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Evaluating challenges to implementing eco-innovation for freight logistics sustainability in Nigeria

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Abstract – Globally, even as environmental protection and sustainability are becoming increasingly important, freight transportation firms are faced with the enormous need to reduce the significant environmental burdens that accrue from transport vehicles. Eco- innovation can aid freight transport firms through fostering sustainable transportation alternatives at best possible costs to ensure effective decision- making for freight logistics sustainability. Yet, freight logistics companies are faced with numerous difficulties when attempting to implement eco-innovation practices along their supply chains. This paper therefore identifies the challenges to implementing eco-innovation practices for freight logistics sustainability to aid management to take informed decisions to overcome these challenges before the environmental burdens become critical. The Best- Worst method is adopted to evaluate and rank these challenges in terms of their relative importance in Nigeria, an emerging economy, which is characterized by increased consumption due to huge population size coupled with government green requirements. The results depict that unavailable funds, lack of clarity on the financial benefits of eco- innovation practices, poor technology infrastructure and reluctant attitude towards eco- innovation practices are the most pressing challenges amongst the challenges faced by Nigeria freight logistics companies. These results will provide insight and guidelines for decision-makers and policymakers in the freight logistics sector who seeks to integrate eco-innovation initiatives to achieve sustainability.

1. Introduction

With the rapid development of domestic economy, international trade and globalization, the demand for freight transportation as the backbone of economic prosperity and social welfare is increasing in many countries (Dai and Gao, 2016). Despite the work done to improve the efficiency of logistics operations in the supply chain over the years, freight transport continues to be detrimental on the environment (Bektas et al, 2019). This is because freight transportation consumes about 36% transportation fuel and highly dependent on highway trucking which has increased energy consumption of more than 270% (Kelle et al, 2018). Trucking vehicles have significant burdens such as carbon footprints and pollution emissions resulting from the use of petroleum products as the primary energy source. It is expected that the demand for petroleum products will increase by 30 – 82% between 2010 and 2050 to push the total CO_2 emissions from 16% to 17% consequent upon the amount of vehicular movements (World Energy Council, 2011). With an increasing worldwide concern for the environment, logistics providers and freight carriers are forced to pay more attention to the negative externalities of their operations (Demir et al, al, 2014). In recent years, several initiatives in the freight transport context have emerged to tackle the negative environmental impacts generated by transport operations. Local authorities address

environmental concerns of freight transport through policies e.g. licensing and regulation while the transport operators are forced to operate in more sustainable manners using initiatives e.g. information systems, use of cleaner energy sources and routing optimization (Bandeira et al, 2018). Such initiatives mainly based on logistics organization and technical improvements have failed due to their inability to simultaneously satisfy the objectives of stakeholders including transport operators, government and consumers (Munoz- Villamizar et al, 2018).

In this context, eco- innovation is positioned as a target for organizations to be more sustainable in order to satisfy stakeholders' objectives such as reducing negative environmental externalities and reaching governments' green requirements and consumer demands (Garcia- Granero et al, 2018; Kuo and Smith, 2018). Eco-innovation provides both environmental and economic benefits, resulting in a win- win situation (Hojnik et al, 2018; Lee et al, 2018). Eco- innovation has become an inevitable choice for firms as a means to gain a competitive advantage and pursue sustainability under increasing environmental pressure (Cai and Li, 2018). When compared to pre-existing initiatives, eco- innovation presents better results for reducing environmental risks, pollution risks and negative impacts linked to the use of the resources involved (Vieira de Souza et al, 2018). Due to its huge sustainability benefits, eco- innovation has been widely studied with regards to its concepts, drivers and consequences by various researchers. However, little is yet known about the challenges to driving knowledge of eco- innovation into practice to reduce negative environmental impact of freight transport emerging markets and achieve freight logistics sustainability. Shareholders, investors and management in the freight transport sector are often unaware of the critical challenges to focus on and ignore the warning signs. If the key challenges are preemptively identified, management could monitor them periodically and put some preventive mechanism in place to ensure successful implementation of eco- innovation practices for freight logistics sustainability.

Most of the studies on freight transport industry available in extant literature are based on evaluation of transportation systems at various levels, leaving freight logistics sustainability measures inadequately discussed (Kumar and Anbanandam, 2019). In addition, researchers and practitioners focus more attention on economic issues than on environmental sustainability particularly in studies on emerging economies (Silvestre, 2015). The freight transport industry in emerging economies operates in a very competitive scenario due to huge demand for transport operations caused by increased production and consumption coupled with government incessant pressures to achieve sustainability. For instance, in Nigeria, an emerging market which is known as the most populous black African nation with about 200 million people, there is continuous pressure on the industrial sectors to ensure that operations are carried out in line with the sustainable development goals (Atanda and Olukoya, 2019; Breau, 2018; Gungah et al, 2019). Also, the role of e- commerce in fostering increased consumption and promoting economic growth and development in emerging markets particularly in Nigeria cannot be over- emphasized (Adejoh, 2018). Moreover, Nigeria has a basket of policies aimed at implementing sustainability objectives and the Nigerian government promotes initiatives that aid the country's transition to a greener economy (Aoyi et al,

2016). Introduction of legal framework for clean energy and license provision to private sector to adopt sustainable initiatives are some of the strategies that has been set up by the government to actualize green objectives (Maji, 2015). In addition, emerging economies are generally known to lack the implementation of technologies that promote lower pollution as well as measures to cut down emissions resulting from their industrial activities (Luthra et al, 2016). It is thus imperative to understand the challenges of implementing eco- innovation practices to achieve environmental sustainability of freight logistics from an emerging economy perspective particularly within the Nigerian context.

Hence, this paper focuses on the identification, selection and prioritization of these key challenges, which tends to hugely influence the driving of knowledge of eco-innovation into practices for freight logistics sustainability in Nigeria. The Best- Worst multi- criteria decision making model is adopted in this paper to rank the key challenges based on their relative importance on the sustainability of freight logistics. Nigeria's freight logistics sector was selected for this study due to their future growth potential resulting from huge population size and the importance of transportation as a key UN sustainable development indicator (Tob- Ogu, et al, 2018). In Nigeria, freight transportation consumes about 80% of the total petroleum products, making it the largest consumer of fossil fuels in the country (Gujba et al, 2013). It is thus imperative to make efforts to achieve sustainability objectives in the Nigeria's freight logistics sector. The adoption of eco- innovation initiatives in the Nigerian logistics sector can aid in enhancing sustainable performance and increasing competitive advantage of freight logistics firms. This study makes contributions in this direction.

Research objectives
- To identify the key challenges which hinder the implementation of eco- innovation to achieve freight logistics sustainability in Nigeria.
- To prioritize the identified key challenges using the Best- Worst methodology.
- To provide relevant managerial and practical implications on these challenges.

To identify the key challenges in this context, a detailed evaluation was made for the transport firms in Nigeria which carried out freight logistics service operations. Responses were obtained from managers in the transport firms based upon which the influential challenges were prepared, and then ranked using a modeling technique built on Best- Worst methodology (BWM). BWM is a multi- criteria decision making modeling technique, which determines the best criterion and worst criterion based on the most important and least important respectively. The method leads to lower inconsistency of the results and reduces the number of required pair wise comparisons relative to other methods such as Analytic Hierarchy Process (Aboutorab et al, 2018). Since its inception, the BWM has been applied in supply chain management (Badri Ahmadi et al, 2017), energy studies (Wang et al, 2019), airports evaluation (Shojaei et al, 2018) and other domains for real- world decision making.

This paper is organized as follows: Section 2 reviews the literature on the identification and prioritization of challenges that hinder the implementation of eco-innovation practices to achieve sustainability of freight logistics. Section 3 provides the

research methodology and Best-Worst method. Section 4 deals with calculation of weights for all the challenges. In Section 5, the discussion of the results is highlighted. The conclusion, managerial implications and limitations of research are provided in Section 6.

2. Literature review

Freight logistics entails an integrative and systemic support function applying trade-offs to determine optimal cost levels in order to address the time and place discrepancy between the supply and demand of goods and services (Havenga and Simpson, 2018; Mesa- Arango and Ukkusuri, 2015). This definition does not explicitly consider the impact of the logistics activities on the socio-environmental dimensions. Many different decisions of organizations drive and influence freight transport demand and execution of the logistics process (Tavasszy et al., 2012). Thus, logistics plays a very imperative role in organization's efforts to achieving sustainability; hence, logistics managers ought to understand the impact of firm's daily activities on its image (Marchet et al., 2014). For instance, whether a firm will source for its materials locally or internationally, have an impact on the firm's logistics sustainable performance. Another example is whether sustainability issues form part of logistics service provider's selection criteria, is an issue that can aid in achieving improved sustainable logistics performance (Marchet et al., 2014). Also, the vehicles used in freight transport have environmental and social burdens. Thus, managing these issues require the need to integrate socio-environmental concerns into the freight transport decision making process for aiding the transitioning towards a more sustainable freight transportation. The need for vehicle fleet greening is an important initiative that needs serious attention especially for enhancing freight logistics company's image (Marchet et al., 2014). Freight logistics sustainability allows for decision-making scenarios for sustainable transport strategies and policy to improve the overall supply chain sustainability performance and increase organizational competitive advantage (Kumar and Anbanandam, 2019). Unfortunately, the sustainability viewpoint is often preceded with economic interest as the foremost requirement for achieving the target service level (Marchet et al., 2014). However, for a truly sustainable logistics to be achieved, freight logistics companies must balance their efforts in considering the three sustainability dimensions, namely, economic, environmental and social, reflecting on the triple-bottom-line (Badri Ahmadi et al., 2017; Marchet et al., 2014; Orji and Wei, 2015). This is because freight logistics operations impact on the economic, environmental and social domain (Janjevi et al, 2019). In particular, sustainable initiatives are very effective to reduce emissions due to obvious differences in emission patterns for freight vehicles, thus, freight logistics sustainability has become a research hotspot (Kelle et al, 2019). For instance, Bandeira et al. (2018) presented a fuzzy multi- criteria decision making approach for selecting alternative configurations for the distribution chain in urban areas in terms of sustainability. Their study does not provide any view on the challenges which might hinder implementation of freight logistics sustainability. Shankar et al. (2018) developed a risk analysis approach by innovatively integrating the intuitionistic fuzzy set theory and D- number theory to quantitatively model the sustainability risks in

freight transportation systems. Their work does not present the challenges to adopting sustainable initiatives to actualize freight logistics sustainability. Kumar and Anbanandam, (2019) proposed a research framework for computing social sustainability index in freight transportation systems based on the social sustainability enablers, dimensions, and attributes. Their study does not include the challenges to employing sustainable practices for environmental sustainability in freight logistics. Havenga and Simpson (2018) in their work tested the hypotheses that the internalization of externalities costs in freight logistics sustainability can lead to shift in supply chain behavior. But, their study fails to present the key challenges to employing sustainable initiatives in freight logistics. These are some few examples of studies that have occurred and focused on freight logistics and are more related to the subject of investigation. A consistent pattern in these studies is the evaluation of factors that promote sustainable freight transportation systems but clearly depicting limited if not none focusing on those that investigates the challenges that confront the freight logistics industry when attempting to integrate sustainable initiatives into their freight logistics operations. This is in spite of freight logistics policy and decision making processes on the implementation of sustainable initiatives taking place in a highly complex environment which presents numerous challenges (Janjevic et al, 2019). Thus, this literature gap has warranted and motivated the need to investigate and analyze the challenges that hinders the implementation of sustainable initiatives within the freight logistics industry for achieving sustainability, enabling management to strategize and provide mechanisms to overcome such challenges and achieve competitive advantage.

However, driving the sustainability concept within the freight logistics industry requires the need for ecological innovation (eco-innovation) (Kusi-Sarpong et al., 2018). Eco- innovation practices are sustainable initiatives which have the potential to simultaneously increase economic benefits and reduce negative environmental consequences (Lee et al, 2018). These sustainable initiatives are hampered by numerous challenges, relating to the inherent characteristics of innovation and technological change, and to environmental externalities (Polzin, 2017). An in- depth insight on the challenges to implementing eco- innovation practices is important to enable management to proactively take measures to overcome them and achieve sustainability. An industry and country- specific approach to study the challenges to eco- innovation practices will enable firm management to make accurate predictions (Mahtani et al, 2018). To accurately identify the key industry and country- specific challenges to implementing freight technological eco- innovation such as cleaner vehicles and the use of alternative fuels (Marchet et al., 2014), remains a major concern to organization's management. Several studies exist in available literature on the key industry and country- specific challenges to implementing eco- innovation with no reference to the freight logistics sector. Wilts et al (2013) studied the challenges to employing eco- innovation in the German waste prevention industry without any outlook on the freight logistics sector. Their work shows that the lack of institutional frameworks to coordinate the different interests and for the exchange of experiences hinder the eco- innovation practices. Gupta and Barua (2018) presented a three- phase methodology to identify the barriers to eco- innovation in small and medium enterprises. Their work is

based on Indian small and medium enterprises and fails to provide the perspective of the freight logistics sector. Long et al (2016) studied the barriers which inhibit the adoption of eco- innovations to achieve sustainable supply chain in the European agricultural sector. Their work shows that barriers exist on both user and supply sides but does not provide any perspective on the freight logistics sector. Polzin (2017) analyzed the barriers to eco- innovation and the consequences for finance in his study which infers that technological, economic, institutional and political barriers contribute to sub- optimal environmental sustainability. Aloise and Macke (2017) studied the barriers to eco- innovations in the Manaus Free Trade Zone (MFTZ), outside the scope of freight logistics in Brazil. They concluded that most industries in the zone had little concern over local issues and investment in eco- innovations. Ravi (2015) proposed an interpretive structural modeling for the study of the barriers to eco- innovation practices in the Indian electronic packaging industry. While their work shows that lack of awareness, lack of top management commitment and short- term decision making perspectives are the most important strategic level barriers, it remains silent on the freight logistics sector.

The increment in freight transport operations coupled with the increased production and consumption has heightened the need for achieving freight logistics sustainability, particularly in emerging economies (Bektas et al, 2019). These suggest the need to understand the key barriers and their importance to implementing eco- innovation practices in freight logistics of emerging economies to achieve sustainability objectives. Emerging economies are assuming an increasingly prominent position in the global market; thus, they represent both an important and interesting focus for research in transportation, innovation and environmental sustainability (Rao- Nicholson et al, 2017). With much eco- innovation and transportation research centered on advanced economies (Silvestre, 2015; Pacheco et al, 2018), emerging markets provide a new perspective within which insight is provided on the relationship and association between the two domains. Moreover, the consumers in many African countries most especially the emerging economies such as Nigeria are becoming increasingly aware of the changing consumption patterns and the negative environmental impacts (Sanni, 2018). The Nigerian freight logistics sector, being influenced by increased consumption coupled with government and customers' sustainable requirements emphasize the increasing need for logistics firms to employ eco- innovation practices to satisfy stakeholders' demands and achieve sustainability.

To aid in understanding and identifying the importance of the key barriers, a multi-dimensional and multi-criteria issue, a reliable modeling methodology is required to effectively estimate these key barriers to implementing sustainability initiatives in the Nigerian freight logistics sector. The Best- Worst method is one of the effective modeling techniques to aid in studying the relative importance of system variables (Badri Ahmadi et al, 2017). Thus, the research modeling framework in this study focuses and employs the Best- Worst model in evaluating and ranking the key challenges to implementing eco- innovation practices in the Nigerian freight logistics sector. The modeling framework provides an accurate process of determining the key challenges and provides management with the crucial barriers to strive to overcome

them to effectively achieve sustainability. The managerial and practical implications are provided to encourage the implementation of eco- innovation practices to achieve sustainability goals in freight logistics.

2.1. Identification of challenges to freight logistics sustainability

The challenges which hinder the actualization of sustainability in freight logistics operations have been collated from previous studies and responses from transport industry experts. The list of dimensions and respective challenges are shown in Table 1. The identified challenges have been grouped into four dimensions: management and organizational, strategic, social/ legal related and technological dimensions. Each of these dimensions has within it a list of challenges which are given detailed explanations below. The finalized list consists of eighteen challenges which are spread across the four dimensions (see Table 1).

Table 1 List of the challenges that hinder freight logistics sustainability

Dimensions	Challenges	References
Management and organizational (MO)	Insufficient management support and commitment (MO1)	Chang and Wong, 2012; Lee et al, 2012; Bossle et al, 2016; Dubey et al,
	Lack of available funds (MO2)	2016; Orji and Wei, 2016; Mahtani
	Uncertainty/ reluctant behavior towards eco-innovation (MO3)	and Garg, 2018; Vieira de Souza et al, 2018; Gardas et al, 2019; Orji, 2019
	Incompetent workforce in adopting eco-innovation practices (MO4)	
	Poor knowledge of implications of eco-innovation practices (MO5)	
Social and legal (SL)	Improper communication and collaboration amongst logistics partners (SL1)	Wilts et al, 2013; Ravi, 2015; Bossle et al, 2016; Aloise and Macke, 2017;
	Porous security network (SL2)	Polzin, 2017; Yenipazarli, 2017;
	Profiling and complexity issues (SL3)	Gupta and Barua, 2018; Luthra and
	Poor legal framework (SL4)	Mangla, 2018; Moktadir et al, 2018
Technological (TL)	Lack of technology integration (TL1)	Triguero et al, 2013; Dekoninick et al, 2016; Fernado and Wah, 2017;
	Lack of robust database (TL2)	Ghaffar et al, 2018; Kuo and Smith,
	Poor global standards and data sharing protocols (TL3)	2018; Pacheco et al, 2018
	Poor technology infrastructure and facility (TL4)	
Strategic (ST)	Unavailable government support and policies (ST1)	Wilts et al, 2013; Beltran- Esteve and Picazo- Tadeo, 2015; Lee and Min,
	Lack of improvement culture (ST2)	2015; Przychodzen and Przychodzen,
	Lack of clarity on the financial benefits of adopting eco- innovation practices (ST3)	2015; Ravi, 2015; Cluzel et al, 2016; Moktadir et al, 2018
	Unavailability of research and development on adoption of eco- innovation (ST4)	
	Fierce competitive pressure (ST5)	

2.1.1. Management and organizational challenges

These are challenges which pertain to the management and organizational structure of the transport firm. One of the most crucial challenges in this dimension is the insufficient management support and commitment, which entails that sufficient information to encourage eco- innovation adoption are not readily available to top management (Orji, 2019). Lack of available funds is also an important challenge which can be defined by insufficient budgetary allocations for investment in eco- innovation practices (Kusi-Sarpong et al., 2018). Another challenge in this dimension is uncertainty/ reluctant behavior towards eco- innovation which entails that firms are reluctant to adopt eco- innovation due to unfamiliarity/ uncertainty. The workforce in most transport firms in Nigeria lack the competency to function effectively in highly customized and flexible environment for adopting eco- innovation to achieve freight logistics sustainability. Poor knowledge of the implications of eco- innovation is another important challenge which entails that information is not sufficiently available on the sustainability implications of eco- innovation practices (Gardas et al, 2019).

2.1.2. Social and legal challenges

Transport firms are faced with challenges which are related to the social and legal dimensions during implementing eco- innovation practices to achieve freight logistics sustainability. Improper communication and collaboration is a key challenge in this dimension, in that adopting eco- innovation can be encouraged when there is proper synchronization of data amongst relevant partners to achieve sustainability (Luthra and Mangla, 2018). Porous security network is another challenge which tends to hamper implementation of eco- innovation consequent upon inherent security vulnerabilities which are exploited by attackers resulting in phishing and mass data exposure. There is also high profiling and complexity issues associated with transport firms which hinder eco- innovation practices arising from complex data analysis and lack of roadmaps which guides its adoption for achieving sustainability objectives (Polzin, 2017). Poor legal framework is another challenge in this dimension which plays a major role in implementing eco- innovation practices to achieve freight logistics sustainability. This entails that proper legal framework is not adequately available especially with regards to data privacy and security issues for adopting eco- innovation (Gupta and Barua, 2018).

2.1.3. Technological challenges

These challenges are associated with the technological innovations which reduce negative environmental impacts. Transport firms can benefit from the adequate design of a flexible interface to incorporate different heterogeneous components to encourage adoption of eco- innovation practices (Ghaffar et al, 2018). Hence, lack of technology integration can inhibit implementing eco- innovation for freight logistics sustainability. Availability of quality data can aid the effective adoption of eco- innovation in the Nigerian transport sector. A lack of robust database can pose a huge hindrance to achieving freight logistics sustainability through eco- innovation practices (Kuo and Smith, 2018). There is need to follow global standards and data sharing protocols during coupling logistics systems for implementing eco- innovation practices. In Nigeria, the lack of global standards and data sharing protocols pose a huge threat to adopting eco- innovation to achieve freight logistics sustainability. Adequate infrastructure facility is

highly recommended to ensure successful implementation of eco- innovation practices (Dekoninick et al, 2016; Pacheco et al, 2018). Lack of technology infrastructure and facility can impede the implementation of eco- innovation for freight logistics sustainability.

2.1.4. Strategic challenges

These are challenges that are associated with the strategic dimensions and tend to impede the successful implementation of eco- innovation to achieve environmental sustainability in the freight logistics sector in Nigeria. Transport firms have limited control to overcome barriers which are related to government policies and support. Thus, implementing eco- innovation can be hindered by lack of government support and policies to encourage sustainability objectives (Moktadir et al, 2018). Clearly, there are unavailable government directions and guidelines on the implementation of eco-innovation in emerging economies including Nigeria resulting from policy analysts and government agencies not revealing the roadmap for achieving sustainability. Presence of improvement culture is a crucial requirement for adopting eco- innovation practices in business environments (Ravi, 2015). The lack of improvement culture can hinder the effective implementation of eco- innovation to achieve freight logistics sustainability in Nigeria. Eco-innovation has huge environmental and financial benefits (Hojnik et al, 2018). In Nigeria, just like in most emerging economies, there is lack of clarity in the financial benefits of implementing eco- innovation in transport firms for freight logistics sustainability. Adequate research and development on eco- innovation issues particularly in emerging economies can foster the effective implementation of eco-innovation practices to achieve sustainability (Silvestre, 2015). Currently, there is unavailable research and development on the adoption of eco- innovation in transport firms in Nigeria thus impeding the actualization of freight logistics sustainability. Most transport firms are faced with fierce competition due to increased production and consumption patterns and constant aim to balance consumer pressures with government pressures. The presence of fierce competitive pressure can underscore efforts to adopt eco- innovation practices in transport firms to achieve freight logistics sustainability.

2.2. Application of Best- Worst Method

This paper applies the Best – Worst modeling framework to evaluate and prioritize the key challenges to implementing eco- innovation practices in transport firms in Nigeria to achieve freight logistics sustainability. In the Best- Worst framework, the best and worst criteria are specified by decision makers, then, the best criterion is compared with all the other criteria, and all other criteria compared with the worst criterion after which a maximum problem is generated and solved to calculate the weights of criteria (Hafezalkotob and Hafezalkotob, 2017; Bai et al., 2019). Many authors have used this modeling framework in various domains and have found the framework to be effective and robust in such scenarios. Table 2 shows the application of Best- Worst technique by different authors.

Table 2 Application of Best- worst modeling framework

Authors	Nature of contribution
Rezaei et al, 2015	Linking supplier development to supplier segmentation
Rezaei et al, 2016	Supplier selection life cycle approach

Gupta and Barua, 2016	Identification of enablers of technological innovation in MSMEs
Badri Ahmadi et al, 2017	Assessing the social sustainability of supply chain
Ozawa et al, 2017	Ranking factors affecting vaccination demand in northern Nigeria
Ren et al, 2017	Multi- criteria sustainability assessment of technologies
Van de Kaa et al, 2017	Selection of biomass thermochemical conversion technology
Gupta and Barua, 2018b	Supplier selection on the basis of innovation ability
Gupta, 2018a	Evaluation of manufacturing organizations on the basis of GHRM criteria
Irlam and Zuidgeest, 2018	Evaluation of barriers to cycling mobility in a low- income community
Rezaei et al, 2018	Measuring the relative importance of the logistics performance indicators
Van de Kaa et al, 2019a	Analysis of competing technologies for standard dominance
Van de Kaa et al, 2019b	Residential grid storage for batteries

3. Research methodology

The procedure for the Best- worst modeling framework that is applied in this study to evaluate and prioritize the identified challenges to eco- innovation practices for freight logistics sustainability in the Nigerian context is shown in Fig. 1. The Best-Worst method (BWM) provides superior performances in terms of consistency, minimum violation, total deviation and conformity compared to other multi- criteria decision-making techniques (Malek and Desai, 2019). The past applications of BWM indicated in Table 2 have not attempted to explore it in the context of ranking challenges to implementing eco- innovation for sustainability in the Nigerian freight logistics companies. Hence, this study pioneers the utilization of BWM to discover how the prioritization of challenges to implementing eco- innovation practices for sustainability can provide practical and managerial implications for the Nigerian freight logistics companies.
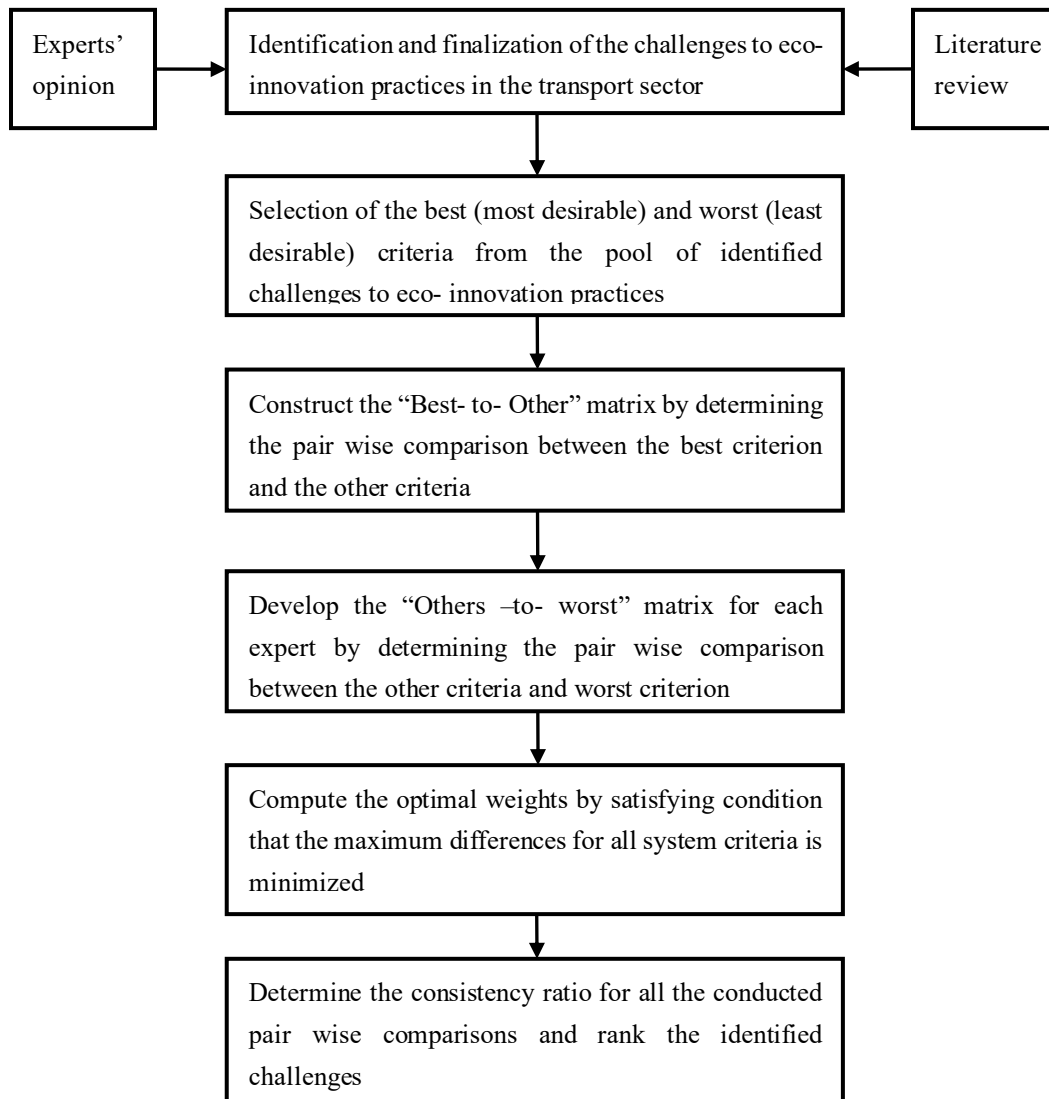
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┌──────────────┐    ┌─────────────────────────────────────────┐    ┌──────────────┐
│ Experts'     │───▶│ Identification and finalization of the  │◀───│ Literature   │
│ opinion      │    │ challenges to eco-                      │    │ review       │
│              │    │ innovation practices in the transport   │    │              │
│              │    │ sector                                  │    │              │
└──────────────┘    └─────────────────────────────────────────┘    └──────────────┘
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                    │ Selection of the best (most desirable)  │
                    │ and worst (least                        │
                    │ desirable) criteria from the pool of    │
                    │ identified                              │
                    │ challenges to eco- innovation practices │
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                    │ Construct the "Best- to- Other" matrix  │
                    │ by determining                          │
                    │ the pair wise comparison between the    │
                    │ best criterion                          │
                    │ and the other criteria                  │
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                    │ Develop the "Others –to- worst" matrix  │
                    │ for each                                │
                    │ expert by determining the pair wise     │
                    │ comparison                              │
                    │ between the other criteria and worst    │
                    │ criterion                               │
                    └─────────────────────────────────────────┘
                                      │
                                      ▼
                    ┌─────────────────────────────────────────┐
                    │ Compute the optimal weights by          │
                    │ satisfying condition                    │
                    │ that the maximum differences for all    │
                    │ system criteria is                      │
                    │ minimized                               │
                    └─────────────────────────────────────────┘
                                      │
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                    ┌─────────────────────────────────────────┐
                    │ Determine the consistency ratio for all │
                    │ the conducted                           │
                    │ pair wise comparisons and rank the      │
                    │ identified                              │
                    │ challenges                              │
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Fig. 1   Research modeling framework

3.1. Best- worst method

The Best- worst method (BWM) is a multi- criteria decision making model which uses two vectors of pairwise comparisons to determine the weights of criteria (Rezaei, 2016). The steps to deriving the weight of criteria using the BWM are shown below:

Step 1: Identification and finalization of the challenges to eco- innovation practices

The challenges to implementing eco- innovation practices denoted as $\{d_1, d_2 \dots d_n\}$ for n main category/dimension were identified from available literature review and finalized using the opinions of ten logistics managers in the freight logistics sector in Nigeria. The finalization was done to ensure that all the relevant challenges to implementing eco- innovation practices in the Nigerian context were duly captured and allow for effective decision- making process. A list of twenty one challenges identified from the literature that hinder freight logistics sustainability were utilized to design questionnaires for the finalization of the challenges. The questionnaires for the finalization was designed to indicate a "YES' or 'NO' response which signifies that an identified challenge is 'relevant' or 'not relevant' in the Nigerian freight logistics

industry respectively. Additionally, the managers were requested to provide any relevant challenge to implementing eco- innovation practices that might have been omitted from the list. No addition was made. The feedback of the ten logistics managers in the Nigerian freight logistics sector are detailed on Table 3 (See Appendix 1).

Furthermore, a threshold value of 7.38 was calculated by dividing the sum total of 'YES (Number of responses)' for all the identified challenges to implementing eco- innovation by the total number of the identified challenges. If a particular challenge has a 'YES (Number of responses)' above the threshold value, then it was selected to be relevant in the Nigerian freight logistics industry. After analyzing the responses received from the ten managers, three of the challenges from the list (Table 3) did not meet the threshold and so were deleted. These challenges include "Unclear business vision" (MO6), "Lack of consideration for human factors" (SL5), and "Lack of technical expertise" (TL5). The final list was further categorized into four dimensions by the authors (for details see Table 1).

Step 2: Selection of the best (most desirable) and worst (least desirable) criteria.

Here, each of the ten logistics managers in the Nigerian freight logistics industry selects the most desirable and least desirable criteria from the pool of identified challenges to implementing eco- innovation in Step 1 based on his/ her opinion.

Step 3: Construct the Best- Others matrix by determining the pair wise comparison between the best criterion and the other criteria.

The aim of this step is to ascertain the preference of the most desirable criterion to the other criteria by using a linguistic scale for the Best- Worst methodology having numbers from 1 to 9. The linguistic scale is shown in Table 4.

Table 4   Linguistic scale for pair wise comparison in Best- worst methodology

Semantic attributes	Assigned numbers
Equally important	1
Equal to moderately more important	2
Moderately more important	3
Moderately to strongly more important	4
Strongly more important	5
Strongly to very strongly more important	6
Very strongly more important	7
Very strongly to extremely more important	8
Extremely more important	9

Source: Gupta (2018b)

The result of the pair wise comparison of the best criterion and other decision criteria is expressed by a "Best- to- Others" vector as follows:

$$C_B = \left(c_{B1}, c_{B2}, ..., c_{Bn} \right)$$

Where, c_{Bj} represents the preference of the most desirable criterion B over a criterion j amongst the decision criteria, and $c_{BB} = 1$

Step 4: Develop the "Others –to- Worst" matrix by conducting a pair- wise comparison of the other criteria over the least desirable criterion using the linguistic scale for Best- worst model shown in Table 4. The result of comparison of the other criteria to the worst

criterion is shown as follows:

$$C_W = (c_{W1}, c_{W2}, ..., c_{Wn})^P$$

Where, c_{Wj} represents the preference of the criterion j amongst the criteria in Step 1 over the least desirable criterion W, and $c_{WW} = 1$.

Step 5: Computing the optimal weights $(v^*_1, v^*_2, ..., v^*_n)$ by satisfying the condition that the maximum differences for all criteria is minimized.

Here, the weights of the criteria are determined such that the maximum absolute differences for all criterion j are minimized over the following set $\{|v_B - c_{Bj}v_j|, |v_j - c_{jW}v_W|\}$.

A minimax model can be formulated as:

$$\min \max_j \left\{ |v_B - c_{Bj}w_j|, |v_j - c_{jW}w_W| \right\}$$

Subject to:

$$\sum_j v_j = 1 \tag{1}$$

$$v_j \geq 0, \text{ for all criterion } j$$

Model (1) can be solved by converting it into the following linear programming problem model:

Min R^L

Subject to:

$$|v_B - c_{Bj}v_j| \leq R^L, \text{ for all criterion } j$$

$$|v_j - c_{jW}v_W| \leq R^L, \text{ for all criterion } j$$

$$\sum_j v_j = 1$$

$v_j \geq 0$, for all criterion j (2)

Solving the linear model in Eqn (2), will result in optimal weights (v_1^*, v_2^*... v_n^*).

Step 6: Determine consistency ratio for all conducted pair wise comparisons and rank the identified challenges

Finally, the consistency ratio (R^L) of pair wise comparisons are also determined and the challenges are ranked based on the determined values. A value closer to 0 is more desired for consistency (Rezaei, 2016).

4. Determination of weights of specific challenges

After the challenges to implementing eco- innovation practices for freight logistics sustainability are identified and finalized by literature review and opinion of experts, the next steps of the BWM were carried out to collect data to determine the weights of

the specific challenges for possible ranking. The data to compute the weights of the specific challenges were sourced through questionnaire survey of freight logistics companies located in Nigeria. Two freight logistics firms that are similar in their zeal to actualize sustainable development goals as part of government requirements which promotes initiatives that aid the country's transition to a greener economy (Ayoi et al, 2016; Maji, 2015) and consumers' demand were selected for this study. Also, the selected freight logistics firms are similar in their functional profile and size (with number of employees within the range of 20- 99). Ten respondents in the selected freight logistics companies agreed to participate in the survey and were assured of the confidentiality of their responses. The respondents considered in this research were logistics managers with up to 10 years of experience in strategic freight logistics decision making in the Nigerian context to ensure questionnaire data efficiency and result accuracy. Moreover, multi- criteria decision making models such as analytical hierarchy process (AHP) and BWM has been applied in previous published studies to provide accurate results with small sample size (Kusi- Sarpong et al, 2018; Luthra et al, 2016; Mahtani and Garg, 2018). For instance, AHP was applied to study the barriers to adopting sustainable initiatives in the manufacturing supplier using the opinions of five experts in a case manufacturing company (Luthra et al, 2016). Also, BWM was utilized to proffer reliable findings with regards to sustainable innovation framework in the Indian manufacturing industry using the opinions of five experts (Kusi- Sarpong et al, 2018). Hence, in this study, ten managers five each from two Nigerian freight logistics companies were asked to identify the best and worst criteria among main category criteria as well as subcategory criteria as the second step of the BWM. The best and worst criteria identified by the different respondents/ experts are shown in Table 5 below:

After each of the managers considered in study had obtained the best and worst criteria, all the managers were asked to give preference rating of 'Best to Others' and 'Others to Worst' criteria challenges for main category criteria challenge as well as subcategory challenge. The preference rating obtained by one of the managers (Manager 1) for main category challenge is shown in Table 6 (See Appendix 2).
Table 7 (See Appendix 3) shows the preference rating that was obtained by one of the managers (Manager 2) for main category challenge. Likewise, the preference ratings as obtained by Manager 3 for the pair wise comparison of main category challenges are shown in Table 8 (See Appendix 4).

Similarly, all the managers were also requested to rate the sub- criteria challenges, as it was done for the main category challenges. The preference rating given by Manager 1 for management and organizational challenges is shown in Table 9 (See Appendix 5). Also, the preference ratings given by Manager 1 for social and legal challenges are shown in Table 10 (See Appendix 6).

Table 5 Identification of Best and Worst challenges to freight logistics sustainability by experts/managers 1-10

Challenges to freight logistics sustainability	Determined as Best by experts	Determined as Worst by experts
Management and Organizational dimensions (MO)	1, 4, 5, 6, 8, 10	
MO1	5	6
MO2	1, 4, 6, 8, 9, 10	
MO3	2, 3, 7	
MO4		1, 2, 3, 4, 5, 7, 8, 9, 10
MO5		
Social and Legal dimensions (SL)		1, 2, 3, 4, 5, 6, 7, 8, 9, 10
SL1	5	
SL2		1, 4, 6, 8, 9, 10
SL3		2, 3, 5, 7
SL4	1, 2, 3, 4, 6, 7, 8, 9, 10	
Technological dimensions (TL)		
TL1		5
TL2		
TL3		1, 2, 3, 4, 6, 7, 8, 9, 10
TL4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	
Strategic dimensions (ST)	2, 3, 7, 9	
ST1	1, 3, 7	
ST2		
ST3	1, 4, 5, 6, 8, 9, 10	
ST4		1, 2, 3, 4, 5, 6, 7, 8, 9, 10
ST5		

In addition, the preference ratings as given by Manager 1 for all the technological challenges and strategic challenges in this study are shown in Table 11 and 12 (See Appendices 7 and 8) respectively.

The same process to obtain the ratings of all the main category challenges and their respective sub- category challenges as carried out by Manager 1 was similarly employed by the other managers in this study to obtain the ratings for all the main category and sub- category challenges. After obtaining the ratings from the ten managers/ experts, the next step was to obtain the weights of all the criteria challenges using the aforementioned Eqn. (2). A simple average method was employed to compute the aggregated weights and ranks based on the average sum of data obtained from all the ten managers as presented in Table 13.

Table 13   Final ranking of Main and sub- category challenges for all the Experts

Main	Weights of Main	Sub-Category	Weights of Sub-	Global	Ranks

Category Challenges	Category Challenges	Challenges	Criteria Challenges	Weights	
Management and Organizational dimensions (MO)	0.413	MO1	0.204	0.084	5
		MO2	0.323	0.134	1
		MO3	0.258	0.107	4
		MO4	0.059	0.024	13
		MO5	0.156	0.065	7
Social and Legal dimensions (SL)	0.065	SL1	0.201	0.013	16
		SL2	0.123	0.008	18
		SL3	0.158	0.010	17
		SL4	0.518	0.034	10
Technological dimensions (TL)	0.203	TL1	0.164	0.033	11
		TL2	0.155	0.031	12
		TL3	0.084	0.017	14
		TL4	0.597	0.121	3
Strategic dimensions (ST)	0.319	ST1	0.261	0.083	6
		ST2	0.180	0.057	8
		ST3	0.390	0.124	2
		ST4	0.052	0.017	15
		ST5	0.116	0.037	9

5. Results analysis and discussions

The results of the analytical process carried out by using the Best- worst methodology are shown in Table 13. A graphical representation of the results on Table 13 was carried out to increase result visibility. Thus, the weights and respective global weights (aggregated weights) of each challenge have been plotted on a radar graph as shown in Figure 2. Also, the ranking of the challenges to implementing eco- innovation practices for freight logistics sustainability in Nigeria has been expressed graphically as shown in Figure 3. The global weights of the main category challenges have also been plotted on a radar graph as depicted on Figure 4. The following has been inferred from the results of the Best- Worst Method applied for analytical procedures in this study:

1. Ranking of the main category dimensions
2. Global ranking of the sub- category challenges
3. Rank of individual challenges within all the main category dimensions

The extent of the importance of the challenges is identified by its ranking position in the table. The global rank of the identified challenges as shown in Table 13 and Fig. 3 is computed by multiplying the preference weights of the respective challenge's dimension and the respective weight of the challenge. The ranking of the main category dimensions and sub- category challenges is discussed in detail in the next section.

5.1.Ranking of the main category dimensions

The results indicate that the challenges under the management and organizational dimension are the major criteria which influence the implementation of eco-

innovations for freight logistics sustainability in Nigeria. These are followed by the strategic dimension, social and legal and lastly technological dimension.

The management and organizational challenges are very crucial and should be effectively overcome to ensure actualization of sustainability objectives in the sector. The second dimension is strategic, which is associated with the strategic level of the firm will lead to a robust adoption of eco- innovation practices and ensure the logistics firm is able to achieve sustainability. The technological- related challenges are the next in line with regards to the influence of the main category dimensions on freight logistics sustainability. The social and legal challenges encompass the legal framework and other social attributes and have the lowest influence on freight logistics sustainability. Effective mechanisms must be put into place to ensure these challenges are monitored and overcome to achieve freight logistics sustainability.
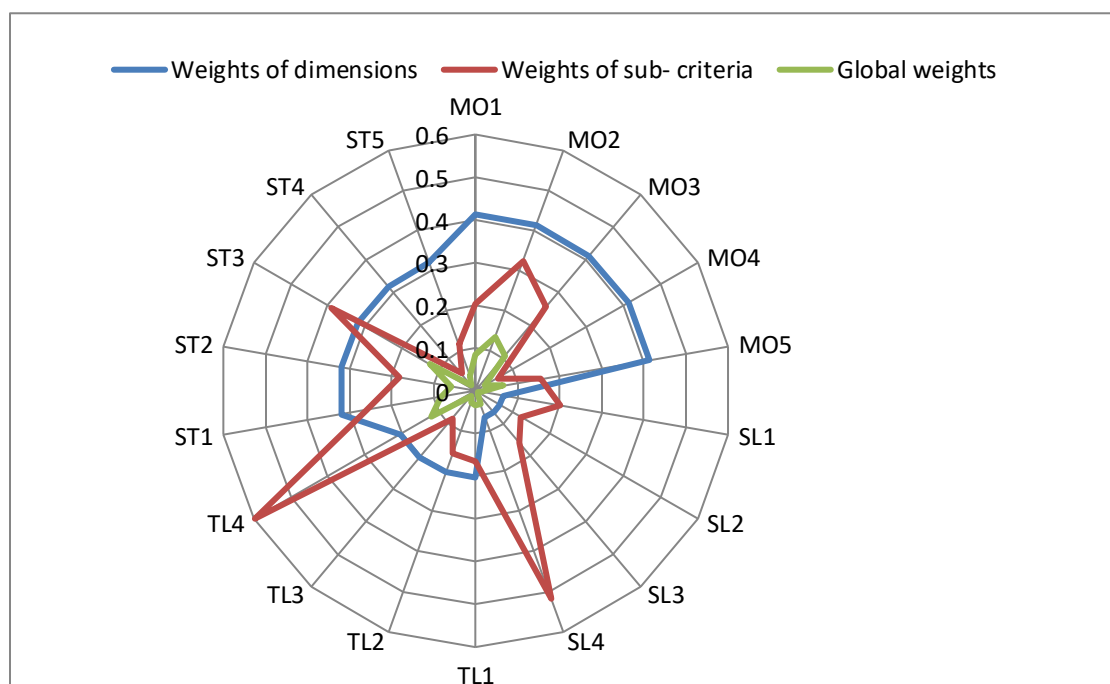
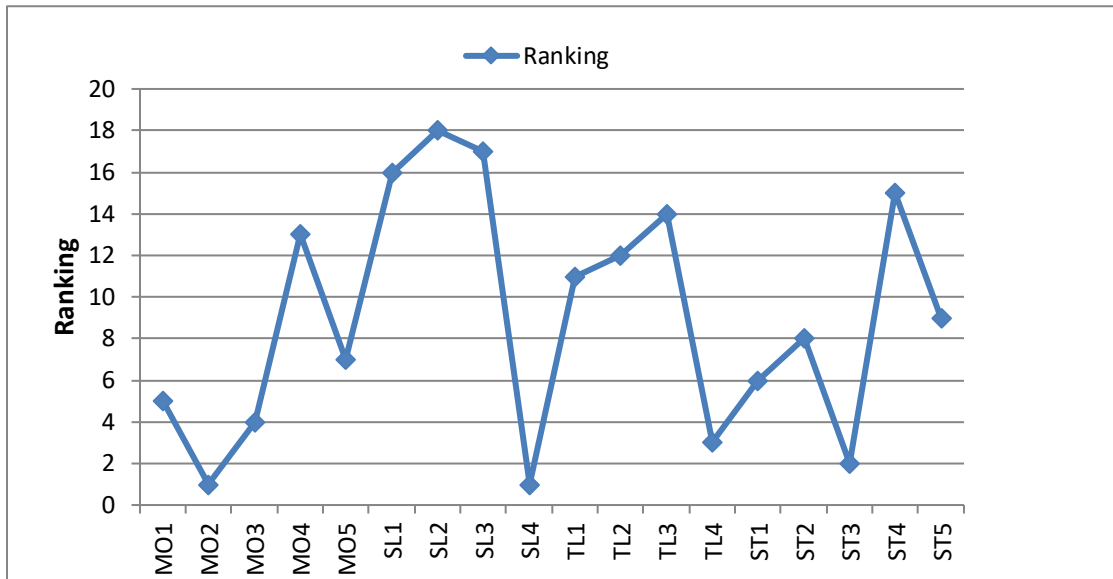Fig. 2   Results (weights and global weights)

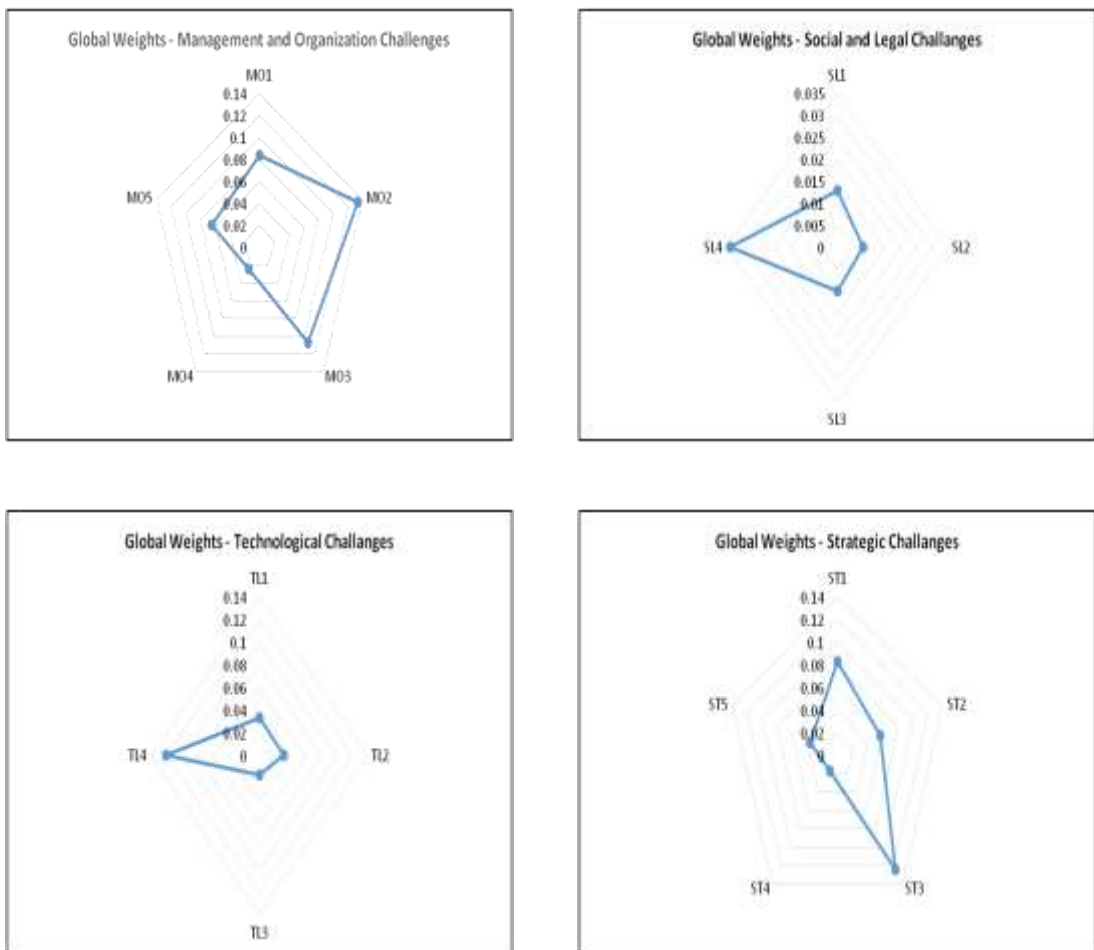Fig.3　　Results (ranking of sub- category challenges)

Fig. 4　　Results (Global weights of individual challenges within each main category)

5.2.Global rank of individual challenges

The results give the global rank for each respective challenge as shown in Table

13. The top four challenges under global ranks belong to all the other dimensions considered in this study except the social and legal dimension. These include improper communication and collaboration amongst logistics personnel, porous security network, profiling and complexity issues and poor legal framework. This ranking shows that freight logistics sustainability through implementing eco- innovation practices is highly impeded by budgetary constraints/ lack of available funds (Kusi-Sarpong et al., 2018). Innovations require high initial and operating costs to effectively implement. As costs/ budgetary allocations form a major component of the operational structure of the logistics firms, budgetary constraints/ unavailable funds can hinder the implementation of eco- innovation to actualize of sustainability objectives. A lack of clarity of the financial benefits accrued from implementing eco- innovation practices can also deter firms from achieving sustainability. Firms can effectively embrace the idea of implementing eco- innovation practices when they have the understanding that financial gains/ profits can be achieved through the means. Other highly influential challenges include poor technological infrastructure and uncertain behavior/ attitude towards eco- innovation practices. The fifth global rank belongs to the lack of commitment of top management in adopting eco- innovation which is indicative that top management plays a huge role to ensure sustainability goals in the firm. The next in line is lack of government support and initiatives to encourage sustainability objectives.

5.3. Rank of individual challenges in each dimension

Management and Organizational challenges: The analysis of individual challenges shows that the lack of available funds has the highest rank. High initial direct costs of investment have been analyzed as being influential in companies' commitment to the environment- through implementing eco- innovation practices (Scarpellini et al, 2017). Thus, lack of available funds is a critical challenge which impact on achieving freight logistics sustainability through eco- innovation. The next ranked in this dimension is insufficient management support and commitment. The challenge is critical to achieving sustainability and indicates that top management is highly influential if eco-innovation practices are to be adopted in the firm. Reluctant behavior towards eco-innovation have been included in prior literature in the examining the barriers to organizational change for sustainability (Mahtani and Garg, 2018; Vieira de Souza et al, 2018; Gardas et al, 2019; Orji, 2019). Other challenges which are lower in influence include poor knowledge of eco- innovation and incompetent workforce.

Strategic challenges: The strategic challenges are ranked second are critical in hindering the logistics firm effectively implements eco- innovation and efficiently achieves environmental sustainability objectives. Among these, lack of clarity on the financial benefits of adopting eco- innovation practices occupies top rank and is a key challenge which impedes freight logistics sustainability. The next rank in this dimension is unavailable government support and policies. Government policies and support can aid the implementation of sustainable initiatives in industries to increase competitive advantage (Wilts et al, 2013; Ravi, 2015; Moktadir et al, 2018; Orji and Liu, 2018). Lack of improvement culture is next in importance as the absence of organizational culture geared towards sustainable improvement can hinder

sustainability objectives. Fierce competitive pressure is next in rank and has a major impact on the implementation of eco- innovation for freight logistics sustainability. The last rank in this dimension is occupied unavailable research and development on the adoption of eco- innovation. The challenge is of least importance for it's relatively less impact on the eco- innovation practices.

Technological challenges: This dimension has poor technology infrastructure and facility as the highest rank. This challenge is extremely important for the Nigerian freight logistics sector as this can hinder sustainability objectives. Eco- innovation is dependent on efficient technology infrastructures for effective implementation to achieve sustainability (Fernado and Wah, 2017). Lack of technology integration is ranked second and is a major challenge that impact on the implementation of eco-innovation practices for freight logistics sustainability. Technology relevant to eco-innovation can be efficiently maximized on a platform which supports their integration in the Nigerian freight logistics sector. Lack of robust database is ranked third in this dimension and has a huge impact on freight logistics sustainability. The last challenge in this dimension is poor global standard and data sharing policies.

Social and legal challenges: These challenges are related to the legal framework and societal challenges which influence freight logistics sustainability. The primary challenge here is poor legal framework (Bossle et al, 2016; Gupta and Barua, 2018; Moktadir et al, 2018). The next two challenges in the social and legal dimension are improper communication and collaboration amongst partners and profiling and complexity issues. This indicates that lack of effective communication flow amongst the relevant actors in the Nigerian freight logistics sector can impede sustainability objectives. Also complex technologies and unavailable profile for relevant technology platforms can hinder the implementation of eco- innovation practices. The challenge, which is lowest in terms of influence in this dimension, is porous security network.

6. Conclusion and managerial implications

6.1 Conclusion

The freight logistics sector in Nigeria, just like others in emerging economies, have its inherent barriers with regards to implementing eco- innovation, which need to be identified and addressed to improve the sustainable performance of firms in this sector. These barriers are classified into strategic, management and organization, social and legal and technological dimensions. This paper evaluates those challenges, identified through literature review and experts' opinion with a major influence on the implementation of eco- innovation practices for freight logistics sustainability. These challenges were further analyzed and prioritized based on their severity and impact on the sustainable performance of the firms. The modeling technique adopted for this prioritization is the Best- worst modeling framework. This method obtains the relative weights of dimensions and their respective challenges, by using the pairwise comparisons to identify the maximum importance (maximum severity) the system criteria/barriers have on the freight logistics sustainability.

The results of the analysis show that, the management and organizational challenges happen to be the most severe and key barriers that require greater managerial

attention and monitoring and overcoming strategies for the actualization of sustainability objectives in the freight logistics sector. The order of criticality among the categories indicates management and organizational challenges as the highest followed by strategic, technological and then social and legal challenges.

Among the individual ranking challenges (sub-categories) in this study, the top-ranked is "budgetary constraints/ lack of available funds" which influences the adoption of eco- innovation for freight logistics sustainability. In a competitive environment, logistics firms find it difficult to implement eco- innovation practices due to the high initial cost of investment in such practices, hence hindering sustainability goals. The next individual challenge is the "lack of clarity on the financial benefits of eco-innovation practices" followed by "poor technological infrastructure facility" and "uncertainty/ reluctant attitude towards eco- innovation practices". This ranking shows that among the global ranks, the top four challenges belong to the management and organizational, technological and strategic dimensions which confirms that the Nigerian freight logistics sector are highly confronted by barriers belonging to these dimensions and less on social and legal dimension when seeking to achieving their sustainability objectives. Other high- ranking individual challenges are "insufficient management support and commitment" and "unavailable government support and policies". "Poor knowledge of the implications of eco- innovation practices" which belongs to the management and organizational dimension is the next severe and importance barrier for freight logistics firms.

The contributions of this study to the sustainability literature are multifold. First, it identifies and develops a theoretical framework of barriers to sustainable freight logistics based on existing literature and industrial managers' input. This framework is composed of 18 barriers which are further grouped into four areas namely, management and organization, social and legal, technological, and strategic dimensions. Second, it proposes and introduces a novel MCDA method called BWM for aiding the evaluation of the barriers to sustainable freight logistics. BWM is capable of computing the relative weights of the barriers using lessened decision-maker input; making it easier and more efficient to apply. Few decision-maker involvements and inputs prove to be more advantageous for MCDA techniques due to decision-maker fatigue, lack of time and interest in providing information. All these advantages are brought into the study. Third and finally, it applies this method to practically investigate the theoretical barriers framework using empirical data from logistics and supply chain managers' of the Nigerian logistics sector, helping build up studies from emerging economies on this subject.

6.2 Managerial and practical implications

The practical and managerial implications from the results of the study are that, managers should focus on the top ranked barriers and allocate enough resources to overcome these barriers in order to gain the most potential sustainability return. Thus, management of freight logistics firms in Nigeria can focus on monitoring these top-ranked challenges and ensure that effective mechanisms are put into place to overcome them before they become critical. More specifically, Nigeria freight logistics companies should develop/build a very strong financial base as an initial step for successful

sustainable freight logistics. This will help develop and support other initiatives to enable them deal with the pressing environmental and socio-cultural issues that are confronting them. Another option will be that, if these freight logistics firms wish to build sustainability into their operations, they can also focus and invest in the lower ranked barriers, which seems to be either more immature or less reinforced. The study's results do inform and provide options to managers of the Nigeria freight logistics industry to enable them choose among the barriers and identify which barriers to initially pay much attention during implementation and those that can be delayed, as a means of dealing with the barriers in a more systematic way. The results of the study although specific to a given industry in emerging country, the outcome may be applicable to other emerging economies and context.

Country and industry specific implications do exist. For example from the results, it is obvious that Nigeria freight logistics sector may be confronted with managerial and organizational, technological and strategic pressures when compared to social and legal pressures. Thus, the key barriers that potentially hinder freight logistics sustainability implementation programs are more internal rather than external. This means that these firms somehow have the power to deal with these barriers and progress to achieve the sustainability goal. In addition, firms may not have the required resources to deal with all the barriers simultaneously and so may choose among the barriers. Maximizing output in a resources constrained environment is a goal of most sectors. This study and its outcome can serve a foundation for prioritization. Therefore, it is important to offer freight logistics companies some useful guidance from a theoretical base and evaluation outcomes. This study does provide some initial guidelines to managers for dealing with the barriers that hinders freight logistics sustainability implementation.

6.3 Limitations and further research

Even though there are number of great contributions made by this study, there exist some limitations and concerns, and these provide an opportunity for further research. Given that this study was based on the opinions of experts in the Nigerian freight logistics industry, the results may be biased as they are hinged on the experts' understanding and human judgment. Further studies can apply this research methodology for analyzing and prioritizing challenges in different industries. This approach can also be tested in other countries for the freight logistics sector. A study can provide a comparison of the results for the freight logistics firms from different countries and show the variation of the top- ranked challenges/ barriers to sustainability among them. Furthermore, the research methodology employed in this study can be altered using different decision models such as DEMATEL, TOPSIS, ANP and systems dynamics modeling approach.

Clearly, more work across emerging economies, especially those economies from the Southern Saharan Africa, with respect to the barriers that hinder freight logistics sustainability implementation is required. It is further recommended that a wider view of freight logistics and transportation management study that consider barriers to the integration of sustainability innovation be investigated. Overall, this study set the stage for additional works on this important sustainable freight logistics and transportation management topic.

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Appendices

Table 3 Finalization of the challenges to implementing eco- innovation for freight logistic sustainability in Nigeria (Appendix 1)

Identified challenges to freight logistics sustainability	Relevant to the Nigerian freight logistics sector	
	Yes (Number of responses)	No (Number of responses)
Insufficient management support (MO1)	8	2
Lack of available funds (MO2)	9	1
Uncertainty behavior (MO3)	8	2
Incompetent workforce (MO4)	8	2
Poor knowledge of implications of eco- innovation (MO5)	8	2
Unclear business vision (MO6)	1	9
Improper communication amongst logistics partners (SL1)	9	1
Porous security network (SL2)	8	2
Profiling and complexity issues (SL3)	9	1
Poor legal framework (SL4)	8	2
Lack of consideration for human factors (SL5)	3	7
Lack of technology integration (TL1)	8	1
Lack of robust database (TL2)	8	2
Poor global standards (TL3)	9	1
Poor technological infrastructure (TL4)	8	2
Lack of technical expertise (TL5)	2	8
Unavailable government support (ST1)	8	2
Lack of improvement culture (ST2)	9	1
Lack of clarity on the financial benefits of eco- innovation (ST3)	8	2
Unavailability of research and development (ST4)	8	2
Fierce competitive pressure (ST5)	8	1

Table 6 Comparison of main category by Manager 1 (Appendix 2)

Best to Others	Management and Organizational dimension	Social and Legal dimension	Technological dimension	Strategic dimension
Best criteria: **Management and Organizational dimension**	1	9	3	5

Others to Worst	Worst criteria: **Social and Legal dimension (SL)**
Management and Organizational dimension (MO)	9
Social and Legal dimension (SL)	1
Technological dimension (TL)	5
Strategic dimension (ST)	2

Table 7 Comparison of main category by Manager 2 (Appendix 3)

Best to Others	Management and Organizational dimension	Social and Legal dimension	Technological dimension	Strategic dimension
Best criteria: **Management and Organizational dimension**	6	8	3	1

Others to Worst	Worst criteria: **Social and Legal dimension (SL)**
Management and Organizational dimension (MO)	2
Social and Legal dimension (SL)	1
Technological dimension (TL)	3
Strategic dimension (ST)	8

Table 8 Comparison of main category by Manager 3 (Appendix 4)

Best to Others	Management and Organizational dimension	Social and Legal dimension	Technological dimension	Strategic dimension
Best criteria: **Management and Organizational dimension**	4	8	3	1

Others to Worst	Worst criteria: **Social and Legal dimension (SL)**
Management and Organizational dimension (MO)	4
Social and Legal dimension (SL)	1
Technological dimension (TL)	2
Strategic dimension (ST)	8

Table 9 Pair wise comparison of Management and Organizational (MO) challenges by

Manager 1 (Appendix 5)

Best to Others	MO1	MO2	MO3	MO4	MO5
Best criteria: **MO2**	3	1	6	9	4

Others to Worst	Worst criteria: MO4
MO1	3
MO2	9
MO3	2
MO4	1
MO5	5

Table 10 Pairwise comparison for Social and Legal (SL) challenges by Manager 1 (Appendix 6)

Best to Others	SL1	SL2	SL3	SL4
Best criteria: **SL4**	5	8	2	1

Others to Worst	Worst criteria: **Social and Legal dimension (SL)**
Management and Organizational dimension (MO)	9
Social and Legal dimension (SL)	1
Technological dimension (TL)	5
Strategic dimension (ST)	2

Table 11 Pairwise comparison for Technological (TL) challenges by Manager 1 (Appendix 7)

Best to Others	TL1	TL2	TL3	TL4
Best criteria: **TL4**	3	5	9	1

Others to Worst	Worst criteria: **TL3**
TL1	2
TL2	3
TL3	1
TL4	9

Table 12 Pairwise comparison for Strategic (ST) challenges by Manager 1

(Appendix 8)

Best to Others	ST1	ST2	ST3	ST4	ST5
Best criteria: **ST3**	8	3	1	9	7

Others to Worst	Worst criteria: **ST4**
ST1	2
ST2	4
ST3	9
ST4	1
ST5	3