental impacts for a complete sustainability assessment. IS can move remote working beyond telecommuting to include systems that support collaboration, group document management, cooperative knowledge management, and so forth; track environmental information (such as toxicity, energy used, water used, etc.) about the creation of products, their components, and the fulfilment of services; monitor a firm's operational emissions and waste products to manage them more effectively; and provide information to consumers so they can make green choices more conveniently and effectively. Green IS has a greater potential than Green IT because it tackles a much larger problem. It can make entire systems more sustainable compared to reducing the energy required to operate information technologies (Boudreau et al., 2008).

2.2 Supply Chain and Sustainability Defined

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers and even customers (Chopra and Meindl, 2007).

Green supply-chain management (GSCM) is gaining increasing interest among researchers and practitioners of operations and supply-chain management. The growing importance of GSCM is driven mainly by the escalating deterioration of the environment, e.g. diminishing raw material resources, overflowing waste sites and increasing levels of pollution. However, it is not just about being environment friendly; it is about good business sense and higher profits (Srivastava, 2007).

Green supply-chain management has its roots in both environment management and supply-chain management literature. Adding the ‘green’ component to supply-chain management involves addressing the influence and relationships between supply-chain management and the natural environment. Similar to the concept of supply-chain management, the boundary of GSCM is dependent on the goal of the investigator. The definition and scope of GSCM in the literature has ranged from green purchasing to integrated green supply chains flowing from supplier to manufacturer to customer (Zhu and Sarkis, 2004).

The difference between green supply chain management and sustainable supply chain management can be identified from the definition given by various scholars. Wee, Lee, Yu, and Wang (2011) define green supply chain management as an integration of environment considerations into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers, and end-of-life management of the greening products. According to Carter and Rogers (2007) sustainable supply chain is the strategic, transparent integration and achievement of an organization’s social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains.

Sustainability is the strategic, transparent integration and achievement of an organisation's social, environmental and economic goals in the systemic coordination of key inter-organisational business

processes for improving the long-term economic performance of the individual company and its supply chains (Carter and Easton, 2011).

2.3 Supply Chain Performance explained

Neely et al. (1995) present a few of the categories of performance measurement in the literature, including: quality, time, flexibility, and cost. This categorization is a useful tool in systems analysis. For example, a model may be developed to improve one characteristic of a system, i.e. time. The model may then compare manufacturing lead-time or due-date performance by changing the system's configuration. In this way, a single type of measure has been chosen, time, but within this category, many different specific measures of time may be used. Thus, measures within a category can be compared and analysed, so that performance measure selection within a category may be easier. Although with this approach, the performance category is already determined. Holger & Klaus (2011) argue that cloud computing will act as an essential enabler for future supply chains. In order for this to happen, the information systems including cloud-based solutions should offer tangible improvements in the key supply chain performance indicators.

3 METHODOLOGY

In this working research, we employed a systematic literature review as described in Srivastava (2007). We searched Scopus, Emerald, ABI Inform and Sciencedirect using the keywords Green Information Systems, Supply Chain, Sustainability, Performance, and Information and Communication Technologies. The systematic review of the articles led to a synthesis in which the subjects could be grouped together, e.g. green information systems, sustainable supply chain management, environmental sustainability, performance etc. The criterion for a inclusion of a paper in the review was that it should have been treated in several articles either having the same characteristics or relating to a topic of discourse. The grouped subjects are illustrated in Table 1.

Subject	Databases	Articles reviewed	Keywords	Number of hits
Green IS	Scopus, Emerald, ABI Inform	7	GIS, SC, sustainability, ICT, environment	32462
Sustainable Supply Chain	Scopus, Emerald, Sciencedirect, ABI Inform	12	Sustainability, SCM, Green SC	37934
Supply Chain Performance	Scopus, Emerald, ABI Inform	10	Performance, performance improvement, KPI	125855

Table 1. Reviewed journal articles

Since this is the beginning of the research on green information systems and its relation to sustainable supply chain management, the literature review is to be developed further with a greater number of papers reviewed in the very near future. In summary, the research brings together three lines of literature; namely green information systems, supply chain sustainability and supply chain performance. The research question that is likely to follow the literature review once it is completed is: "*How can green information systems contribute to sustainability in supply chains, without compromising the performance?*" Before we set off to answer this research question, we would like to first present our preliminary findings from the systematic literature review.

4 FINDINGS

The research is mainly based on a systematic review and content analysis of a sample of related journal articles. While there have been other recent literature reviews on sustainable supply chains (Carter and Rogers, 2008; Seuring and Muller, 2008; Srivastava, 2007), this research provides a contribution by providing propositions for research based on the emergent outcome of the role of green information systems on supply chain sustainability and performance (Table 2).

Content oriented		**Methodology oriented**
SSC Challenges:	**Sustainability challenges:**	**Different approaches to analyse GIS benefits:**
Sustainability risk	Population growth	Case studies and experiments
environmental cost	Resource depletion (using up planet resources and damaging ecosystems)	Analytical methods
efficient collaboration in meeting the required sustainability standards	hidden costs of unaccountable growth and consumption	Simulations
input from suppliers	individual and organisation behaviour	Structural equation modelling

Table 2. Analysis: content and methodology oriented

As can be seen in Table 2, most of the methods used in the articles are analytical models, simulations, case studies and experiments, descriptive statistics and correlation, data analysis using covariance-based structural equation modelling methodology and case study method using structured and unstructured questionnaire. Most of the literature on sustainable supply chain focussed on environmental issues and partly on economic issues but very few papers focused on the social aspect. Likewise very few articles and literature relates green information systems, sustainable supply chain and performance together.

4.1 Conceptual Framework

The conceptual framework focuses on the key indicators for GIS, SSCM and performance. Table 3 presents the key indicators identified within the conceptual framework.

GIS	**Sustainable SC**	**Performance**
ERP	Environment	Cost
Cloud computing	Economy	Flexibility
Smart grids	Society	Time/Speed
-	-	Quality
-	-	Dependability

Table 3. Conceptual framework key indicators

The paper tries to embody green information systems in the context of the three bottom lines of sustainable supply chain and performance. In this regard, the discussion covers something wider than just an environmentally sustainable supply chain. Figure 1 presents the conceptual framework of the study.

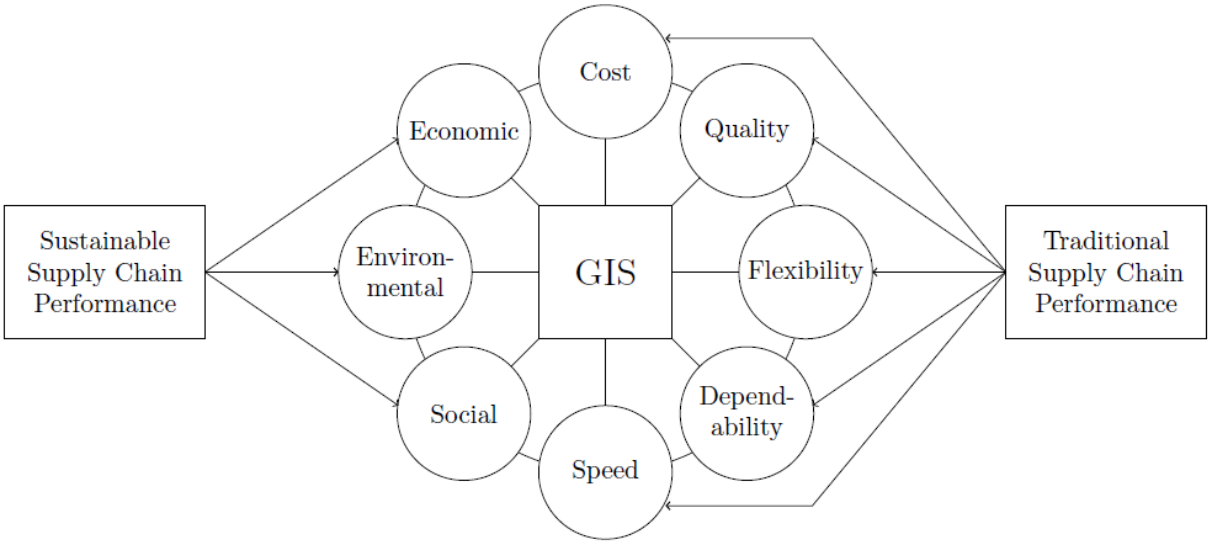

Figure 1. Conceptual Framework.

In Figure 1, Green Information Systems is at the core of supply chain performance which is analysed from two perspectives: a) sustainable supply chain performance; b) traditional supply chain performance. The literature on traditional performance objectives for the supply chain is comprised of cost, quality, flexibility, dependability and speed/time whereas the literature on sustainability integrates economic, environmental and social aspects. The measures for the triple bottom line of sustainability based on review of literature are listed below and they are categorized as internal and external indicators in line with the institutional theory:

- Internal
    - Economic performance - growth, efficiency, employment, competitiveness, choice.
- External
    - Environmental performance - waste, climate change, noise, land use, air quality, biodiversity.
    - Social performance - safety, health, access, equity.

The framework shows the interaction amongst the various key indicators and aims to evaluate how each of these indicators impact one another i.e. what impact the use of GIS have on the environmental, economic and social dimensions of sustainable supply chain, the implications of GIS on cost, quality, flexibility, dependability and speed and how these positively or negatively impact the supply chain performance.

A detail study of the relationship amongst the various key indicators is intended to be carried out later.

4.2 Research Challenges

The research intends to address the following challenges:

- Integrating sustainability performance with traditional performance objectives.

- Measuring the social performance of supply chain.
- Finding the relationship amongst the sustainable supply chain and performance indicators.

5 CONCLUSION

This paper set out to explore the role of green information systems on sustainable supply chain and performance. Based on a systematic review and content analysis of the articles we are able to report on what the relationship information systems have with sustainable supply chain and performance in the literatures reviewed. From this analysis, missing areas for the field of green information systems and sustainable supply chain management have been provided which provide guidance for further research.

Greening all parts of an organisation (both inter-organisation and intra-organisation) as well as the supply chain process will help drive the value in the company's brand, sustain the supply chain and invariably improve performance and information systems has its role to play in that. We are of the opinion that if companies establish better environmental and social practice, their ability to attract and retain customers can be improved; they would become more resource efficient and the companies can make significant cost savings throughout their operations.

In the near future, the researcher intends to carry out an extensive review of more literatures in order to assess how green information systems are used by companies to achieve sustainable development and improvement in their performance, to identify which main green information systems practices were implemented by organisations to improve sustainable development of their businesses in a balanced way, to examine how green information systems practices affect economic, social and environmental performance of business and other key performance indicators mentioned.

The focus of study will be on the comparative study of manufacturing industries specifically looking at the categories of industries already implementing green information systems practices and those that have not implemented the practice especially industries in the developing countries. The findings of the research will assist policy makers and management of industries to discover the critical factors needed in the overall success of their supply chain processes. It will also assist government in their policy-making decisions as regards the manufacturing impact on the environment and society.

References

Azevedo, S. G., Carvalho, H., Duarte, S., and Cruz-Machado, V. (2012). Influence of green and lean upstream supply chain management practices on business sustainability. *Engineering Management, IEEE Transactions on*, 59(4):753-765.

Bititci, U., Garengo, P., Dorfler, V., and Nudurupati, S. 2012. 'Performance measurement: Challenges for tomorrow*'. *International Journal of Management Reviews*, 14(3):305-327.

Boudreau, M.-C., Chen, A., and Huber, M. 2008. Green IS: Building sustainable business practices. Information Systems: A Global Text. http://www.ceport.com/files/file/Green%20IS%20CePORT%20Article.pdf Accessed on 30 July 2013.

Carter, C. R. and Easton, P. L. 2011. 'Sustainable supply chain management: Evolution and future directions'. *International Journal of Physical Distribution & Logistics Management*, 41(1):46-62.

Carter, C. R. and Rogers, D. S. 2008. 'A framework of sustainable supply chain management: Moving toward new theory'. *International Journal of Physical Distribution & Logistics Management*, 38(5):360-387.

Chandra, C., Grabis, J., and Tumanyan, A. 2007. 'Problem taxonomy: a step towards effective information sharing in supply chain management'. *International Journal of Production Research*, 45(11):2507-2544.

Chopra, S. and Meindl, P. 2007. '*Supply chain management. Strategy, planning & operation*'. Springer.

Dedrick, J. 2010. 'Green IS: concepts and issues for information systems research'. *Communications of the Association for Information Systems*, 27(1):11.

Holger, S., & Klaus, T. (2011). SCOR in the cloud – potential of cloud computing for the optimization of supply chain management systems. European and Mediterranean Conference on Information Systems 2011, Athens: 30-31 May.

Howard, G. R. and Lubbe, S. 2012. 'Synthesis of green is frameworks for achieving strong environmental sustainability in organisations'. In *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference*, pages 306-315. ACM.

Jenkin, T., Webster, J., and Mcshane., L. 2011. An agenda for 'green' information technology and systems research. *'journal of information and organization*' 21,(1):17–40

Lai, R. S., Hsu, L.-L., and Chen, J. C. 2012. 'Green supply chain management systems: A case study in the textile industry'. *Human Systems Management*, 31(2):111-121.

Meacham, J., Toms, L., Green Jr, K. W., and Bhadauria, V. S. 2013. 'Impact of information sharing and green information systems'. *Management Research Review*, 36(5):478-494.

Melville, N. P. 2010. 'Information systems innovation for environmental sustainability'. *MIS Quarterly*, 34(1):1-21.

Neely, A., Gregory, M., and Platts, K. 1995. 'Performance measurement system design: a literature review and research agenda'. *International Journal of Operations & Production Management*, 15(4):80-116.

Nudurupati, S. S., Bititci, U. S., Kumar, V., and Chan, F. T. 2011. 'State of the art literature review on performance measurement'. *Computers & Industrial Engineering*, 60(2):279-290.

Piotrowicz, W., & Cuthbertson, R. (2008). Sustainability–a new dimension in information systems evaluation. European and Mediterranean Conference on Information Systems 2008, Dubai: 25-26 May.

Seuring, S. and Muller, M. 2008. 'From a literature review to a conceptual framework for sustainable supply chain management'. *Journal of Cleaner Production*, 16(15):1699-1710.

Shields, P. and Rangarajan, N. 2013. '*A playbook for research methods: Integrating conceptual frameworks and project management skills*'. New Forums Press.

Srivastava, S. K. 2007. 'Green supply-chain management: A state-of-the-art literature review'. *International Journal of Management Reviews*, 9(1):53-80.

Wee, H., Lee, M., Yu, J. and Wang, C. 2011. 'Optimal replenishment policy for a deteriorating green product: life cycle costing analysis'. *International Journal of Production Economics,* 133(2):608-611.

Wong, C., Skipworth, H., Godsell, J., and Achimugu, N. 2012. 'Towards a theory of supply chain alignment enablers: A systematic literature review'. *Supply Chain Management: An International Journal*, 17(4):419437.

Zhu, Q. and Sarkis, J. 2004. 'Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises'. *Journal of Operations Management*, 22(3):265-289.