

Green Supply Chain Management in the Malaysian Automotive Industry: A Systems Thinking Perspective

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Abstract— This study examines the deployment of green supply chain management (GSCM) in the Malaysian automotive industry. Proponents of GSCM suggest that as an advanced corporate environmental governance practice, GSCM is an important corporate sustainability strategy deployed particularly in the automotive industry. However, little is understood about the deployment of GSCM within an automotive industry operating in a developing country like Malaysia. The present study addresses this literature gap by focusing on both the GSCM deployment procedures and practices within the Malaysian automotive industry. The study adopts a qualitative research methodology, with data collected through semi-structured interviews, observation and document reviews from a single automotive manufacturing case firm operating in Malaysia. Consistent with the literature, our findings suggest that the case firm uses a holistic and systemic approach to deploy GSCM practices. This holistic GSCM deployment approach involves a structured regulated procedure-led method that directly supports systemic green practices.

Keywords— Green supply chain management, systems thinking, ISO 14001 EMS, automotive industry, Malaysia

1. Introduction

Centrally located in the ASEAN region with a population of more than 500 million people, Malaysia is an ideal hub for the global automotive

these advantages, the Malaysian automotive industry is identified as a prime contributor to the nation's economic growth [19]. In recent years, it has been noted that factors such as the full implementation of the ASEAN Free Trade Area (AFTA) has adversely affected the performance of the local automotive industry [31]. The same pressure is expected to be experienced by local automotive parts and components suppliers, who are mostly the small and medium firms. This is partly due to a general lack of research and development capabilities and accelerating manufacturing costs. In view of such imminent challenges, it is imperative that automotive firms seek alternative strategies to maintain and even improve their competitive position. Along this line of discussion, green supply chain management (GSCM), also known as advanced corporate environmental governance (CEG) is viewed by many as a potential means of gaining competitive advantage particularly for the automotive industry [12], [16], [36], [40], [49]. Furthermore, to ensure environmental sustainability, proponents of operational supply chain management [22], [33] suggest that firms use a systemic (holistic) approach to deploy GSCM.

In 2014 the Malaysian government revised the National Automotive Policy to promote sustainable manufacturing processes that preserve the natural environmental system. Despite this revision, environmental management of the operational supply chain has yet to be holistically practiced. Hence, the lack of attention on GSCM within the

local automotive industry reflects the timely need to understand the GSCM deployment from a Malaysian perspective. Currently, there is limited literature that holistically addresses GSCM, within the car manufacturing and assembly firms operating in Malaysia. As a result many companies in Malaysia may have embarked on introducing GSCM, with limited understanding of the procedures and practices needed for its deployment success. Therefore, understanding the insights about the deployment of GSCM in a key manufacturing plant within the Malaysian automotive industry may provide an interesting start to build a roadmap for environmental sustainability within the local context.

This research paper thus contributes to generate insights into the automotive GSCM deployment within the Malaysian context. Specifically, this research aims to address the following research questions:

1. What type of procedure supports the integration of GSCM practices within the operational supply chain of the case firm?
2. What GSCM practices are deployed by the selected automotive case firm?

2. Literature Review

2.1 GSCM and Operational Supply Chain (OSC)

GSCM is an advanced CEG practice that addresses and mitigates the adverse impacts of a firm's business operations on the natural environment [12], [15], [27]. GSCM practices include any action to eliminate or mitigate any adverse environmental impacts across the supply chain [12], [21], 28, [36], [47]. A typical supply chain consists of 1) the upstream (supply side), 2) the OSC of the focal company, and 3) the downstream (customer side) [9], [33]. Hence, the supply chain comprises of all the supply chain partners from the ultimate supplier to the ultimate customer in both the upstream and downstream sides.

Several authors [5], [12], [26] commented that the supply chain has been traditionally defined based on a linear production paradigm. However, according to [5], the traditional definition does not explicitly include the natural environment as part of the management strategy and operations. Hence, an 'extended supply chain' framework that includes

the 3'R's recovery operations (remanufacturing, recycling; and, re-use) was introduced [5]. By adopting the circular and systemic philosophy of "ecosystem" thinking [33], [34] introduced an Integrated Supply Chain framework. This framework identified four operational supply chain (OSC) phases for manufacturing companies including car manufacturing and assembly firms, the focus of the study. The four phases consist of (1) purchasing and inbound logistics; (2) production and internal operations; (3) distribution and outbound logistics; and (4) reverse logistics.

Previous studies have noted that the OSC of the focal company – particularly manufacturing companies, has drawn much interest among proponents of GSCM. This is because the activities within the OSC of manufacturing firms whilst within the internal control of a firm, have been noted to be the prime contributors of ecological problems [22], [32]. Given this problem, this study focuses on the GSCM deployment within the OSC of a focal [automobile] company, operating in Malaysia.

2.2 GSCM Procedures and Practices

The literature suggests that the ISO 14001 EMS standard operating procedures which follows the Deming's PDCA framework is widely used by firms to integrate green practices within the four OSC phases-1) purchasing and inbound logistics; 2) production and internal operations; 3) distribution and outbound logistics phases, and 4) reverse logistics phases [3], [10], [27], [33]. These phases are also referred to as the input, throughput, output and end to start stages respectively [27], [33]. Green practices are integrated within the input, throughput and output stages of OSC [11], [46]. The fourth stage, the end to start stage is an extended stage that directly contributes to the closed-loop systems control for GSCM [27].

The literature also suggests ten common GSCM practices within the four stages of the OSC structure. In the input stage, three GSCM practices consisting of green purchasing, green inbound logistics [43], [45], [47], [48] and green waste management [27], [33] are identified. Greening the purchasing and inbound logistics phase is critical as companies are normally held responsible for environmental problems caused by them as well as their suppliers [27]. Four key green practices are identified within the throughput stage of the OSC. These are: 1) green manufacturing; 2) design for environment; 3) green building; and 4) green waste management. Several authors [22], [29] noted that

greening of the production and internal operations phase is critical for manufacturing firms. GSCM practices are also identified within the output stage that is the distribution and outbound logistics phase. Green practices include green marketing [17], green packaging [27], green transportation [4], [25], and, green waste management [14], [38].

The development of the fourth end-to-start stage culminated in the development of the reverse logistics phase. This phase which focused on the reuse, recycling and remanufacturing of materials (3Rs) practices led to a fundamental shift from the traditional linear supply chain operations towards a closed-loop environmental control system [5], [37]. Such practices represent an internal-based inverse flow activity that is tied to the GSCM practices at other phases of the firm's OSC [27].

2.3 Systems Thinking

Several authors [22], [33] suggest that a systemic view should be taken to examine the green operations procedures within an automotive industry. Systems thinking which is rooted in General System Theory [41], is a way of looking at the world in which objects are interrelated with one another. [6], [7] define a system as "a set of elements standing in interrelation among themselves and with environment". Along this line of discussion, General System Theory suggests every entity is an open system and have inputs-throughputs- outputs process flow, linking with its environment [35]. Within the industrial ecosystem, an entity such as an organization will be able to control adverse environmental impacts by controlling its inputs and processes. An entity is thus, a primarily active system.

More recently, [23] proposed the General framework for Green Operations which suggests six steps to improve environmental decision of firms. The framework, based on the Deming's PDCA cycle, is akin to the ISO 14001 EMS five-module model [27]. From a holistic system thinking perspective, [27] defines GSCM as activities "... addressing and minimizing the environmental impacts of all activities related to the different phases of the supply chain comprising inbound logistics, production or internal supply chain, outbound logistics, and reverse logistics". In this definition, [27] views the development of green practices as being the main source of GSCM. In an earlier work, [28], using a procedure approach describes GSCM as being "...how companies are implementing environmental initiatives in different phases of the supply chain". Therefore, Rao's two

definitions of GSCM extend the limited notion of environmental practices to incorporate the wider green implementation procedures. Hence, by drawing on the key elements in the literature, GSCM in this study is therefore holistically defined as:

"The environmental practices and procedure that address and minimize the environmental impacts related to the four phases (purchasing and inbound logistics, production and internal operations, distribution and outbound logistics, and reverse logistic) of a focal firm's operational supply chain."

In line with the above definition and based on the literature reviewed, in this study a system thinking is adopted in explaining the wholeness of GSCM deployment at the focal car manufacturing and assembly case firm. The wholeness of GSCM relates to two interrelated issues: 1) GSCM procedures and 2) GSCM practices perspectives.

3. Research Methodology

A case study approach is used to address the issues identified in the research. The two questions in this paper are essentially 'what' questions, and [42] associates these with an exploratory research approach. Therefore, an exploratory approach is used in this study to examine the research issues. In addition, [42] purported that a single-case study contributes to the body of knowledge as a revelatory case. This is because the investigation such as the current study is conducted on the local GSCM phenomenon where few had previously sought the opportunity to observe and analyse. Thus, a single case allowed for an exploration of the research questions raised in the current study.

3.1 Data collection and analysis

The automotive industry was chosen as the case industry for the current study because it has been identified as being an environmental-sensitive industry [44]. Moreover, the automotive industry plays a key role in the nation's economic growth, and contributes to the aspiration of Malaysia to becoming recognized as a developed nation by the year 2020. Access to the companies was obtained through direct contact between the researchers and the companies. The main source of data for this study was the personal interviews with members of the operational supply chain departments and the environmental, health and safety (EHS) department who are the experts of Environmental Management

(EM) practices at the case firm. An extensive review of the GSCM literature surrounding the research questions was undertaken before developing the interview questions. The interviews made use of a semi-structured approach, the structured component of which served as a guideline for consistency and cross-referencing. The interview involved asking the questions, elaborating and probing where necessary. The personal interviews were supplemented by studies and review of documentations such as annual reports, websites, newspaper clippings, and archival records of annual reports, newsletters and information from the company's website.

The whole data collection process involved tape recording, taking notes and viewing/collecting documents relevant to the GSCM implementations. To eliminate any bias by a single respondent, attempts were made to ensure triangulation of data from multiple sources within the OSC structure. For the qualitative data analysis, this study adopted [42]'s data analytic procedure that relies on theoretical propositions. Following this, [42]'s pattern-matching logic is applied together with more specific analysis as recommended by [20], and [8].

4. Findings

4.1 Case Firm

The case firm, established in 2003, is a wholly owned subsidiary of Malaysia's premier automotive company. The core activities of the case firm involve the manufacture and assembly of personal vehicle models. In addition, the company also manufactures related products such as accessories, spare parts and components. As a car manufacturing and assembly company in Malaysia, the case firm is categorized as a 'Business to Business' (B2B)¹ entity in its supply chain. The case firm is in a RM1.8 billion state-of-the-art manufacturing site. The case firm is also equipped with four multi-model production lines that allow flexibility and rapid response to market demand situations.

¹ Business to Business' (B2B) refers to a firm that provides goods or services for another firm. In this study, the case firm is a B2B company that provides the manufactured and assembled personal vehicles and related products such as accessories, spare parts and components for another company in its supply chain.

The case firm is regarded as an 'initiator firm' whereby under the direction of the parent company, the case firm is the first within the group, to be awarded ISO 14001 certification. The case firm's environmental management (EM) practices are led by the EHS department. These, among others practices, act to indicate the company as a responsible corporate citizen that is always willing to invest not only for health and safety, but also for the environment.

4.2 ISO 14001 EMS and GSCM

The case firm was awarded the ISO 14001 EMS certification in October 2009. The EHS department headed by an Environmental Management Representative (EM Representative), an EMS Coordinator and a special EMS Committee involving senior management and working level personnel are directly responsible for the ISO 14001 EMS implementation at the case firm. Consistent with the literature, the ISO 14001 Environmental Management System (EMS) certification award motivated the case firm to implement GSCM practices. GSCM practices are integrated within the firm's traditional OSC activities. The ISO 14001 EMS framework requirements strictly follow Deming's conventional improvement cycle of Plan-Do-Check-Act (PDCA). Hence, the framework is collectively referred to as PDCA-ISO 14001 EMS. Both the EM Representative and EMS Coordinator from the case firm proclaimed that the PDCA-ISO 14001 EMS is strictly followed by the case firm to execute its environmental responsibility with the aim to continuously improve the environmental performance which in turn fulfils the ISO 14001 EMS requirement.

According to the firm's EMS Coordinator, the procedures which are set out in the PDCA-ISO 14001 EMS framework logically guided the initiation of several GSCM practices in the case firm. The EM Representative asserted that as part of the general requirement of PDCA -ISO 14001 EMS, the case firm must clearly define the scope of their EMS. More specifically, the PDCA -ISO 14001 EMS dictates the scope and focus of green practices within the critical areas of the case firm's OSC. Hence, the PDCA- ISO 14001 EMS is a procedure-led system that plays a vital role in the identification and initiation of GSCM practices within the firm's OSC activities.

The EMS team used the PDCA- ISO 14001 EMS framework, to analyse the firm's traditional operational supply chain activities, and subsequently they identified critical areas within the OSC for green initiatives. The identification of critical areas and green initiatives, culminated with the EMS team developing and implementing formal GSCM practices at the case firm. These findings suggest that the deployment of GSCM involves two integrated deployment activities. In this study, these two integrated activities are broadly classified as: 1) GSCM Procedure-led deployment (PDCA-ISO 14001 EMS and 2) GSCM Practices-led deployment (GSCM Practices). Drawing from the literature, an Integrated GSCM framework (Figure 1) is put forward. The framework will be used as a guide to explain the results from the case study.

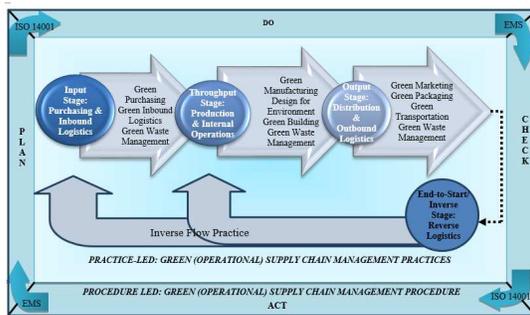


Figure 1. An Integrated GSCM framework

4.3 An integrated GSCM Framework

In Figure 1, the outer rectangle represents the Procedure-led PDCA-ISO 14001 EMS, and the inner rectangle houses the firm's four green OSC phases- 1) purchasing and inbound logistics; (2) the production and internal operations; (3) the distribution and outbound logistics; and (4) reverse logistics. Prior to the implementation of PDCA-ISO 14001 EMS the case firm's traditional OSC included only the first three phases. However, with the implementation of PDCA-ISO 14001 EMS, a fourth phase, reverse logistics was developed. According to an EMS personnel, the Procedure-led PDCA-ISO 14001 EMS initiates and supports the Practices-led GSCM deployment in the case firm. These developments are discussed in the subsequent sections.

4.3.1 GSCM Procedure-led Deployment

Figure 2 presents the case firm's procedure-led PDCA-ISO 14001 EMS deployment process.

The PDCA ISO 14001 EMS (2004) requirements provide a procedure-led structured approach for addressing and mitigating environmental issues particularly within the case firm's OSC.

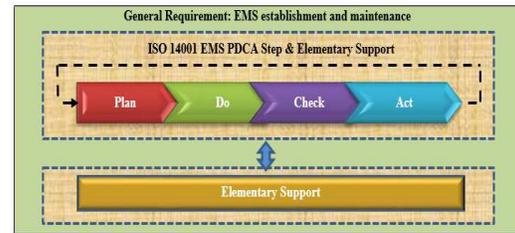


Figure 2. Case firm's procedure-led PDCA-ISO 14001 deployment

The EMR from the case firm highlighted that (Figure 2), the procedure-led PDCA-ISO 14001 EMS framework is divided into two interlinked sections. The first section, housed within the inner top rectangle (Figure 2) represents the EMS PDCA steps (Plan, Do, Check and Act); whilst the second section housed within the lower inner rectangle represents the elementary support for the PDCA framework. Both these sections are inter-linked, and collectively they fulfil the ISO 14001 EMS General requirement: EMS establishment and maintenance at the case firm. This is represented in Figure 2 by the green outer rectangle.

In Figure 2, the general requirement (clause 4.1) focuses on EMS establishment, maintenance and continuous improvement. As part of the general requirement, the case firm must clearly define the scope of their EMS. The EMR highlighted that their scope of the PDCA-ISO 14001 EMS only covered the supply chain activities within the case firm. The case firm's EMS Co-ordinator however highlighted that the production departments (Engine & Transmission, Stamping, Body Assembly, Painting and Trim & Final Assembly within the production & internal operations phase) and Environmental Management Centre (a waste management centre for the case firm) are specific 'critical areas' for green initiatives. This is due to the significant impact of the processes to the natural environment. As such, the deployment of PDCA-ISO 14001 EMS focuses mostly on these 'critical areas', which are areas within the case firm's OSC. This general requirement clause therefore forms the basis for the initiation and implementation of the PDCA-ISO 14001 EMS framework, and this in turn support the deployment of GSCM at the case firm.

Guided by the EHS policy and based on the aspect-impact analysis, the Plan step in Figure 2 includes the planning of objective and target (O&T)

programs to control the significant environmental aspects. The many identified planned control programs collectively forms the Environmental Management Program (EMP) at the case firm. In the Do step, the O&T programs in the EMP and the established O&T (existing green programs) are the operational controls used to tackle the significant environmental aspects within the case firm's operational supply chain. With regards to the operational supply chain, the administrative and engineering measures of the operational controls are associated with the GSCM practices deployed. The implementation of these operational control measures requires proper monitoring and the development of appropriate measurements, thus the need for the Check step in Figure 2.

The conduct of Evaluation of Compliance and internal EMS audit as well as performance measurements at the Check step in Figure 2 produces useful information that acts as inputs for continuous improvement actions. As a closure point for the implementation of the PDCA-ISO 14001 EMS at the case firm, the management review is the Act step which is the final step within the procedure-led framework (Figure 2). The management review also serves as an important support mechanism for GSCM deployment at the case firm. This is because during the management review meeting, the top management will annually review the EMS to ensure its continued suitability, adequacy, and effectiveness.

Further investigations showed that the procedure-led PDCA-ISO 14001 EMS has resulted in an extension to the case firm's three phased linear operational supply chain structure to a closed loop four phased operational supply chain structure. Therefore, as shown in the Integrated GSCM framework (Figure 1) and parallel with the literature [27], [33], green practices are integrated in the four phases of the operational supply chain comprise of: 1) purchasing and inbound logistics, (input stage); 2) production and internal operations (throughput stage); 3) distribution and outbound logistics (output stage); and, 4) reverse logistics (end-to-start/inverse stage). Of these four phases, the reverse logistics phase is a new development that supports the GSCM at the case firm. The integration of green practices within the case firm's OSC, clearly supports a GSCM practices-led deployment.

4.3.2 GSCM practices-led deployment

As shown in Figure 1, the GSCM practices are integrated into the case firm's traditional OSC structure- (Input stage; Throughput stage and output stage), thus improving the business activities. Consistent with the literature [27], [33],

the findings in Figure 1, reveals that GSCM practices are found in four phases of the case firm's closed loop green operational supply chain structure. Further investigations, affirmed that the GSCM practices at the case firm are mostly inter-related and inter-dependent practices that supported a holistic GSCM deployment. These practices are discussed below.

(a) Green Purchasing

Proponents of green purchasing suggest that a holistic green purchasing focuses on initiatives covering three central areas which are greening of suppliers, green products/supplies and, green packaging [13], [27], [33], [39]. However, the case evidence suggests that green purchasing at the case firm is not holistically practiced. Though the Procurement Executives within the purchasing and inbound logistics phase affirms on green purchasing initiatives for non-components and service suppliers (Table 1), none is evidenced with regards to the component suppliers. Green purchasing practice pertaining to component suppliers are currently not practiced because the selection and appointment of this type of suppliers are responsibility of the parent company. At the point of investigation, green initiatives practiced by the case firm include integration of green specification in the purchasing process, integration of environmental criteria for supplier selection and environmental audit on service providers/suppliers. Despite integrating environmental criteria for supplier selection, the case firm does not enforce any green purchasing initiatives such as certification of ISO 14001 EMS among its component suppliers.

(b) Green inbound logistics

Green inbound logistics includes green packaging, green inbound external and internal transportation as well as abiding by green receiving guidelines. As part of green packaging, the case firm uses recyclable and returnable pallets and poly-boxes for purpose of delivery of parts and components to and from suppliers. Meanwhile, to minimise the number of suppliers that need to be managed and to increase the delivery efficiency of parts and materials, two logistics contractors, referred to as Lead Logistics Providers or Third Party Logistics Providers are hired. Using a pre-determined schedule and route, these Third-Party Logistics Providers will collect and deliver materials, parts and components from suppliers to the case firm. This will then reduce the number of lorries and frequency of transportation to and from the case firm which in turn, indirectly contributes to the reduction of CO₂ emission. In addition, green internal transportation is an initiative which

considers environment-friendly in-house transportation of goods within the premise. According to an Executive from the Improvement Section, Production Planning & Control/Logistics department, to curb emission, special filters are used in the forklifts used for in-house transportation of goods.

The Section Manager, from the Production Planning & Control/Logistics department also highlighted that green receiving/handling guideline is an important aspect to ensure environmental issues as well as the health and safety matters are properly addressed for an efficient green inbound logistics process. All EMS personnel including the logistics operators need to be well informed on the product's criteria that can be hazardous, how to use them as well as the necessary action to be taken upon pressing situations.

(c) *Green manufacturing*

Consistent with the literature [22], [27], [29], [30], [39], green manufacturing practice at the case firm emphasizes on pollution prevention at source. The key focus of green initiatives at source includes the materials/resources, process, technology, energy, and housekeeping activities at the production site. As such these initiatives are broadly classified as: 1) Material and resources oriented; 2) Process oriented; 3) Energy oriented; 4) Technology oriented; and, 5) Housekeeping oriented.

The case firm's internal 3Rs (reduce, reuse, and recycle) activities besides contributing to waste reduction, also supports material cost reduction. Process-oriented green manufacturing initiative includes process improvement to achieve closed-loop manufacturing system which promotes reuse of material, whilst cleaner technology initiatives is associated with the use of robots, machinery, and automation manufacturing systems. A review of the company's annual reports suggests that the manufacturing and assembly plant is highly dependent on automation and automatic line control system. Another key focus of the plant is on energy (i.e. electricity, water and LPG) conservation. Hence, one of the activities launched is electrical and water utility cost saving program. For instance, Body Assembly department practices switching off lights during breaks and turning off water pipes during idle time.

At the case firm, housekeeping oriented initiatives relate to pollution prevention by means of continuous production site housekeeping. Among others, 'Genba' (shop floor) audit is conducted. Apart from having plant-wide Genba audit led by EHS, each department also performs their own

Genba audit which may focus on various issues including the natural environment. This exercise aims for improvement on overall aspects of ISO 14001 and ISO 9001 related issues including housekeeping of the production site at the case firm.

(d) *Green Building*

Green building is another key GSCM practice handled at the production and internal operation phase at the case firm. The 'environment-friendly' concept is widely infused in the design of the case firm's manufacturing plant. From the case interviews and the annual report of the group of companies, it is noted that the case firm's state-of-art building is viewed as a prestigious contribution towards environmental sustainability.

(e) *Green Waste Management*

Green waste management initiatives are inter-related practices implemented in the purchasing and inbound logistics phase, the production and internal operations phase and the distribution and outbound logistics phase. At the purchasing & inbound logistics phase, the green waste management initiative is confined only to the end-of-pipe/pollution control facilities and procedures. The implementation of this initiative while aiding pollution control at the work place is also consistent with the requirements of ISO 14001.

Green waste management is also a key GSCM practice deployed at the case firm's production and internal operation phase. The key green waste management initiatives include the 'R's of waste management; end-of-pipe/pollution control facilities and procedures; Industrial Waste Exchange Program (IWEP); and/or, hire of licensed waste contractors/ suppliers. Case evidence shows that the 'R's of waste management in the production & internal operations phase however, is closely tied to green manufacturing practice. In addition, green waste management practice is closely linked to other GSCM practices such as green building. For instance, to enable green waste management practice at the production departments within the production & internal operations phase of the case firm, end-of-pipe/pollution control facilities and procedures initiative such as oil collecting sump and the connecting parameter drains, bailer machine and the supporting conveyors need to be installed within the green built environment.

Green waste management is the only practice at the distribution and outbound logistics phase. Contrary to the literature, green outbound transportation, green marketing, and green packaging are not

evident. The green waste management practice within the distribution & outbound logistics phase is directly managed by the Environmental Management Centre (EM Centre). The EM Centre (distribution & outbound logistics phase) and the five² production departments (production & internal operations phase) are jointly involved in green waste management practices. Green waste management practices are implemented through three key green initiatives: 1) in-house, end-of-pipe / pollution control facilities and procedures; 2) IWEP; and, 3) hire of licensed waste contractors/suppliers. In-house incinerator and waste water treatment plant are examples of the case firm's end-of-pipe, pollution control solutions. According to the EM Centre Supervisor, specific schedule wastes from the production & internal operations phase will be incinerated to reduce solid waste volume and the related disposal cost. The ashes are subsequently transferred to a third party licensed recycling company. Hiring of a Department of Environment (DOE) licensed waste contractors/suppliers are thus another green initiative within the green waste management practice at the case firm.

(f) *Inverse Flow*

The case findings revealed that inverse flow practice was implemented thus providing evidence on the change of the traditional operations to an environment integrated operation at the case firm. The inverse flow practice however, is not strongly deployed, indicating a modest existence of the inverse stage. This is because as the findings suggested, the case firm is not directly involved with any external-based inverse flow practice. As highlighted by the HOD of EHS department, the core business of the case firm is making and assembling cars. Hence, the main concern of the firm is to concentrate in fulfilling this function. Currently, the case firm's inverse flow practice is confined solely to internal activities only. Specifically, the internal-based inverse flow initiative involves manufacturing returns involving materials and wastes with 3Rs activities of recycling, reuse and reduce which promotes a closed-loop system and this is consistent with the literature [27], [30], [32], [37]. Table 1 summarizes the key GSCM practices within the four phases of the case firm's OSC.

Table 1. Green practices within the OSC structure

OSC Phase	GSCM Practices	Green Initiatives
Purchasing & Inbound Logistics Phase /Input Stage	Green purchasing	Green policy/guidelines for the procurement of non-component and services Integration of green specifications in the purchasing process Integration of environmental criteria for suppliers' selection Environmental audit on service providers/suppliers
	Green Inbound Logistics	Green packaging for transportation Green inbound transportation Green internal transportation Green receiving guideline
	Green Waste Management	In-house, end-of-pipe/pollution control facilities and procedures
Production & Internal Operations Phase/ Throughput Stage	Green manufacturing	Material & resources oriented - pollution prevention via resource conservation or reduction in consumption Process oriented - pollution prevention via process improvement that brings about closed-loop manufacturing system which promotes reuse & recycle Energy oriented - energy conservation Technology oriented - Pollution prevention via use of cleaner technology Housekeeping oriented - Pollution prevention via production site housekeeping
	Green Building	Built environment - Environment concept & design in construction or rebuilding of production facilities (Green concept & design)
	Green Waste Management	3Rs of waste management End-of-pipe/pollution control facilities and procedures Industrial Waste Exchange Program (IWEP) Hire of licensed waste contractors/ suppliers
Distribution & outbound logistics Phase (Output Stage)	Green Waste Management (inter-linked to purchasing & inbound logistics and production & internal operations phases)	In-house, end-of-pipe / pollution control facilities and procedures. Industrial waste exchange program Hire of licensed waste contractors/ suppliers.
-Reverse Logistics Phase/Inverse Stage	Inverse Flow practice (closely tied to green manufacturing & green waste management)	Internal-based inverse flow initiative

5 Conclusions, Contributions, Limitations and Suggestions for Future Research

Consistent with previous studies, the case firm used the procedure-led PDCA-ISO 14001 EMS to integrate GSCM practices within its four-phased operational supply chain structure. The findings concur with [1], [24] that reported ISO 14001 EMS as the most preferred and adopted deployment framework for environmental management. The PDCA-ISO 14001 EMS further provides a structured framework for a holistic deployment of green practices, thus enabling a prescribed Practices-led GSCM deployment. Thus, the PDCA-ISO 14001 EMS provides an opportunity for firms to implement GSCM in a holistic manner, rather than in an unsystematic, piecemeal approach. Therefore, the evidence provides support for systemic approach of GSCM deployment procedures as suggested by [22], [23], [33].

At the case firm, the PDCA-ISO 14001 deployment procedure also contributes to the development of an operational supply chain with a closed loop structure. Among others, this demonstrates the beginning of a fundamental shift from a traditional linear operation to environmental integrated sustainable operations. The findings also revealed that GSCM practices at the case firm comprises of green practices within the four phases of a closed

² Stamping, Body, Painting, Engine & Transmission, and Trim and Final Assembly

loop operational supply chain structure. However, as found in the Asian region [27], [30], the GSCM practice involving the reverse logistics phase at the case firm is still at its infancy. As reported in the literature [27], [33], the case evidence shows that the GSCM practices and initiatives within the OSC phases are interlinked. The integration of these interlinking GSCM practices and initiatives as well as the development of the additional reverse logistics phase have enabled the case firm to successfully deploy GSCM holistically. These findings culminated in the development of an Integrated GSCM Framework that could be used to support the successful deployment of GSCM practices.

By adopting a case study approach, the current study contributes to the body of literature by using a holistic approach to provide in-depth understanding about GSCM deployment that might not be evident otherwise of a relatively new phenomenon, like GSCM.

This study is not without limitations. Firstly, this study concentrates on the operational supply chain which limits the scope of study to the internal value chain of the firm. Secondly, since this study focuses only on a single case firm within the Malaysian automotive industry, the data, findings, conclusions, and recommendations may not be generalizable to all industries deploying GSCM.

Several opportunities for future research arise from the findings of this study. Firstly, as more companies adopt GSCM, researchers will have more opportunities of refining the GSCM framework used in the study. Secondly, future research may consider adopting a quantitative methodology to investigate the extent to which the adoption of GSCM promoted the application of Environmental Accounting.

Acknowledgments

The authors would like to thank the Ministry of Higher Education (MoHE), Malaysia and Universiti Teknologi MARA for supporting this research through FRGS grant awarded.

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