Investigating the relationship between green supply chain management practices and greenhouse gas emission performance

Md Mostain Belal
Ph.D. candidate at Cardiff Metropolitan University, Department of Cardiff school of management, United Kingdom

Arvind Upadhyay (a.upadhyay@brighton.ac.uk)
Senior Lecturer, Brighton Business School, University of Brighton, United Kingdom

Hector Victoria
Head of academic partnership – OTHM qualifications, United Kingdom

Mohammed Chowdhury
Ph.D. candidate at Cardiff Metropolitan University, Department of Cardiff school of management, United Kingdom

Abstract

Although the literature has predominantly investigated the relationship between green supply chain management practices (GSCMP) and overall environmental performance, research till date has rarely focused on elemental environmental performance such as air emission or greenhouse gas emission (GHGe). Additionally, the level of GSCMP varies in different industrial contexts due to different drivers and institutional pressures. The study of GSCMP in the UK chemical industry is still undiscovered. Hence, this study investigates the relationship between GSCMP and GHGe through multiple-regression. Data has been collected from 45 environmental reports and CDP reports from UK chemical companies applying quantitative content analysis.

Keywords: Green supply chain management practices, greenhouse gas, content analysis

Introduction

The industrial revolution and globalization after the 1800s, attention was drawn from agriculture system to manufacturing industries and their harmful emission (Nunes, 2011). From raw material extraction to final disposal through manufacturing, remanufacturing and recycling every step produces harmful air emission such as Greenhouse gas emission (GHGe). Carbon dioxide, methane, nitrous oxide and F-gases such as hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride are being considered as Greenhouse Gases in the Kyoto Protocol Standards (Kyoto Protocol, 1998). The effect of GHGe on the earth is appalling and numerous. Climate change is

primarily the result of GHG emission (EPA, 2009) and this human-induced GHG emission endangers the public health welfare of current and future generations (Martin, 2009).

Scientific evidence suggests that significant change in climate is predominantly as a result of human activities (IPCC, 2013b). Observations of the atmosphere, land, oceans and cryosphere are the most compelling evidence of climate change. Evidence has also shown that greenhouse gasses such as carbon dioxide, methane, and nitrous oxide have increased over the last few centuries. The ocean absorbs the emitted anthropogenic carbon dioxide, causing ocean acidification (Cubasch et al., 2013). Thus, the accumulation of greenhouse gasses in the atmosphere leads to the risk of a more than 2 degree Celsius temperature rise (IPCC, 2013b). Even if emissions of carbon dioxide are stopped today, most aspects of climate change will persist for many centuries. It shows a multi-century climate change commitment created by the past, present and future emissions of carbon dioxide (IPCC, 2013a).

It is obvious that there is an urgent need for reducing GHG emission in the atmosphere for a safer planet to live in, for the present and future. The businesses need to look at its rudimentary level of doing business and consider the environmental emission (Gupta & Palsule-Desai, 2011; IPCC, 2013b). The United Kingdom, for an example and being a study of interest, is aimed to reduce 80% of carbon dioxide emission from the base year of 1990. Even though this is very challenging and long-term commitment, the country has already started implementing new emission related legislation. This is still, however, uncertainty for the UK Government whether it will reach its target. Specifically, the UK chemical manufacturing industry is seeking alternative energy for reducing the anthropogenic emissions. The industry is concerned with stricter and tighter emission limit because of unprecedented growth in coming years. However, the mitigation option for reducing GHGe in the UK chemical business context is an ongoing complex issue to solve (Gilbert et al., 2013; CIA News, 2013).

While the contemporary business operation and supply chain activities in the process industries emit a considerable amount of GHGe (Paksoy, 2011), companies have started to redesign its supply chain considering economic and environmental balance (Amemba et al. 2013). The conventional business process, however, has been altered considerably through the initiation of innovative Green Supply Chain Management (GSCM), considering environmental protection in each node of the supply chain to gain environmental sustainability, for reducing greenhouse gas and other environmental degradation throughout the entire operation in an organizational setting.

However, the role of green supply chain management practices (GSCMPs) in inducing profitability and improving environmental performance has been investigated extensively in the literature (Jr et al., 2012; Zhu et al., 2013). The understanding of elements, barriers, drivers and opportunities of Green Supply Chain Management (GSCM) is well conceptualized in studies (Amemba et al., 2013; Dashore & Sohani, 2013). Some optimization models in literature (Paksoy et al., 2011; Mishra et al., 2012) explain how to minimize both cost and environmental impacts.

It is evidenced that different industries have implemented different green practices (GSCMPs) due to different drivers and pressures (Zhu & Sarkis, 2006). Reuse, remanufacturing and recycling practices are broadly introduced under closed loop supply chain (Quariguasi et al., 2010). On the other hand, other GSCMPs such as internal environmental management, green purchasing, investment recovery and eco-design are widely investigated in cross industries (Zhu et al., 2007).

However, literature (Montabon et al., 2007; Zhu & Sarkis, 2004; Zhu et al., 2007) has predominantly investigated the relationship between GSCM practices and overall environmental performance rather than focusing on elemental performance such as air emission or greenhouse gas (GHG) emission. Even though the study of Plambec (2012), Abdallah et al. (2012) and Zhang et al. (2012) have addressed the issue of GHG emission, they do not explain the relationship between GSCMP and GHG emission.

The issue of GHG emission, on the other hand, is being addressed continuously by companies to redesign its supply chain (Amemba et al., 2013). For instance, recent regulations on reducing GHG emissions by the UK government have become a new challenge for the UK chemical industry's (Gilbert et al., 2013) operation. Although sustainability analysis was conducted in the UK oil and gas industries (Yusuf et al., 2013) and UK wheat bio-ethanol plant, GSCM practices in the UK chemical manufacturing industries still need to be demonstrated.

Considering the theoretical gap and practical issues, this study aims to investigate the relationship between GSCMP and GHG emission performance in the UK Chemical industry. The study aims to focus on both scope one and scope two emissions in the companies. The study is aimed to achieve the following objectives:

- To develop a conceptual framework for the investigation. Prior to develop the conceptual model, it critically reviews the relevant literature on the concept of green supply chain management and environmental performance focusing on greenhouse gas emission;
- To understand the impact of a set of GSCMP and scope one GHGe;
- To understand the impact of a set of GSCMP and scope two GHGe;
- To understand the impact of a set of GSCMP and GHGe (both scope one and scope two);
- To investigate other green practices employed in the industry and
- To provide a recommendation for both practitioners and academic.

As the previous papers did not focus on scope one and scope two GHGe against a set of GSCMP, the new link is aimed to explore the relationships. It also aims to confirm the GSCMP – GHGe (scope one and scope two) link. Thus, the exploratory and confirmatory nature of the study aims to contribute to the environmental operation management. The next section presents a critical review of the existing works on GSCMP and environmental performance with a special focus on air emission performance.

Literature Review and Hypothesis development

UK Chemical Industry and emission category: Being an energy intensive industry (consumption of 22% of total UK industrial energy) and major user of raw materials, the UK Chemical Industry releases a significant amount of GHG. Under the Greenhouse Gas Protocol the total emission can be categorized into three: Scope one or direct emission: source of emission that are owned or controlled by the reporting entity such as fossil fuel combustion; Scope two or indirect emission: emissions that are the consequences of the activities of the reporting entity but occur at sources owned or controlled by another entity such as purchased electricity; and Scope three: all other indirect emissions (Plambeck, 2012; Skelton, 2013). The UK chemical supply chain is a multi-tiered complex supply chain system composed of a wide range of process and

products which are highly interlinked. Considering the major operational and process activities within the supply chains and availability of the emission data, this study focus on scope one and scope two emissions.

Theoretical underpinning of GSCMP: It is undoubtedly evidenced that GSCMP is an ecological innovation in the modern GSCM studies (Murphy & Gouldson, 2000; Zhu et al., 2011; Zhu et al., 2012; Er et al., 2012). From this point of view, GSCMP is underpinned by ecological modernization theory (EMT). The theory has encouraged both practitioners and researchers for policy making and technological innovation. Even though the initial effort for environmental protection was inspired by studying and imitating the natural eco-system (Jelinski, 1992; Erkman, 1997) to adjust it with industrial eco-system, as time goes, different environmental practices are being adopted considering different institutional drivers and pressures. Hence, GSCMP is underpinned by institutional theory. Although environmental innovations such as GSCMP are built on both EMT and institutional theories, adoption of innovations and GSCMP practices largely depend on types of industries and ecological development within different contextual pressures (Zhu & Sarkis, 2006; Zhu et al., 2013; Chiou et al., 2011).

However, this study has intended to investigate a set of GSCMP, which has become a new paradigm in the study of GSCM due to continuous validity and acceptability in different industries across different countries around the world (See Table 1). The practices are Internal Environmental Management (IEM), Green Purchasing (GP), Eco-Design (ECO) and Investment Recovery (IR).

GSCMP and environmental (emission focused) performance: Although the win-win arguments have been evidenced to justify the relationship between adoption of GSCMP and environmental performance (Jr et al., 2012; Zhu and Sarkis, 2007; Zhu et al., 2013), especially emission based performance, a case study based analysis has contextualized that even though the statistical relationship exists between GSCMP and environmental performance, the tangible and direct results are not always distinct (Zhu et al., 2007). Table 1 shows the summary of major investigations in the GSCM field.

Table 1 – Summary of major investigations in the GSCMPs and environmental performance

Authors	**GSCMP**	**Industry**	**Country**	**GSCMPs Vs environmental performance including air emission**
Zhu et al. (2013)	Internal environmental management	Manufacturing firm	China	Positive
	Green purchasing			Positive
	Eco design			Positive
	Co-operation with customers			Positive
	Investment recovery			Positive
Azevedo et al. (2012)	Environmental management system	Automobile Industry	Portuguese	Reduce CO2 emission
	Monitoring supplier's Environmental performance			Reduce CO2 emission
	Green purchasing			Reduce CO2 emission
	Using reusable packaging			Doesn't reduce

	(eco-design)			CO2 emission
Jr et al. (2012)	Co-operation with customers	Manufacturing companies	USA	Positive
	Eco-design			Positive
	Investment recovery			Positive
Laosirihongthong et al. (2013)	Green purchasing	Manufacturing firm	Thailand	Positive
	Eco-design			Not significant
	Reverse logistics			Not significant
Prajogo et al. (2012)	Internal environmental management	Firms	Australia	Positive
	External environmental management			Negative
Amit and Pratik, 2012	Internal environmental management, Green Supply, Customer cooperation, Investment recovery, Eco-design, Reverse Logistics	Pharmaceutical Industry	India	Positive
Perotti et al., 2012	Green Supply, Green building, Reverse Logistics, Customer cooperation, Investment recovery, Eco-design, Internal Management	Chemicals, Food, Pharmaceuticals	Italy	Positive

IEM and environmental performance: IEM has been sought as an effective GSCM practice since the inception of ecological practice in organizations (Giovanni, 2012**;** Zhu et al., 2013). The study of Zhu and Sarkis (2004) shows positive result against environmental performance having reduced air emission. Similar statistical evidence has been sought in other studies (Giovanni, 2012; Giovanni and Vinzi, 2012; Zhu and Sarkis, 2007; Zhu et al., 2013). The previous researcher has concluded that IEM dimension is a successful driver of TBL while an investigation was conducted among Italian firms to see the effect of IEM and environmental performance (Giovanni, 2012). Another case study based analysis has evidenced that IEM practices such as collaborative environmental management practice with first tier suppliers reduce the Co2 emission from the Portuguese automaker (Azevedo et al., 2012). A similar argument can be found in the study of Plambeck (2012). Therefore, it can be hypothesized as follows***:***

Hypothesis1. IEM practice has a positive impact on GHGe reduction in the UK chemical industry.

Hypothesis1a. IEM practice has a positive impact on scope one GHGe reduction in the UK chemical industry.

Hypothesis1b. IEM practice has a positive impact on scope two GHGe reductions in the UK chemical industry.

GP and environmental performance: Green purchasing practice is getting significant attention for improving environmental standards. The positive impact of green purchasing practice on the environmental performance including reduced air emission has been evidenced in the studies continuously (Azevedo et al., 2012; Eltayeb et al., 2011; Zhu et al., 2013). Even though very few negativity exists in the literature for

instance, study of Jr et al. (2012), majority of the studies conducted investigation related to the impact of GSCMP on environmental performance shows that GP practice significantly improves environmental performance including air emission criteria (Laosirihongthong et al., 2013; Zhu & Sarkis, 2007). A case study (Ho et al., 2010) analysis also supports environmental performance including reduced GHG emission against GP. Therefore, the aforementioned arguments lead to the following hypothesis:

Hypothesis 2: GP Practice has a positive impact on GHGe reduction in the UK Chemical Industries.

Hypothesis2a. GP practice has a positive impact on scope one GHGe reduction in the UK chemical industry.

Hypothesis2b. GP practice has a positive impact on scope two GHGe reductions in the UK chemical industry.

Eco-design and environmental performance: The urgency of implementing of Eco-design in the manufacturing firms has been pointed out continuously in the literature either due to perceived economic and environmental benefits or to understand the missing link between practice and performance (Zhu et al., 2008; Eltayeb et al., 2011; Laosirihongthong et al., 2013). Even though a few studies for example, the study of Zhu et al. (2013) observed indirect connection between eco-design practice and environmental performance, most of the recent research have investigated and observed direct positive impact of eco-design on environmental performance through measuring air emissions (Eltayeb et al., 2011; Lee et al., 2012). So it can be hypothesized that:

Hypothesis 3: Eco-design Practice has a positive impact on GHGe reduction in the UK Chemical Industries.

Hypothesis3a. Eco-design practice has a positive impact on scope one GHGe reduction in the UK chemical industry.

Hypothesis3b. Eco-design practice has a positive impact on scope two GHGe reductions in the UK chemical industry.

IR and environmental performance: Although IR practice has been used as a cost reduction tool in the industries through reuse, recycle and remanufacture of used products (Zhu et al., 2005; Eltayeb et al., 2011), it also shows the significant positive impact on environmental performance. For instance, the study of Jr et al. (2012) has confirmed a significant positive relationship between IR practice and environmental performance including air emission performance. Similar findings have been found in the study of Azevedo et al. (2012) and Quariguasi et al. (2010). However, a range of other investigations, for example, Zhu and Sarkis (2007), Laosirihongthong et al. (2013) and Zhu et al. (2005) found opposite results. This balanced argumentations for environmental performance leads to the following hypothesis:

Hypothesis 4: IR Practice has a positive impact on GHGe reduction in the UK Chemical Industries.

Hypothesis4a. IR practice has a positive impact on scope one GHGe reduction in the UK chemical industry.

Hypothesis4b. IR practice has a positive impact on scope two GHGe reductions in the UK chemical industry.

Hypothesis 5: IR Practice does not have a positive impact on GHGe reduction in the UK Chemical Industries.

Hypothesis5a. IR Practice does not have a positive impact on scope one GHGe reduction in the UK chemical industry.

Hypothesis5b. IR Practice does not have a positive impact on scope two GHGe reductions in the UK chemical industry.

Research Methodology

This research has used innovative data source examining the contented information in the environmental and CDP (Carbon Disclosure Project) reports. It involves the conversion of qualitative data into quantitative using content analysis. Hence, the content analysis is used here to prepare the data for statistical analysis. The similar methodological approach in the related field was used in the study of Montabon et al. (2007), Albino et al. (2012) and Hofer et al. (2012). The main reason was to accept this technique due to the unavailable access to primary data. Conducting strong statistical relationship using secondary data in the related field is relatively new.

Quantitative content analysis (ratings technique): preparing data for statistical analysis: Quantitative content analysis approach is used for hypothesis testing through systematization, quantification and statistical data analysis, generalization and separation of the data from the researcher to maintain objectivity (Bryman, 2012). The study collects numerical data applying ratings technique throughout the selected environmental/sustainability/corporate social responsibility/environmental citizenship reports and Carbon Disclosure Project (CDP) Report as the primary data source. The unit of analysis in the data collection is each company. Each company report is subjected to interpret, evaluate, and is rated by the hired raters on a structured rating-matrix. The concept of rating matrix is adapted from the study of Montabon (2007). Six raters have been recruited for this project. Two of the raters are MBA students. Two of them are Ph.D. students researching in the related field, and rest of the two raters are supply chain professionals. Although previous studies (Montabon et al., 2007; Hofer et al., 2012) employed only MBA students, a mix of both professionals and students bring strong insight from the reports to facilitate consistent ratings. It will also be interesting to see if there is any significant difference among this different level of raters.

The study has four independent variables (IEM, GP, ECO & IR) and one dependent variable (GHG emission).The rating matrix is composed of a set of the simple statement (or construct) relating to each variable. Each construct of the independent variable is measured on a five-point rating scale such as 1 - not considering it; 2 - planning to consider it; 3 - considering it currently; 4 - initiating implementation; 5 - implementing successfully. Both scope one and two GHG emissions are available on the CDP report. The emission has been measured as carbon dioxide equivalent (CO2e) in a metric ton. The constructs of independent variables have been adapted from the study of Zhu et al. (2008) due to its universal acceptability across different industries and contexts. The study also involves thematic content analysis to find out other green practices in the industry. Multiple regressions will be used to validate the proposed hypothesis in the study.

Data source and sampling: The sample has been drawn from the 'Alliance of chemical Association' (http://www.acauk.org/) listed member companies because it consists of twelve major chemical trade associations representing companies operating in many sectors of the chemical industry supply chain. This sampling frame consists of 1200 companies. However, the final sample size is 45 environmental and CDP reports which disclose relevant information including scope one and scope two GHG emission. The

sample size of 45 is consistent with other studies in the same field (Ramanathan et al., 2010; Montabon, 2007).

Conclusion:

The study is expected to contribute to the environmental operation management field through understanding the relationship between GSCMP and both scope one and scope two GHG emission performances separately and aggregately in the industry. It is also expected to address previous researchers' (Zhu & Sarkis, 2007) concern whether GSCMP improves elemental environmental performance.

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