Examining Freight Performance of Third-party Logistics Providers within Automotive Industry in India: An Environmental Sustainability Perspective

Abstract

The purpose of this study is to examine relationships between measures of sustainable freight transport performance (in context of mid-sized third-party auto components' logistics players) with the associated externalities and firms' intrinsic characteristics when information exchange occurs between logistics firms and the auto manufacturer. Employing a survey-based research methodology, appropriate data were collected for a number of third-party logistics players, thus yielding a total of 708 responses from operational managers of these firms. The research construct was validated through rigorous procedure involving measurement and structural equation model. From a theoretical perspective, results of this study provide evidences supporting systemic relationships between internal enablers of the logistics firms and externalities in backdrop of environmental sustainability. Major findings indicate that transportation planning and distribution network and, commodity considerations backed by top management support can further environmental performance. Further, we also find evidence that effective transport planning and distribution network design used in conjunction with commodity considerations can be a source of sustainable supply chain performance. By bridging the literature pertaining to environmental sustainability, information exchange, and pertinent external/internal nuances of logistics firms, this study reveals novel findings that can help logistics players streamline operations focused at achieving environmental sustainability performance.

Keywords: Sustainability, Logistics Industry, Environment, Freight Transportation, Empirical Study

1. Introduction

The adverse impacts of green-house gases (GHG) on climate have been extensively researched and well documented (Bouzon *et al.,* 2015). Owing to the fact that core operations pertaining to logistics/transport sector contribute significantly towards GHG, the broad domain of sustainable freight transportation has received considerable attention in recent times both from academic and practitioner's perspective (Pan *et. al.*, 2013, Walker *et al.*, 2014, and Cagliano *et al.*, 2017). Sustainability in freight operations entails management of triple bottom line (TBL) such that the three key associated considerations i.e. economic, environmental and social perspectives can be addressed simultaneously (Pathak et al., 2019). At the firm level, for freight logistics and transport providers, a number of variables influences outcomes pertaining to the performance of sustainable freight operations. In this research, we explicitly focus on environmental dimension of freight transportation performance in that GHG reduction and low carbon growth are the two key outcomes considered resulting from operations of logistics and transport players. Specifically, we consider case of third-party (3PL) logistics providers associated with major auto-component aggregate manufacturers (having wide variety of components' portfolios that include axles, gear-boxes, propeller shafts etc.) supplying a number of engineering aggregates to a major automotive company in India.

It is a well-established fact that, broadly speaking factors intrinsic to organizations and pertinent externalities have a significant bearing on firms' operational performance (Wang et al., 2015 and Barrick et al., 2015). The study carried out by Hong et al., (2019) have also emphasized the role of execution through internal and external integration to achieve environmental sustainability related objectives for firms. Further, information exchange and sharing between internal and external stakeholders and, within internal stakeholders and within external stakeholders have been underscored as a pivotal dimension that influences the operational performance of firms. From a freight transportation perspective as well, information sharing has been identified as a critical dimension crucial for orchestration of entire logistics activities (Baz, et al., 2017). Few studies (often in a disparate manner) have modelled and underscored the role of intrinsic organizational factors, externalities involved, and information sharing in supply chain orchestration (Hong et al., 2019, Chan et al., 2018, and Flamini et al., 2015). To the best of authors' knowledge, no such study exists that investigates the interrelations amongst these three in context of sustainable performance of freight transportation of 3PL operators associated with transportation of automotive aggregates.

Further, the necessity of such integrational study is also driven by the fact that though environmental sustainability orientation is often initiated at the firms' corporate level, but too often at tactical and operational levels, concerned actors are not engaged to the desirable extent (Glover et al., 2011, Hahn et al., 2015, and Marshall et al., 2015).

In view of the above presented arguments, therefore, in this study primarily three key dimensions are postulated to have an influence on environmental sustainability performance of 3PL organizations (associated with transportation of automotive components) operating in India. The first dimension is essentially related to internal drivers pertaining to firms (termed as internal enablers); second dimension pertains to the externalities associated with the firms, while the third pertains to efficacy of information sharing within the value chain. Moreover, we consider India as a suitable field for this research as it is a large emerging country that has made considerable effort to modernize its freight transportation related infrastructure and logistics sector (Bloomberg, 2017). Within the manufacturing sector in India, automotive business is perhaps the largest sector that contributes to significant chunk of GHG and carbon growth (IBEF, 2018). The central government in India has become increasingly proactive in dealing with the logistics industry to make it accountable for missions resulting from associated operations. Last, but not the least, India's geographical position and democratic setup have over the last decade attracted big automotive players from across the world. In view of such key underpinnings, it is imperative that sustainable freight transportation and its relationships with respect to externalities, intrinsic factors and information sharing be examined in depth from the lens of 3PL firms so that meaningful inferences can be extricated. These inferences however would not be just localized for Indian case in that they can be generalized to other emerging/frontier countries as well, whose characteristics in terms of general economy, automotive industry, 3PL practices, environmental challenges etc. remain similar to that of India.

In context of 3PL logistics providers in India operating in auto-component transportation business, there has not been any study that empirically examines ecological aspects of sustainability, explicitly in terms of GHG reduction and low carbon growth and its interrelations with external dimensions, facets intrinsic to firms, and information sharing. Therefore, in view of this key research gap we posit the following research questions.

RQ 1: what kind of relationships exists between information sharing and sustainable freight transportation?

RQ 2: what kind of influence externalities exert on the freight transportation performance?

RQ 3: how internal enablers of 3PL firms influence the performance of sustainable transportation performance?

RQ 4: how information sharing influences freight transportation performance through mediating role of intrinsic considerations and externalities.

To address these questions, we conceptualize a structural equation model that aims to measure influences of internal enablers (related to 3PL firms), external enablers (related to externalities), and information sharing on the performance of freight performance expressed in terms of GHG reduction and low carbon growth. The choice of structural equation modeling (SEM) for statistical modeling of our devised construct pertaining to sustainable freight transportation is motivated by a number of reasons. Firstly, SEM would enable evaluation of the overall construct in its entirety thus allowing us to answer the research questions in terms of assessment of formulated hypotheses. Secondly, SEM is suitable for testing the construct involving both direct and indirect effects, and effects related to intra-construct dependencies. Finally, usage of SEM also allows us to overcome potential identification problems as has been argued in the study of Cheng et al. (2017).

At the firm level, enablers are hypothesized to be a function of transport planning and distribution network design, commodity considerations, and the extent of the top management support and commitment in adhering to the sustainable performance goals. Transport planning related considerations seem to have a certain relationships with respect to performance of the freight transportation in that transport planning influences performance parameters of sustainable freight operations at all level including strategic, tactical, and operational (SteadieSeifi *et al.,* 2014 and Dadsena et al., 2019). For instance, at the tactical plane, types of transportation modes involved, transshipment aspects, transportation synchronization, extent of FTL (full truck load) etc. are some of the key variables influencing overall freight performance measured in terms of CO_2 footprint (SteadieSeifi *et al.,* 2014 and Santen *et al.*, 2017). Further, capturing sustainability aspects in freight transportation requires a nuanced approach depending upon the type of commodity being transported. Consider for example shipping iron ore through sea lanes or transporting through trains; in such a case due to non-perishable nature of product, certain minimum level of product quality need not be maintained from origin to destination. Therefore, from a practice point of view, transportation related complexities remain within a certain threshold. In case of perishable commodities such as fruits and vegetables however, delivering these would be relatively complex in that other critical inputs need to be considered. Some of these inputs pertain to the fact that as opposed to non-perishable commodities, fruits/vegetables are characterized by finite shelf life and certain demand pattern (Nahmias, 2011). The complexities associated with transporting perishable commodities are further compounded by refrigeration requirements during transportation. Continual involvement and commitment from the top management team has also been illustrated as one of the key drivers that ensure success of the adoption of the green practices in organizations (Elmualim *et al.*, 2012).

In Indian context, the central government mandated adoption of Bharat Stage-VI emission norms for vehicles plying on roads by April 2020. At the same time, regulatory practices dictate that logistics and transport companies operate fleets having appropriate emission compliance. Recycling and suitable waste management practices have also been instituted for transporters operating in freight transportation of certain commodities. Therefore, public and regulatory pressures, adoption of environmental standards, as well as adoption of the green practices are also postulated as some the key drivers influencing the manner in which logistics providers operate. Important aspects of information exchange have also a mediating effect on the sustainable performance of freight transportation. The relevance of regulations and adoption of green practices while conceptualizing our empirical model pertaining to India's 3PL logistics operators also assumes importance due to the fact that India is amongst a handful of major countries that are striving for (in fact is on track) to achieve the national targets set to address climate change under the Paris agreement. Therefore, companies have to increasingly align themselves with the climate goals the government has set (The Economic Times, November 2017 and Annachiara et al., 2018).

Our research augments extant body of knowledge related to sustainability in freight transportation in that this study investigates (1) relationships between information sharing and sustainable freight transportation; (2) influences of externalities on freight transportation performance; (3) influences of intrinsic considerations of 3PL firms on freight transportation performance; and (4) influences of information sharing on freight transportation performance through mediating role of intrinsic considerations and externalities.

Rest of the article is arranged as follows. Section 2 examines pertinent and recent research literature in detail. Section 3 presents the conceptual model and postulates the hypotheses. Section 4 details research design and related methodology. The discussions and managerial insights based on the results are covered in Section 5. Finally, paper concludes by enumerating the conclusions and future research in Section 6.

2. Literature survey

In this section, we review the extant literature on sustainable freight performance and its relationships with respect to externalities, firm level enablers, and information sharing. The literature review provides the theoretical foundation for this research.

2.1 Sustainable freight transport performance

It is a well-established fact that one of the key metric of sustainable freight performance at firm level is extent to which the firm has been able to reduce its carbon footprint (Tyan *et al.,* 2003). Different studies have proposed different ways of mitigating GHG reduction. Pan *et al.,* (2013) advocated geographical and product flow pooling as the two-primary mechanisms of reduction of greenhouse gases. These two interventions broadly were devised as a part of supply chain pooling strategy such that geographical consolidation among suppliers and retailers with similar flows could be carried out. Allen *et al.,* (2012) examined the impact of use of urban consolidation centers (UCC) as an enabler to reduce vehicular pollution. In particular, this study considered 114 UCCs in 17 countries that were either operational or under feasibility study to assess the extent to which UCC had been effective in ensuring reduced pollution levels. Ni *et al.,* (2014) studied the interrelation of service time in a multi-echelon supply chain with carbon emission cost rate. This study further modeled carbon emissions pertaining to individual stages of supply chain such that trade-offs between service time and carbon emissions could be performed. Dhar *et al.,* (2015) underscored the need for low carbon policies to clean the transport sector, significant chunk of which was constituted of freight transportation activities. This study further considered primarily rail and road-based modes for policy formulation of low carbon-based framework in Indian context. One of the key insights arising out of this study was that actions oriented around global carbon price trajectory result in both positive co-benefits such as superior air quality and negative co-benefits such as need for energy security. Menezes et al. (2017) evaluated low-carbon urban development strategies for urban transportation in a large city in Brazil. This study advocated that two measures namely usage of biofuels and transport pooling present the highest potential for reduction in GHG emission. Creutzig *et al.,* (2016)'s contributions primarily related to assessing different approaches including policy level, technological level, and cultural level in context of low-carbon transportation future. This study further concluded that typically integrated assessment models focus on fuel composition; while transport-sector models emphasize upon efficiency measures. Cui *et al.*, (2015) modeled freight turnover volume as input and, carbon growth, capital, and labor as output for developing a virtual frontier DEA based model that aimed to evaluate freight transport carbon efficiencies using data from 15 countries. Further, this model also employed Tobit regression model to identify important influencing factors for increasing the transportation carbon efficiency.

2.2 Externalities

At the policy level, Koppenjan *et al.,* (2015) examined risks associated with a public private partnership (PPP) model in developing green infrastructure aimed at achieving GHG reduction. The study suggested need for greening of the economy in general and transport sector in particular around a PPP based regulatory framework. Evangelista *et al.*, (2014) assessed the environmental sustainability initiatives undertaken by third-party logistics providers (3PL). Specifically, this research identified two primary research gaps viz. identifying the type of green initiatives implemented and converging on the barriers and drivers influencing adoption of such practices. Dablanc *et al.,* (2017) examined the effectiveness of urban freight transportation strategies in context of U.S. in that three broad categories of strategy were focused upon i.e. last-mile/first-mile delivery and pickups, environmental mitigation, and trade node strategies. This study further assessed the extent to which firm level adoption of green practices influences the carbon footprint of a given logistics firm. Wangsa et al., (2017) introduced greenhouse gas penalty and incentive policies for freight transportation considering both industrial and transport related emissions. The study intended to analyze total cost of transportation from both penalty as well as incentive standpoint in context of an economic lot size problem. Ellram et al., (2017) in their state of art literature review detailed the role governmental regulations and policies play in promoting environmental sustainability in freight transportation. This study inferred that strict regulations pertaining to emissions might in short term inflict significant costs to concerned stakeholders such as logistics operators and governments; however, in long run the overall costs for entire ecosystem gets mitigated significantly.

2.3 Firm level enablers

Schliwa *et al.,* (2015) investigated potential of cargo cycles thus making within city freight logistics more sustainable. This study further explored ways in which diffusion can be ensured. This paper contributes to the existing body of knowledge in that it suggested ways such as incentivizing large logistics firms to integrate cargo cycles into supply chain and thus drive a long-term modal shift. Beske *et al.,* (2014) outlined how sustainable supply chain management and dynamic capabilities strengthen the key dimensions of sustainability viz. economic, social and ecological in context of food industry. A key contribution of this work pertained to identification of sustainability practices to enhance traceability and tracking of food delivery. Mathivathanan *et al.,* (2014) contributed towards sustainable supply chain research in context of automobile transportation by identifying some of the most useful practices in automotive industry incorporating views from multiple stakeholders including managerial, environmental, societal, and governmental. Specifically, results obtained (using decision making trial and evaluation methods), in this study revealed a number interrelated factors including product considerations etc. in enhancing sustainability practices in automotive industry. Glover *et al.,* (2014) explored the role of supermarkets in development of sustainable practices in dairy supply chain using institutional theory. In particular, this study focused on dairy firms and associated energy consumption spread across various stages of value-chain such as transportation, storage etc. Thirupathi et al., (2016) studied the interrelations between sustainability enablers namely economic prosperity, environment well-being, social well-being, and performance management, thus explicating practical insights for manufacturing sector in southern India. Mathivathanan *et al.,* (2018) in their research related to sustainable practices in Indian automotive industry identified top management support and commitment as a crucial enabler for success of sustainability efforts at firm level. Further, this research identified internal management commitment of firms assuming larger role in ensuring sustainability than governmental rules and regulations. A caveat associated with this study however was that management commitment assuming a greater role (than governmental regulations) holds good primarily for private entities and not for governmental or semi-governmental organizations. Chan et al., (2016) underscored the role of quick response accompanied by cleaner technology for coordination amongst stakeholders in logistical value chain. Specifically, this research modeled two supply chain contract types viz. minimum ordering quantity (MOQ) and minimum ordering quantity with buyback (MOQ-BB). Colicchia *et al.*, (2013) examined aspects related to environmental sustainability among logistics service providers (LSP) by identifying barriers and drivers that hinder or facilitate adoption of environmental initiatives. This work also underscored the fact that perhaps at the firm level, support from top management and their continual engagement significantly enhance the likelihood of success of green initiatives.

2.4 Information sharing

Hao *et al.,* (2015) suggested various mitigation strategies for dealing with growing GHG emissions in Chinese freight transportation sector. Among other interventions, this study identified lack of information platform as one of the key impediments in achieving optimal mileage utilization rate. At a policy level, this study advocated establishing uniform logistics information platform as a way to mitigate GHG emissions in freight transportation sector. Ni et al., (2016) investigated the impact of information technology-based platforms using spatial autocorrelation model considering freight flow data from a leading less-than-truckload (LTL) company in China. The results of the analysis suggested that information technology related variables have positive effect on freight flows – an important finding also validated by the study of Wang et al., (2015). Ramanathan *et al.*, (2014) identified effective collaboration in freight supply chain (consisting of suppliers, logistics providers, and retailers) as one of critical variables for ensuring environmental sustainability. Flamini et al., (2018) evaluated the added value created by re-optimizing off-line information exchange-based solutions with real-time information exchange. This study holds all the more importance due to the fact that the studied freight under investigation belonged to perishable class of goods.

Based on an exhaustive review of pertinent and recent research, literature taxonomy is provided in Table 1(a) in that articles considering externalities, internal enablers and information sharing related dimensions are considered and contrasted with respect to our research.

<<Insert Table 1 here>>

For 3PL firms, very few studies have examined the issue of ecological sustainability from perspectives of externalities related to firms, their intrinsic dimensions, and information exchange. As evident from literature review and the taxonomy provided in Table 1, there have been very limited scholarly attempts that sew together sustainable supply chain practices from an ecological perspective with external and internal enablers of 3PL firms (belonging to auto component freight transportation in India), and information sharing aspects. Further, the influence of information sharing through mediating roles of internal and external enablers have not been investigated yet in Indian context. The extant research literature on sustainable freight transportation including those related to urban transportation, logistics service providers and 3PLs have can be classified in one of the six broad approaches (Centobelli, et al., 2017 and Lagorio et al., 2016) from a methodological perspective. These six approaches are: a) Case study/interview based; b) Quantitative modeling based; c) Industry survey based empirical studies; d) Experimental/pilot studies; e) Simulation based; f) State of art literature reviews.

Methodologically, our study falls under industry survey based empirical study. Such studies have often utilized statistical methods such as structural equation modeling, path modeling, linear regression/multiple linear regression, higher order regression model etc.

3. Conceptual model and hypothesis development

In this article, we postulate hypotheses seeking to test empirical linkages amongst sustainable freight transportation, information sharing, external and internal enablers of considered firms. We deploy a structural equation model (as illustrated in Figure 1) to test various influences and mediating roles.

<<Insert Figure 1 here>>

3.1 Hypotheses based on direct influences

3.1.1 Based on relationship between information sharing and sustainable freight performance

Many of the 3PL logistics players operating in freight transportation of auto components in India (for that matter even in developed world) share auto components' manufacturer related information with OEMs either on a real time or periodic basis. However, such practices are largely limited to large logistics companies. Moreover, these practices are intended more for the inventory management rather than for mitigating emission levels. For instance, dimensions related to packaging (certain components for example rubber parts need special weather proofing), lot size, requirements for transport pallets, delivery pickup information etc., can have an influence on emission level and carbon footprint. However, to what extent these facets are predominant as far as effecting any significant reduction in emission level is something that has remained unexplored in context of mid-sized 3PL operators considered in this study. At best there are a few anecdotal evidences suggesting some correlation between emission levels and inclusion of manufacturer related information of components during transportation. Although, there have been anecdotal evidences suggesting benefits of such practices (Gunasekaran, et al., 2017, Tatoglu, et a., 2016, Chandra et al., 2016); there has not been any formal study substantiating environmental benefits of such a practice in context of 3PL automotive suppliers. Therefore, we postulate the following hypothesis.

Hypothesis 1(a): Ensuring effectiveness in supplying manufacturer information pertaining to components to be transported (either on a real time or periodic basis) to 3PL operators have a positive impact on performance of the freight transportation in terms of sustainable GHG reduction and low carbon growth.

Dimensions related to information quality in supply chain such as exchange of real-time information, information completeness, information relevance, and information accessibility between 3PL operators and concerned stakeholders etc. have been shown to have a significant influence on operational measures of supply chain such as total distance traversed per ton of goods, fuel consumption etc. (Zhou *et al.*, 2007, Zaman et al., 2017, Geiger, 2016). Moreover, the need to have rich information quality would assume primacy when auto components are being transported from manufacturers to OEM's facilities (i.e. 3PL operators pick components from components' manufacturer' facilities and deliver to the OEM's facilities) as opposed to the reverse trips. In such instances, it would be pretty prudent to say that the 3PL operator, the component manufacturer and the OEM need to coordinate amongst themselves such that high-quality information can be exchanged seamlessly. Based on above premise, we formalize the following hypothesis.

Hypothesis 1(b): Effectiveness of quality of relevant information concerning stakeholders involved in value-chain has a positive impact on sustainable performance of freight transportation particularly when the 3PL operators carries out a trip from manufacturers' locations to the OEM's locations.

Critical customers related aspects such as changes in purchase order information, planned delivery order information, product design specifications, product planning information etc. have been shown to have influences on the supply chain performance measures (Zhou *et al.,* 2007 and Kuiti et al., 2019). As argued in the work of Lai et al., (2015) and also backed by the work of Tatoglu et al., (2016), sharing customers' related information within supply chain ecosystem of manufacturing enterprises can aid in obtaining economic as well as environmental benefits to the concerned stakeholders. However, in order to explicate the benefits associated with environmental considerations, it would be imperative that appropriate hypothesis be formalized concerning environmental aspects only. Therefore, we proposed the following hypothesis.

Hypothesis 1(c): Ensuring effectiveness in supplying customer related information to 3PL operators have a positive impact on sustainable performance of freight transportation.

Use of information system support technologies including both hardware and software, and frequency of information exchange between 3PL and concerned stakeholders have also been shown to have an influence on sustainability performance of the supply chain (Zhou *et al.,* 2007). As argued in the work of Gonzales-Feliu et al., (2016) and also supported up by that of Agostinho et al., (2016), information system support technology if implemented with adequate capabilities can serve to enhance the overall operational performance of supply-chain ecosystem. However, to what extent information sharing support technologies can further the sustainability performance within the automotive component logistics sector (that too from a 3PL's perspective) is something that need further exploration. Therefore, we propose the following hypothesis.

Hypothesis 1(d): Effectiveness of information sharing support system has a positive impact on the environmental sustainability measures of freight transportation.

3.1.2 Based on relationship between external enablers and sustainable freight performance

Public and regulatory pressures and enforcement for adoption of environmental standards by federal government (for example ISO 14001 for pollution control in core operations) resulting in adoption of green practices on the transport sector in general and logistics operators in particular influences the manner in which 3PL logistics firms report sustainability footprint in terms of energy consumption, efficiency of fleet and so on. These measures can be adopted as a proxy measure of gauging the extent of sustainability in freight transport operations (Furst *et al.*, 2012; Link 2012). Further, ever tightening environmental regulations in large developing countries (including India) have made 3PL operators not only comply with existing regulations, but also influenced subsequent regulatory measures that might affect the industry. Regulatory norms such as "cap and trade" in USA have put considerable pressures on entire freight ecosystem (including 3PL operators) to operate "greener" supply chain (Leib et al., 2010). There have been analytical and case based investigations demonstrating positive relationships between sustainability outcomes of the supply chain and regulatory pressures (Evangelista et al., 2014 and Ellram et al., 2017). However, in an Indian setting and that too particularly for freight transportation, it is imperative to investigate the relationship between regulatory forces and sustainability related performance. Therefore, we hypothesize the following.

Hypothesis 2(a): Public and regulatory pressures force 3PL operators to institute practices that have a positive impact on sustainability outcomes of the firms.

There are well established environmental standards defining guidelines that are aligned with environmental sustainability outcomes. Though theoretically, adherence to such guidelines can further the environmental performance of organizations, the empirical evidences are mixed (McGuire 2014). For instance, Nishitani (2009) found a positive correlation between ISO 14001 certification and environmental sustainability performance in context of Japanese manufacturers. McGuire et al. (2014) did not find any such relationships in their sample of Mexican freight transportation associated with manufacturing firms Adoption of such environmental standards (often voluntary in nature) developed to overcomes weakness of traditional regulatory instruments provides incentives for firms to lower emission in their operations while reducing the administrative and monitoring costs associated with traditional regulators. However, in context of

Indian 3PL sector, its potential need to be examined in view of lack of empiricism. Therefore, we postulate the following hypothesis.

Hypothesis 2(b): Adopting environmental standards by 3PL operators have a positive impact on sustainability outcomes of the firms.

Adoption of environmental standards and being compliant to environmental regulations are primary instruments that firm adhere to in mitigation of their environmental sustainability related outcomes. In addition to these two, adoption of green practices is another important instrument that firm deploy to improve their environmental sustainability related performance. Though characteristically closer to environmental standards (due to voluntarism), green standards are different from regulatory pressures in that in context of environmental regulations, typically governmental authorities are involved (Stelling et al., 2014). Studies such are that of Stelling et al., (2014) have demonstrated positive correlation between greenness of firms (in term of measurable and relevant key performance indicators) in context of Swedish freight transport sector. However, a key challenge that persists for the 3PLs considered in our study is that, often well laid down procedures are typically instituted for only plant level processes for example warehousing, storage, intra-plant movement of goods at the logistic operator's premises. From a green logistics perspective however, such procedures are not standardized and is not deployed uniformly by 3PL firms (Malik et al., 2019). Therefore, it would be imperative for a 3PL operator to consider sustainability outcomes from a decoupled view in that effectiveness of deployment of green practices during freight transportation must be objectively ascertained. In view of the above, we posit the following hypothesis.

Hypothesis 2(c): Green practices adopted by 3PL operators have a positive impact on the sustainability outcomes of logistics firms.

3.1.3 Based on relationship between internal enablers and sustainable freight performance

Efficient transport planning and distribution network design in context of 3PL firms play a pivotal role in ensuring reduced fuel consumption, lower waiting of fleet(s), and lesser kilometerage traversed for delivery. Analytical models and several case based research methods have demonstrated the utility of transportation and distribution planning as far as mitigation of carbon footprint is concerned (Cui et al., 2015 and Russo et al., 2016). Further, commodity considerations play a significant role in the total energy footprint of the transportation sector (for instance rubber components requires a cold transportation-based infrastructure to maintain the desired mechanical properties of such components). Oberhofer et al., (2013) in their work emphasized upon continuous execution and monitoring of operational level sustainability related measures for effecting positive changes in transportation and logistics sector particularly from a commodity and transport planning related perspective. However, such assertions require empirical testing rather than relying purely on anecdotal assertions. Therefore, following hypotheses are postulated.

Hypothesis 3(a): Efficient transport planning and effective distribution network does have a positive impact on measures of the sustainable freight transportation performance.

Hypothesis 3(b): Including commodity considerations does have a positive impact on measures of sustainable freight transportation performance.

As Hambrich and Mason (1984) have suggested that organizational choices are a reflection of the top management values. Cognitive base of top management plays an important role in shaping and implementing the firm's strategies in terms of continual support. This is achieved by top management's belief structure in analyzing and responding to the environment and use these beliefs to guide their administrative behaviors (Lee et al., 2014, Liang et al., 2007, and Yuan et al., 2020). Such a supportive role of top management in furthering the organizations' initiatives has found evidence in the study carried out by Yigitbasioglu et al., (2015). Mathivathanan *et al.,* (2018) in their research related to sustainable practices in Indian automotive industry identified top management support and commitment as a crucial enabler for success of any sustainability effort at firm level. Therefore, in line with the above argument and in context of 3PL logistics players, we postulate the following hypothesis.

Hypothesis 3(c): Continued top management support at the firms' end does have a positive impact on measures of the sustainable freight transportation performance.

3.2 Hypothesis based on mediating roles

Dimensions of information sharing can have an influence on the effectiveness of role of external enablers that in turn can further sustainable performance of 3PL firms under consideration in this research. A case in point would be for instance when the end customer (OEM) desires packaging of components to have a paper-based packaging rather than plastic-based packaging to reduce

OEM's own disposal costs. In such a case, clearly information sharing in the form of customer information at the particular 3PL firms would have a mediating role on adoption of green practices such that positive impact on GHG reduction (in terms of reduced energy footprint) and low carbon growth can be realized. Extant research literature has both empirically (Zhou et al., 2007; Klimova et al., 2016, and Kormos et al., 2014) and analytically (Khan et al., 2016) demonstrated the positive relationship between efficacy of information sharing and extent of sustainability in supply chain and freight transportation. These outcomes have been typically measured in terms of reduction related to GHG, carbon footprint, energy consumption etc. However, how information sharing mediates the extent to which various aspects of internal enablers influence sustainable freight transportation performance is something that remains uninvestigated. This question assumes even the more importance from the perspective of information exchange in that individual dimensions of information sharing such as quality, asymmetry, distortion, availability would have a bearing on sustainable freight transportation performance when mediated though the respective technical and commercial aspects discussed in Section 3.1. Studies such as those of Sternberg et al., (2012) and Bisogno et al., (2015) have demonstrated that information exchanges amongst involved actors strongly improve efficiency of freight operations. This implies that it can improve the measures of sustainable freight transportation, Respective dimensions of both internal and external enablers are driven primarily by techno-commercial considerations (transportation planning and distribution network, commodity considerations, adoption of environment standards and adoption of green practices), regulatory considerations (public and regulatory pressures) and other organizational considerations (top management support). Since these considerations get mediated through the information exchange amongst the concerned stakeholders (top management and concerned manpower of OEM and 3PL operators, and regulatory body etc.), it would be quite prudent to investigate the following hypotheses.

Hypothesis 4(a): Effective information sharing would have a mediating role on transportation planning and distribution network in such a manner that it would have a positive impact on sustainable freight transportation performance.

Hypothesis 4(b): Effective information sharing would have a mediating role on commodity considerations in such a manner that it would have a positive impact on sustainable freight transportation performance.

Hypothesis 4(c): Effective information sharing would have a mediating role on top management support in such a manner that it would have a positive impact on sustainable freight transportation performance.

Hypothesis 5(a): Effective information sharing would have a mediating role on public and regulatory pressures in such a manner that it would have a positive impact on sustainable freight transportation performance.

Hypothesis 5(b): Effective information sharing would have a mediating role on adoption of environmental standards in such a manner that they would have a positive impact on sustainable freight transportation performance.

Hypothesis 5(c): Effective information sharing would have a mediating role on adoption of green practices in such a manner that it would have a positive impact on sustainable freight transportation performance.

4. Research Design and Methodology

4.1 Instrument design and data collection

In this research, we consider a total of one hundred and fifty four 3PL providers holding contractual agreement with a major automotive company in India for transporting primarily A class items (engines, gear-boxes, propeller shafts and so on) from and related components various auto-component manufacturers' locations. The study involved two distinct data collection stages i.e. pilot survey and formal survey. The pilot survey is essentially intended to ensure viability of such study and rationalization of the data collection mechanism. Further, we also relied on five academic researchers and five senior level industry practitioners for relevance and clarity. The questionnaire designed for the study was iteratively refined based on inputs of these ten subject matter experts. Further, to each of these one hundred and fifty four 3PL operators, 20 surveys were mailed (requesting inputs primarily from middle and top management operational managers). All these companies in the last financial year had an annual turnover ranging from ($50 - $80) Millions. The workforce strength of these companies ranged from 750 to 1100 number of employees. These 154 companies are essentially the mid-level market players in India's logistics industry. As evident from the declared attributes, the kind of sample that we are considering in this study is rather homogenous. Out of the total 3080 surveys sent, 708 were received, thus making response rate approximately at 23%. Therefore, the data analysis is based on 708 useable questionnaires. In order to test non-response bias, the responses of those who returned questionnaire earlier were compared with those who returned later to gauge if there are any statistical differences (Lessler e*t al.,* 1992 and Zhou *et al.,* 2007). Since, the sample considered in this study is relatively homogenous, we ascribe 708 numbers of responses to be adequate. However, this might not have been the case if companies would have belonged to different annual turnover scales or significantly different workforce strengths. Table 1(b) presents the profile of 154 companies considered in the study. The data related to the firms' age, annual turnover, and firms' size were taken from publicly accessed registered companies' websites (such as- data.gov.in hosted by Ministry of Corporate Affairs, Government of India) and other commercially run Indian online business websites (such as moneycontrol.com). The survey data as collected from respondents were dealt in the following manner. Because of the fact that the respondents belonged to different parts of India characterized by different linguistics, we also developed corresponding questionnaires in respective region specific languages (seven different languages in this case were Hindi, Marathi, Guajarati, Tamil, Telugu, Bengali and Kannada). We developed questionnaires corresponding to these seven languages from originally developed English questionnaire through a back-translation process. First, we translated all the items of the original questionnaire into respective items of these seven languages. Thereafter, we asked independent translators to back-translate into English. In case there was significant difference between the original English questionnaire and for instance that of Hindi, we translated the original English version into Hindi version and then back-translated that translated Hindi version into English. We continued this process until there was no significant different between original items and back-translated ones. Zhou et al., (2020) also details instance of such iterative translation process.

Referring to Figure 1, there are 12 variables viz. *information sharing support technology, customer information, manufacturer information, information quality, transport planning and distribution network, commodity considerations, top management support, public and regulatory pressure, adoption of environment standards, adoption of green practices, GHG reduction,* and *low carbon growth.*

The excerpt of the questionnaire for the study is detailed in Appendix section. It is to be noted that for variables related to "*information sharing"*, we use the questionnaire as devised by Zhou *et al.* (2007). The questionnaire essentially is based on a 7-point Likert scale.

4.2 Measurement

The measurement items related to the construct and related references are provided in Table 2. These measures included in our study are from those used in established studies.

<<Insert Table 2 about here>>

4.2.1 Internal enablers

The constructs related to internal enablers viz. top management support, transportation planning and distribution network, and commodity considerations have a number of measurement items adapted from extant studies. Chino et al., (2013) in their study of high performance supply chain management formalized communication, motivation, commitment, and continuous implementation and momentum as four key enablers driving the extent of top management support. This study also established definitions of each of these enablers in context of high performance supply chains. For instances communication was defined as "to establish mutual trust and coordinate supply chain functions, we should pay attention to the related channels of communication and coordination. We and our suppliers need to solve problems together, and communication is the key to this". It is to be noted that these four enablers were categorized within the bucket of tactical enablers in the backdrop of this study. Building upon the work of Chinho et al., (2013), we further refined the definitions to include the sustainable supply chain performance outcomes in our study. As far as the survey is concerned, respondents were asked to indicate the extent of top management support on a Likert scale of 1 to 7 such that these have a mitigating effect on the two outcomes of sustainable freight transportation considered in our study i.e. low carbon growth and GHG reduction. For instance, first level is demarcated by 1 wherein the top management support is barely minimal with no reflection from top management to support the environmental sustainability related initiatives within their respective organizations. On the other end of the spectrum lies 7 indicting proactive involvement and long term commitment from top management in furthering the sustainability goals of respective organizations.

Sharma et al., (2013) in their study pertaining to intelligent transport system and aimed at reduction of carbon print, considered five key operational dimensions viz. logistics planning (outbound and inbound), management of transport congestion, schedule related to freight dispatch, backorder management and extent of full truck load (FTL) etc. as broad parameters influencing realization of environmental sustainability in freight handling operations. Amongst these five, perhaps backorder management and extent of FTL perhaps are rather objective criterions in that lower the extent of backordering and higher the FTL, better would be environmental sustainability related outcome (Szeto et al., 2012). Thus, the first level is demarcated by 1 to indicate that extent of backordering and FTL is more than 90% and less than 10% respectively. On other side of spectrum, respondent giving a rated score of 7 indicates extent of backordering and FTL remaining less than 10% and more than 90% respectively.

The studies carried out by Pires et al., (2015) and Martinho et al., (2015) emphasized a number of factors driving both consumers' purchasing decisions and operational decisions within the supply chain of commodities (particularly those characterized by perishability). Certain commodities such as food items, vegetables and fruits have a rather higher decay rate. The commodities however under consideration in this study (for instance automotive rubber parts decaying at a certain rate in terms of their mechanical properties) is characterized by much slower decay rate. From a commodity centric perspective, extant studies have proposed a number of dimensions playing a role in attainment of environmental sustainability performance in freight transportation (Shamshi et al., 2014). These dimensions have primarily revolved around materials, processes, and extent of energy efficiency provided by freight infrastructure (for both storage and transportation). Environment friendly packaging requiring least energy input in production and usage is often considered a major variable. White et al., (2015) in their study pertaining to green packaging design in context of automotive supply chain evolved five key dimensions associated with environment friendly packaging. These five dimensions are reusability, recoverability, recyclability, compostability, and biodegradability. Similarly, studies by Aung et al., (2014) and White et al., (2015) identified five drivers of energy efficiency viz. consumption of energy and other resources, emission to air, water or soil, anticipated pollution, generation of waste material, improvement in re-use of energy. In order to ascertain the ratings from respondents related to sustainable sourcing, we utilized the framework proposed by Akhavan et al., (2017). This study proposed two key drivers for sustainable sourcing viz. supplier screening and supplier development with focus on environmental issues. Supplier screening is further characterized by definition of minimum green standards, supplier assessment, supplier monitoring, penalties in case non-compliance, and suppler selection process. Supplier development with focus on environmental issues is characterized by collaboration, joint development, training and education, supplier incentives, and, share knowledge and asset investment. Building upon these drivers of sourcing for sustainability, we refined the definitions to include the sustainable freight transportation outcomes in our study.

4.2.2 External enablers

Yu et al., (2015) in their study related to stakeholder pressures and green operations practices for environmental performance utilized the stakeholder pressure constructs and related variables for ascertaining their implications for environmental sustainability of supply chain. We adapted the same variables therefore as far measurement of societal inputs for regulatory compliance is concerned. In particular, the measurements in our study revolves around customers', supply chain parterner', competitors', and respective marketing department's pressure on the firms in attainment of environmental sustainability objectives. Compliance to environmental regulations and penalties in case of non-compliances are relatively much easier to deal with structurally in that we specifically looked for the degree to which firms were served penalties/notices in previous years' operations in case freight operations violated governmental stipulated regulations.

Our study further utilizes the frameworks developed by Yu et al., (2015) and Guenther et al., (2010) in ascertaining the measurement items for green products and services. In particular, this was ascertained considering four major aspects and were based on whether:

a) extent to which firms achieved important environment related certifications.
b) extent to which firms regularly achieved targets imposed on energy conservation, recycling, and waste reduction.
c) extent to which environment friendly practices saved significant amount of money in the past.
d) extent to which overall environmental performance has improved in preceding five years.

Yu et al., (2015)'s theoretical constructs in adoption of environmental standards is another importance variable that characterizes various underpinning aspects as far as measurement is concerned. For instance, nuances related to internal green management as proposed in the study of Yu et al., (2015) gives a glimpse into the number of measurement items related to technological interventions, control mechanisms, and environment oriented practices. For the sake of brevity, these measurement items are not discussed in detail; nonetheless they are detailed in this study of Yu et al., (2015).

4.2.3 Information sharing

As far as the construct "information sharing" is concerned, measurement items related to information sharing support technology, customer information, manufacturer information,

information quality, and information quality are adapted from the study of Zhou et al., (2007). Therefore, their treatment is not detailed in this article for the sake of brevity.

4.3 Response analysis, measurement scale and reliability study

Descriptive statistics for each of the survey statements are presented in Table 3(a).

<<Insert Table 3 here>>

4.3.1 Testing independence across responses

Referring to Table 3(b), 708 collected responses came from 154 different companies. As evident, there were five different group of companies associated with multiple responses. However, these 708 responses were unique in that each of these responses belonged to particular OEM-supplier's facility pair implying that there were 708 distinct routes connecting the OEM to facilities of individual suppliers in context of the inbound/outbound logistics of components/aggregates of A class items. The way the logistics business operate in this setting is that an employee belonging to an individual 3PL player are typically stationed at the facilities of each suppliers so as coordinate the inbound/outbound logistical activities. This means that no personnel belonging to a particular 3PL firm is co-located with their other colleagues belonging to the same firm. Thus, a 3PL firm's staff is essentially deputed to serve a particular OEM-supplier's facility pair and hence is not co-located with any of their firms' colleagues.

Further, in order to test for independence of responses belonging to same firms, we followed two step process. First step entailed Chi-Squared test of independence for each of these companies associated with multiple responses. The descriptive statistics (based on measurement items) from individual responses for all companies were run through Chi-Square test of independence. In this test, we found Chi(statistic) to be less than Chi(critical), thus signifying independence of responses. Second step involved segregating all responses belonging to a single firm and then choosing the response that came from the operational manager of respective firms possessing the highest number of work experience. Thus, there were 154 individual responses (one each from 154 companies) to each of the measurement items. If respective mean of individual measurement items related to these 154 responses can be proven to be not statistically different from respective mean of those provided by original descriptive statistics based on 708 responses, we can rely upon the 708 responses for subsequent reliability analysis. To test for statistical significance, we carried out Paired two-tailed t test for means. For the sake of brevity, the paired differences related to means of measured items is not being included in the manuscript (available on request). At 0.01 significance level, the t(statistic) was found out to be -0.454; while the t(critical) was found to be 2.653. The *p* value was ascertained to be 0.527. Based on the t(statistic) and *p* values it can be ascertained that measurement items considering single response from each of 154 companies vs. 708 responses are not statistically different.

4.3.2 Measurement and reliability

As far as the validation process is concerned, the survey had three primary steps as employed by Zhou *et al.,* (2007). These three steps are content validity, construct validity, and reliability. The critical literature review and in-depth discussions with senior level industry practitioners and academic researchers establishes the basis for content validity of survey designed for this study. Construct validity is aimed at ensuring right measurements i.e. questions designed in the questionnaire measure what they intend to measure. Unidimensionality is established with exploratory factor analysis, where 0.30 is usually considered to be the lowest significant factor loading to define a particular construct (Hair *et al.,* 1998). Cronbach's alpha is used in this study as a measure of internal consistency and reliability, as it is most widely used to ascertain the internal consistency and reliability associated with empirical constructs (Taber, 2017). Cronbach's alpha is primarily concerned with measurement of reliability for empirical constructs associated with data collection in a single administration (as is the case in our study). Moreover, Cronbach's alpha considered to reveal about interrelatedness of the construct items is often considered a prime measure of internal consistency (Bonett et al., 2015). Researchers have typically agreed that small sample value of Cronbach's alpha typically is indicative of weak reliability and consistency associated with the study. However, there is no universal minimally acceptable reliability value, since such value is often contingent upon type of empirical construct. In research applications characterized by estimation of size of population effect sizes, acceptable value of Cronbach's alpha can be as even lower than 0.7 (Bonett et al., 2015). Further, acceptable Cronbach's alpha also depends upon whether the empirical construct is completely new (in which case lower value are acceptable as well). Since in this study, our construct for most part is newly developed (except the variables related to information sharing), therefore the minimum acceptable value for Cronbach's alpha is established as 0.65. This value is set empirically as an averaged-out value considering

0.70 as the threshold value for already developed constructs and 0.60 for newly developed constructs. (Nunnally, 1994). The results of the measurement scales are captured in Table 4.

<<Insert Table 4 here>>

Table 4 demonstrates that all factor loadings are significant in that associated values are more than 0.3 (Kerlinger, 1986). Further, it was found that for all the constructs except "GHG reduction", only one eigenvalue is higher than 1. Further, depending upon the eigenvalue obtained and considering the variances, "GHG reduction" is found out to be unidimensional. All the scaled values are found to have higher Cronbach's alpha value than the threshold value of 0.65. Therefore, the measured scale for our construct is deemed reliable (Hair *et al.,* 1998). Higher item AVE for individual construct is higher than shared variance, thus signifying discriminant validity (Fornell and Larcker 1981). Further, All AVEs are greater than 0.5 suggesting adequate convergence validity (Fornell and Larcker 1981). We report variety of goodness-of-fit statistics to determine the overall fit of the model. RMSEA, GFI, NFI, and CFI values for the model was observed to be 0.082, 0.917, 0.923, and 0.915 respectively. All fit indices are within the recommended range, an indication of the acceptable measurement model as recommended by the study of Kaynak, 2003, Hu and Beltler, 1999.

4.4 Structural equation model testing and results

The measurement model developed as illustrated in Figure 1 consists of four constructs: *information sharing, internal enablers, external enablers, and sustainable freight transportation* (dependent variable) and twelve independent variables. After conducting the reliability and validity tests, the data gathered were used to validate hypotheses. Bootstrap procedure was applied using SmartPLS 3. Bootstrap refers to selection of sample of samples repeatedly from the collected data with replacements. The means and variances of the samples thus compiled is compared with the original mean and variance to compute the t-statistic. Statistic related to the inter-construct variables corresponding to the *information sharing, internal enablers* and *external enablers* are illustrated in Table 5.

<<Insert Table 5 here>>

Referring to Table 5(a) and based on the interconstruct correlation values in case of “information sharing”, strongest correlation was observed between “*manufacturer information*” and “*customer information*”. Similarly, in case of “internal enablers” and “external enablers”, strongest correlation was observed between “*commodity considerations*” and “*transportation planning and distribution network*”, and “*adoption of green practices*” and “*adoption of environmental standards*” respectively. These correlations are valid for statistically significant *p* value of less than 1%.

However, devised construct results in good measurement model (i.e. the path coefficients of all indicators to the related variables are significant at 0.01 level). Figure 2 illustrates the measurement model along with path coefficients.

<<Insert Figure 2 here>>

Table 6 enlists measures of the hypotheses related to both the direct and mediating influences in terms of the standardized coefficients and related *p* values. We also comment, whether hypotheses are supported.

<<Insert Table 6 here>>

5. Discussions and Implications

5.1 Theoretical implications and further methodological refinement

5.1.1 Theoretical implications

Theoretically, our study adds to the environmental sustainability oriented freight transportation research by validating as well as refining the effects of external enablers, internal enablers, and information sharing (driven by strategic, tactical, operational aspects that are characterized by spectrum of techno-commercial and techno-regulatory considerations) on GHG reduction and low-carbon growth. This study supports the finding that not all drivers pertaining to both internal orchestration and external influences in context of freight transportation of the automotive components considered in this study further environmental performance outcomes of the firms. Referring to Table 6(a) and the fact that hypotheses 2(b) and 2(c) is not supported effectively dispels the notion that environmental standards and green practices adopted by firms under consideration in this study achieves the desired level of efficiency in mitigating GHG and low carbon growth performance. Infact, from an external enabler perspective, public and governmental regulatory pressures seem to be dominant {based on validation of hypothesis 2(c)} driver in ensuring that logistics firms adhere to their environmental obligations. Another internal enabler i.e. manufacturer information considered in the study also does not seem to further the sustainability performance of the firms. This finding is contrary to that of Zhou et al., (2007) suggesting that including manufacturer information such as production capacity information, order status information, delivery schedule information etc. aids in furthering of environmental performance.

Referring to Table 6(b), an interesting finding pertains to the fact that though adoption of environmental standards does not directly lead to superior environmental performance of the firms. Nonetheless, when it is mediated through collaborative information sharing support technology, the hypothesis between positive relationship between adoption of environment standards and environmental performance outcomes is supported to some degree. This essentially in a byproduct effect in that it is actually the operational orchestration of freight transportation that seem to have some mitigating effect on GHG reduction. This was validated by post-study validation from operations managers of most firms included in the study. For instance, most of these firms recently switched to "collapsible transportation racks" from "returnable transportation racks" in their freight operations owing to higher operating costs associated with returnable transportation racks. This was due to the fact that returnable transportation racks needed to be returned back to the logistics firms once components' delivery is completed to OEM, thus in turn creating additional trips leading to increase carbon footprint.

The theoretic findings discussed in this section would aid both OEM and logistics players in two ways. First, these findings can become the foundation for future studies to uncover mechanisms that drives the efficiency in achieving environmental sustainability objectives. Second, these findings can set up a foundation for future studies to adopt a network view of the freight operations considering operations' multi-stakeholder involvement and need for collaborative information sharing support structure as advocated in the study of Ambra et al., (2018) as well.

5.1.2 Further methodological refinement and challenges

The methodological analysis as carried out in our study can be further refined by taking into account the fixed and random effects. In particular, the motivation for using fixed effect (FE) and random effect (RE) regression model would emanate from identification of such effects explaining variations on measurement items related to output variables i.e. variables explaining environmental performance in our case (Martin et al., 2010). However, such methods for instance those related FE (e.g. ordinary regression uni/multivariate regression models) and RE including meta-analysis related (e.g. Hunter-Schmidt/Hedges-Vevea) are often considered data hungry methods wherein some important questions such as how much and what kind of data need to be collected to deploy such models meaningfully and reliably need to be addressed. Questions for instance whether the data would be pooled in nature or individual respondent based would also aid practitioners in determining the right sampling strategy (Martin et al., 2010).

Schmidt et al. (2011) in their study related to FE vs. RE model comparison for empirical data argued that results often varies substantially given the type of model used since FE is often associated with apriori while RE takes into account statistical calibration. Further, deploying FE models and generalizing findings are often dichotomous in nature in that FE models can lead to inflated Type I error rates and erroneously narrow confidence interval (Hedges & Vevea, 1998; Hunter & Schmidt, 2000).

5.2 Managerial insights

Referring to Table 5(a), it can be observed that *information sharing and support technology* holds a weak correlation with both *manufacturer information* and *customer information*. This signifies that 3PL operators considered in this study don't have adequate information sharing and support infrastructure. This is something that got established through the post study follow-up telephonic sessions as well with middle level operational managers of these firms. The 3PL operators for information sharing primarily relied upon paper and plastic based tags (pasted on the freight itself) containing key information related to both customers and manufacturers. This manual approach however may result in erroneous delivery and at times can be responsible for major undesirable events at the manufacturer's premises for example stoppage of assembly line. Based on this finding, we can theorize the following assertions supported by the studies carried out Pell *et al.*, (2016) and Gharehgozli *et al.*, (2017) as well.

Assertion 1: Mid-sized 3PL operators can improve their information exchange by investing in information technology support architecture thereby minimizing the likelihood of events such as erroneous delivery that can contribute to increased carbon footprint.

This assertion can be perhaps extended for logistics firms not having strong information sharing and support infrastructure. In particular, this assertion is likely to hold true for small to medium sized logistics players (as opposed to large logistics firms) owing to limited budget for making investments in augmenting and automating information sharing platforms. At times, such firms also rely on the support and subject matter expertise of the manufacturer whom they are serving.

Further, referring to Table 5(a), it can be found that manufacturer information and customer information strongly correlate. The manufacturer information in context of the study relates to the manufacturer related information pertaining to the freight that trucks belonging to 3PL operators carry with them to the customer i.e. the automotive company considered in this case. Consider for example transporting lighter and off-the-shelf components such as fasteners; in such a case, the 3PL operators know with fairly high degree of certainty that within the customer's premises which building/unit to offload these freight to. During the post study follow-up interviews, it was further found out that the automotive company under consideration in this study was relying on VMI (vendor managed inventory) for replenishment of auto components within premises of the OEM. Thus, based on these discussions, we can theorize the following assertion.

Assertion 2: Customer and manufacturer related information of freight aid in achieving the sustainable performance related to GHG reduction and low carbon growth particularly in presence of VMI (vendor managed inventory).

The above assertion is also supported partially in the work carried out by Shamsi *et al.* (2014). However, this research recommended VMI for explicitly perishable commodities.

Although it would be fairly reasonable to assume that sharing of manufacturers' information alone by 3PL operators with customers (OEMs where components are destined) would facilitate information exchange thus enriching information quality and furthering environmental sustainability performance of logistics operators; nonetheless Referring to Table 6(a) and based on standardized coefficient and *p* values, hypothesis 1(d) is not supported. Although, the work of Zhou et al., (2015) has shown that right level of manufacturer information does have positive correlation with operational performance. Subsequent follow-up sessions with operational managers of these firms helped us converge upon an important finding. This finding refers to the fact that most of the 3PL operators considered in this study used components' manufacturer related information as inputs for warehouse management and inventory routing – essentially operational level dimensions. Based on this important finding, following assertion can be formalized.

Assertion 3: Sharing of components' manufacturers' information without including customer information by 3PL operators would not further the environmental sustainability performance of logistics operators.

Referring to Table 5(b), we observe that transportation planning and distribution network correlate significantly with commodity considerations in that depending upon the freight type transported (whether A class, B class, or C class), transportation planning and distribution network would play a role in given study of the freight transportation. This finding is in congruence with the fact that typically different freight handling procedures are adopted for different class of auto components. Consider for example an A class auto component like "*engine*" that goes into fitment in automobiles. Such kind of components requires special transportation considerations such as transportation pallets, weatherproof packaging and so on. However, whether effective transportation planning and distribution network alone would serve as an enabler to further the sustainability performance of the operators is questionable if we go by the hypothesis 3(a) which is clearly not supported by our analysis. When transportation planning and distribution network acts in conjunction with commodity considerations, the sustainable freight performance can be furthered when mediated through information sharing as substantiated by hypotheses 4(a) and 4(b). Therefore, following assertion can be formalized.

Assertion 4: Effective transport planning and distribution network design when used in conjunction with suitable commodity considerations mediated through information sharing can be a source of sustainable supply chain performance in freight transportation.

Top management support holds high correlation with respect to both transportation planning and distribution network, and commodity considerations. These values give insight into the importance of top management support in ensuring effective transportation planning and distribution network design taking into account commodity considerations. Since, 3PL operators under consideration in this study are primarily mid-sized players (as opposed to large 3PL operators), it is imperative that initiatives focused upon enhancing sustainable performance of operational initiatives be backed by continued top management commitment. The underlying importance of top management support also gets established by the validation of hypothesis 3(c) considering path coefficient and *p* value. This inference is also partially supported by the work carried out by Johnson (2013) in that within this work it was argued that the operational manager's awareness and commitment hold significant influence in ensuring the success of environmental management practices within small and medium-sized enterprises (nonetheless not in freight transportation sector). Based on these arguments, we theorize the following assertion.

Assertion 5: Transportation planning and distribution network, and commodity consideration backed by top management support can augment environmental performance of sustainable freight transportation.

Our hypothesis related to influencing (positively) role of green practices and environmental standards on sustainable freight transportation performance is not supported by the data at hand. There can be couple of rationales attributed to it. For compliance purpose many of mid-tier 3PL firms adhere to environmental norms mandated by governments. However, adoption of green practices in core operations of firms is something that is voluntary in nature and not really driven by governmental mandates. Larger logistics firms for example owing to their strong corporate governance model adopt stricter environmental standards and green practices. However, owing to the green initiatives adopted by larger 3PL operators, there can be positive influencing relationship between green practices and sustainable freight transportation performance (Rehman *et al.,* 2016). Based on the above discussions, following assertion can be theorized.

Assertion 6: Green practices can be an enabler for furthering the sustainable freight performance only if it is backed by pertinent governmental regulations for mid-sized 3PL logistics operators.

6. Conclusions and future research

The purpose of this study is to aid practitioners involved in logistics business of auto components by examining relationships between variables of sustainable freight transport performance (expressed in terms of GHG reduction and low carbon growth) and associated externalities (manifested in terms of public and regulatory pressures, adoption of environmental standards, and adoption of green practices) and firm intrinsic characteristics (manifested by top management support, commodity considerations, and transportation planning and distribution network) when information exchange occurs between logistics operators and the auto manufacturer. The information exchange construct is further modeled in terms of information sharing support technology, customer information, manufacturer information, and information quality. The detailed construct evolved in this research is based on the state of art literature review that considered recent research literature in the area of freight transportation, environmental sustainability, information sharing, and supply chain.

Employing a survey-based research methodology, appropriate data were collected for a number of third party logistics players in India resulting in total of 708 responses from operational managers of these companies. The research constructs were validated through rigorous procedures involving measurement and structural equation model. In context of the research gaps enumerated earlier, some key insights interlinking externalities related to firms, internal enablers, information exchange, and sustainability performance measures are listed as below.

a) Effective transport planning and distribution network design backed by suitable commodity considerations when mediated through information sharing can further sustainability performance of 3PL logistics operators.

b) Sharing of manufacturers' information without inclusion of customer information would not aid in achieving desired sustainability performance of 3PL logistics operators.

c) For 3PL logistics operators, green practices and environmental standards alone will not be enough to achieve sustainability performance objectives until backed by governmental regulations.

However, our study also supports a few counterintuitive assertions, for instance that information sharing support technology does not seem to positively influence performance variables of sustainable freight transportation.

Our study contributes to the extant research literature in several ways. The study enriches the literature on auto-components' freight transportation by examining interrelations of externalities, firms' intrinsic capabilities, and information sharing in context of achieving environment sustainability. While most of the studies have examined the impact of such interrelationships in context of achieving operational excellence, including GHG reduction and low carbon growth as a measure of environment sustainability augments the extant literature. Apart from contributing towards literature on environmental sustainability, our research also contributes towards the information exchange theory, in that techno-commercial considerations are identified that when mediated through information sharing results in furthering the environmental sustainability outcomes.

Our study has one major drawback in that only environmental sustainability related enablers have been considered as freight transportation performance variable in our developed construct. Future research can incorporate other important dimensions of sustainability viz. societal and economic. Further, this study has been explicitly carried out for auto component logistics business; therefore, generalizing the assertions derived in this study for other logistics business would have scalability issues. From a methodological perspective, the developed construct in this research can consider alternate reliability measures such as Omega coefficient (as opposed to Cronbach's alpha) aimed at measuring the skew items within the construct. This would also enable researchers to mitigate the research construct with respect to some criticism of Cronbach's alpha. Future research can also take into account the aspects related to product and supply chain design such that both product and process related considerations can be included in the constructs leading to identification of crucial implications that can serve as a crucial input for both OEM and component manufacturers in their concurrent product and process design.

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Appendix: Excerpt of the survey questionnaire

Survey questions
Transportation planning and distribution network Assess your firm's capability in transportation planning and effective distribution network such it promotes achieving sustainability transportation [1 = Not capable: 2: Slightly capable; 3: Moderately capable; 4: Significantly capable; 5: Strongly capable; 6: Extensively capable 7: Highly capable?] TP1: To what extent the firm is adept at planning at outbound and inbound logistics based on real time traffic information? TP2: To what extent the firm is adept at finding alternate efficient route(s) in case the primary route is congested? TP3: To what extent the firm is aware of ideal dispatching schedule(s) such that times characterized by traffic congestion can be avoided? TP4: To what extent the distribution network creates favorable conditions for full truck load (FTL) transportation? TP5: To what extent the distribution network creates favorable conditions such that trucks not be scheduled for stock-outs/backordering? **Commodity considerations** [1 = Not capable: 2: Slightly capable; 3: Moderately capable; 4: Significantly capable; 5: Strongly capable; 6: Extensively capable 7: Highly capable?] CC1: Assess your firm's capabilities in identifying the environmentally friendly packaging for the concerned components. CC2: Assess your firm's capabilities in minimizing the need for transporting components that require special energy intensive considerations. CC3: Assess your firm's capabilities in disposing off returnable packaging after having transported the components to the customer(s). CC4: Assess your firm's capabilities in sourcing packaging material associated with lower carbon footprint. **Top management support** [1: Not involved; 2: Slightly involved; 3: Moderately involved; 4: Significantly involved; 5: Strongly involved; 6: Extensively involved; 7: Intensively involved] TM1: Does the top management of your firm get involved in operational planning associated with adopting green practices? TM2: Does the top management of your firm view the impact of adopting green practices positively? TM3: Is the top management committed to executing long term sustainability vision of your firm? TM4: Is the top management of your firm accountable for periodic review of the sustainable vision? **Public and regulatory pressure** [1: Not at all; 2: Slight; 3: Moderate; 4: Significant; 5: Strong; 6: Extensive; 7: Full] PR1: To what extent does the firm consider the voice of society in terms of adoption of environmentally friendly seriously in its core operations? PR2: To what extent does the firm seek inputs from society at large so that environmentally favorable policies can be deployed in its practices? PR3: To what extent does the firm stick to the governmental stipulated regulations? PR4: To what extent does the firm addresses the non-compliance in case certain regulations are not met?

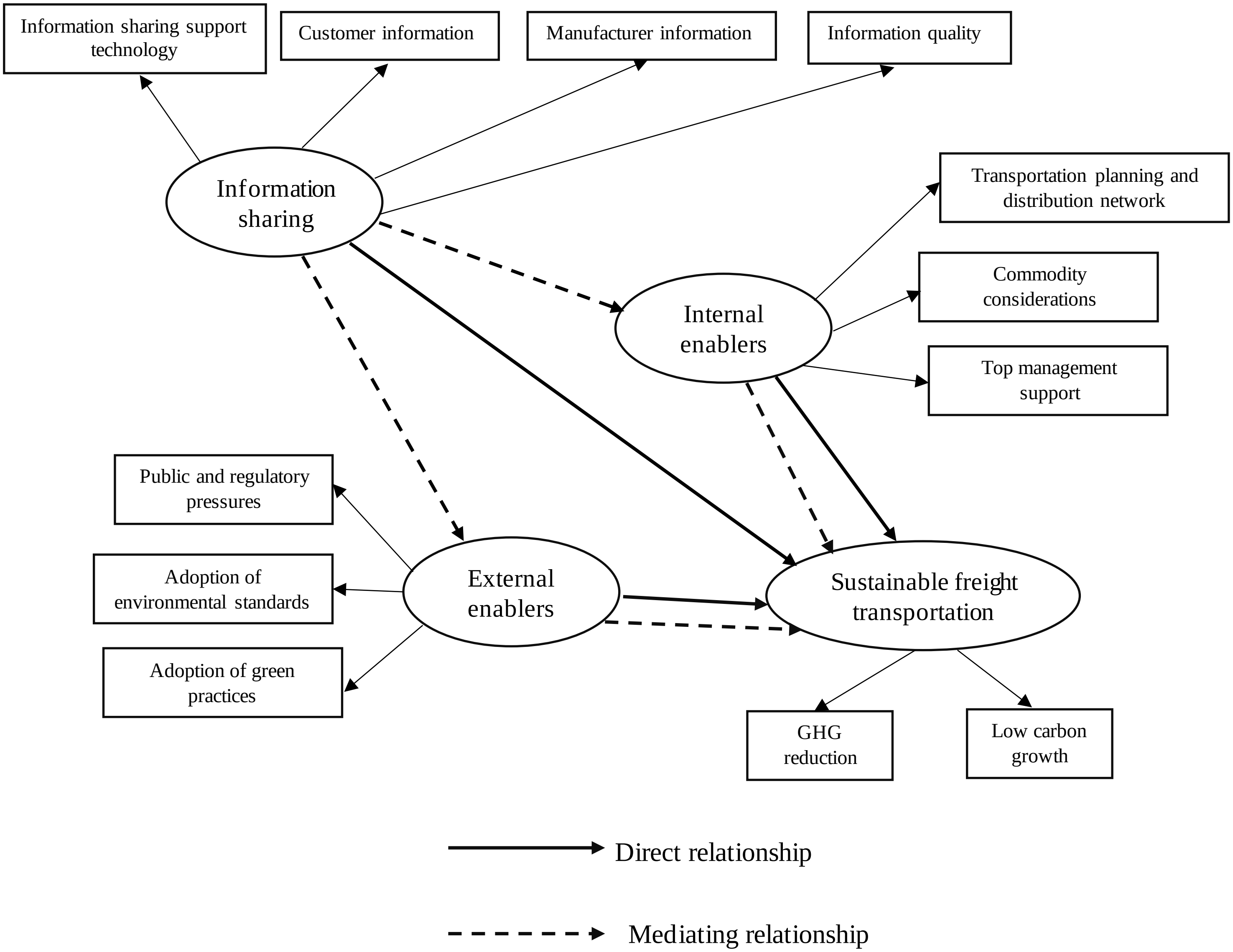

Figure 1: Sustainable freight transportation and information sharing, internal and external enablers (Conceptual model)

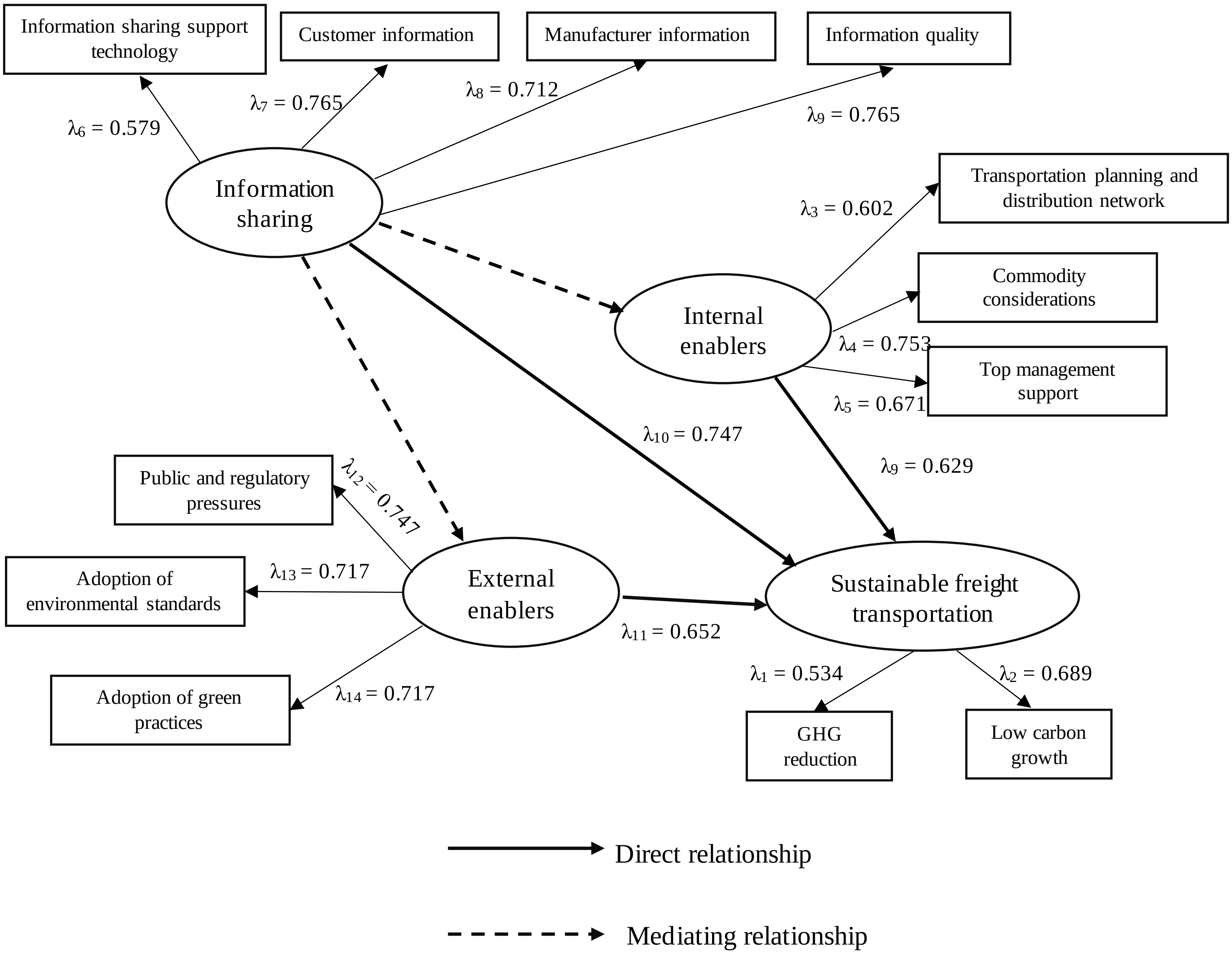

Figure 2: Measurement model with path coefficients

Table 1: Literature taxonomy and companies' profile

Table 1(a): Taxonomy of literature review

Authors	Externalities			Firm level enablers				Information sharing			
	Public and regulatory	Environ. standards	Green practices	Transptn. planning	Distrib. network	Commodity consideration	Top mgmt. commit ment	Info. sharing support technology	Cust. Inf.	Mfg. Inf.	Inf. Qual.
Mathivathanan et al., (2018)	#	#	#				#	#			#
Chan et al., (2018)	#	#	#		#			#			
Flamini et al., (2018)	#		#					#			#
Baz et al., (2017)	#	#	#	#		#					
Ellram et al., (2017)	#	#	#	#	#		#				
Gharehgzoli et al., (2017)	#	#	#					#	#		#
Menezes et al., (2017)	#	#	#					#			#
Creutzig et al., (2016)		#	#	#		#					
Rehman et al., (2016)	#	#	#			#			#	#	
Thirupathi et al., (2016)	#	#	#	#	#	#		#			
Ni et al., (2016)		#	#	#		#					
Schliwa et al., (2015)				#	#						
Koppenjann et al., (2015)		#	#								
Hao et al., (2015)								#		#	
Glover et al., (2014)			#			#					
Ramanathan et al. (2014)									#		#
Beske et al., (2013)			#			#					
Oberhofer et al., (2013)		#	#				#				
Colicchia et al., (2013)			#	#			#				
Wu et al., (2013)			#	#	#						
Elmualim et al., (2012)		#	#				#				
Our research (2018)	#	#	#	#	#	#	#	#	#	#	#

means that the particular dimension(s) were captured and discussed in the particular article

Table 1(b): Profile of the 154 companies considered

Category	Description	Frequency	Percentage
Firm age	< 10 years	13	8.4
	10 – 20 year	46	29.9
	20 – 30 years	81	52.6
	> 30 years	14	9.1
Annual turnover	$ (50-60) Millions	37	24
	$ (60-70) Millions	74	48.1
	$ (70-80) Millions	43	27.9
Firm size	750 – 900 people	47	30.5
	900 – 1050 people	68	44.2
	1050 – 1100 people	39	25.3
Average work experience of logistics operations managers	< 10 years	13	8.4
	10 – 20 years	89	57.8
	20 – 30 year	17	11.0
	> 30 years	35	22.7
Geographic location of the companies' dominant operations	Eastern India	25	16.2
	Southern India	40	26.0
	Western India	70	45.5
	Northern India	19	12.3

Table 2: Constructs and measurement items

Constructs	Variables	Measurement items	Source
Internal enablers	Top management support	○ Communication ○ Motivation ○ Commitment ○ Continuous implementation and momentum	Chinho et al., (2013)
	Tranportation planning and distribution network	○ Outbound and inbound logistics planning ○ Congestion management ○ Dispatching schedule ○ FTL decisions ○ Stockouts/backorder management	Sharma et al., (2013)
	Commodity considerations	○ Environment friendly packaging ○ Energy efficiency ○ Recycling capabilities ○ Sourcing for sustainability	Pires et al., (2015), Martinho et al., (2015), Aung et al., (2014), White et al. (2015), Akhavan et al., (2017)
External enablers	Public and regulatory pressures	○ Compliance to environmental regulation ○ Penalty in case of non-compliances ○ Societal inputs for regulatory compliance	Luthra et al., (2016), Fiorino et al., (2014), Yu et al., (2015)
	Adoption of environmental standards	○ Technological interventions ○ Preventions and controlling mechanisms ○ Environment oriented practices	Singh et al., (2015), Ghadge et al., (2017), Chen et al., (2016)
	Adoption of green practices	○ Institutionalization of green practices within firms ○ Green products and services ○ Green procurement	Guenther et al., (2010) and Yu et al., (2015)
Information sharing	Information sharing support technology	○ Information accuracy ○ Information availability ○ Real-time information ○ Internal connectivity ○ External connectivity ○ Updating information frequently ○ Information completeness ○ Information relevance	Zhou et al., (2007)

		○ Information accessibility	
	Customer information	○ Changes in purchase order information ○ Planned order information ○ Inventory level information ○ Product design specifications ○ Performance evaluation information ○ Future demand forecasting information ○ Production planning information	Zhou et al., (2007)
	Manufacturer information	○ Production capacity information ○ Order status information ○ Delivery schedule information ○ Changes in delivery schedule ○ Lead time information of products	Zhou et al., (2007)
	Information quality	○ Information reliability ○ Information accuracy ○ Information specificity ○ Dynamic information exchange ○ Continuity of information exchange ○ Information dissemination across value-chain ○ Information symmetry	Zhou et al., (2007)
Sustainable freight transportation	Low carbon growth	○ Low carbon technologies ○ Carbon intensity of fuel ○ Fuel efficiency ○ Energy efficiency ○ Loading factor ○ Fuel consumption	Piecyk et al., (2010)
	GHG reduction	○ NOX content ○ CO_2 emissions ○ Particulate matter ○ Reneweable energy based interventions ○ Energy wastage ○ Alternate fuel ○ Net carbon footprint	Piecyk et al., (2010), Wohlfarth et al., (2017)

Table 3: Descriptive statistics and response analysis

Table 3(a): The descriptive statistics

Survey questions	**Mean**	**Standard deviation**
Transportation planning and distribution network		
TP1	5.29	1.09
TP2	5.62	0.89
TP3	5.12	1.78
TP4	5.89	1.5
TP5	6.03	1.24
Commodity considerations		
CC1	3.46	1.58
CC2	3.28	1.75
CC3	4.12	0.98
CC4	3.78	1.58
Top management support		
TM1	6.47	0.25
TM2	6.28	0.89
TM3	6.89	0.78
TM4	6.87	1.08
Public and regulatory pressure		
PR1	4.58	1.25
PR2	4.78	2.15
PR3	6.52	0.89
PR4	6.47	0.98
Adoption of environmental standards		
AE1	5.89	0.58
AE2	5.42	0.45
AE3	5.01	0.68
AE4	5.98	0.89
AE5	5.27	0.87
Adoption of green practices		
AG1	3.58	1.25
AG2	3.25	1.69
AG3	2.89	1.58
AG4	3.15	1.97
Information sharing support technology		
IA1	5.89	1.25
IA2	5.87	2.15
IA3	5.28	2.01
IA4	5.47	1.89
IA5	4.87	1.69
IA6	5.96	1.96
IA7	5.45	1.78
IA8	5.28	1.25
IA9	5.12	1.56

Customer Information		
IB1	5.89	1.89
IB2	5.28	1.25
IB3	5.69	1.36
IB4	5.74	1.87
IB5	4.89	1.47
IB6	4.95	1.29
IB7	5.81	1.68
Manufacturer information		
IC1	3.58	1.25
IC2	3.47	0.89
IC3	2.87	0.25
IC4	1.58	0.58
IC5	1.25	0.69
Information quality		
ID1	5.74	1.26
ID2	5.21	1.96
ID3	5.39	1.23
ID4	5.89	1.58
ID5	5.28	1.89
ID6	5.65	1.62
ID7	5.18	1.52
GHG reduction		
GH1	6.25	1.69
GH2	6.17	1.85
GH3	6.78	1.52
GH4	6.89	1.69
GH5	6.21	1.24
GH6	5.78	1.89
Low carbon growth		
LC1	5.87	1.89
LC2	5.25	1.56
LC3	5.96	0.89
LC4	4.98	2.53
LC5	4.87	2.15
LC6	5.25	1.89
LC7	5.87	1.81

Table 3(b): Mapping of companies vs. corresponding responses

Group	Number of responses from same firm	Number of such firms
1	7	20
2	6	23
3	5	66
4	4	5
5	2	40

Table 4: Reliability results and item statistics

Survey questions	Factor loading	Scale statistics	Composite reliability (CR)	Item AVE	Average variance extracted (AVE)
Transportation planning			0.822		0.914
and distribution network		Cronbach's			
TP1	0.681	alpha: 0.819		0.927	
TP2	0.742			0.916	
TP3	0.583			0.948	
TP4	0.581			0.922	
TP5	0.775			0.949	
Commodity		Cronbach's	0.735		0.731
considerations	0.589	alpha: 0.729			
CC1	0.756			0.758	
CC2	0.784			0.774	
CC3	0.689			0.738	
CC4				0.751	
Top management support		Cronbach's	0.918		0.852
TM1	0.879	alpha: 0.912			
TM2	0.789			0.874	
TM3	0.816			0.858	
TM4	0.798			0.889	
				0.879	
Public and regulatory		Cronbach's	0.802		0.785
pressure	0.845	alpha: 0.801			
PR1	0.789			0.789	
PR2	0.785			0.797	
PR3	0.658			0.788	
PR4				0.799	
Adoption of		Cronbach's	0.785		0.725
environmental standards		alpha: 0.783			
AE1	0.785			0.784	
AE2	0.748			0.759	
AE3	0.741			0.788	
AE4	0.689			0.739	
AE5	0.647			0.749	

Adoption of green		Cronbach's	0.673		0.707
practices	0.678	alpha: 0.671			
AG1	0.614			0.714	
AG2	0.671			0.729	
AG3	0.588			0.747	
AG4				0.785	
Information sharing		Cronbach's	0.764		0.697
support technology		alpha: 0.762			
IA1	0.478			0.718	
IA2	0.589			0.727	
IA3	0.728			0.705	
IA4	0.489			0.805	
IA5	0.478			0.789	
IA6	0.558			0.725	
IA7	0.782			0.806	
IA8	0.709			0.741	
IA9	0.698			0.747	
Customer Information		Cronbach's	0.825		0.847
IB1	0.879	alpha: 0.821		0.904	
IB2	0.784			0.845	
IB3	0.845			0.859	
IB4	0.711			0.826	
IB5	0.742			0.914	
IB6	0.745			0.918	
IB7	0.689			0.974	
Manufacturer information		Cronbach's	0.796		0.788
IC1		alpha: 0.794			
IC2	0.874			0.845	
IC3	0.784			0.847	
IC4	0.745			0.813	
IC5	0.698			0.796	
	0.685			0.805	
Information quality		Cronbach's	0.842		0.798
ID1	0.541	alpha: 0.840		0.815	
ID2	0.772			0.877	
ID3	0.543			0.847	
ID4	0.463			0.801	
ID5	0.653			0.799	
ID6	0.734			0.856	
ID7	0.747			0.847	
GHG reduction		Cronbach's	0.793		0.814
GH1	0.592	alpha: 0.791		0.874	
GH2	0.635			0.827	
GH3	0.544			0.884	
GH4	0.593			0.825	
GH5	0.631			0.849	
GH6	0.438			0.859	
Low carbon growth		Cronbach's	0.815		0.801
LC1	0.890	alpha: 0.813		0.815	

LC2	0.851			0.828	
LC3	0.876			0.809	
LC4	0.874			0.859	
LC5	0.745			0.899	
LC6	0.875			0.878	
LC7	0.805			0.856	

Table 5: Correlation values for interconstruct variables

Table 5(a): Correlation values for latent independent variables corresponding to "information sharing"

	Information sharing and support technology	Customer information	Manufacturer information	Information quality
Information sharing and support technology	1			
Customer information	0.32	1		
Manufacturer information	0.42	0.82	1	
Information quality	0.46	0.73	0.73	1

Notes: Significant at $p < 0.01$

Table 5(b): Correlation values for latent independent variables corresponding to "internal enablers"

	Transportation planning and distribution network	Commodity considerations	Top management support
Transportation planning and distribution network	1		
Commodity considerations	0.82	1	
Top management support	0.68	0.74	1

Notes: Significant at $p < 0.01$

Table 5(c): Correlation values for latent independent variables corresponding to "external enablers"

	Public and regulatory pressures	Adoption of environmental standards	Adoption of green practices
Public and regulatory pressures	1		
Adoption of environmental standards	0.32	1	
Adoption of green practices	0.68	0.74	1

Notes: Significant at $p < 0.01$

Table 6: Independent latent variables and sustainable freight transportation performance

Table 6(a): Direct influences

Variable name	Hypotheses	Standardized coefficient	p value	Hypothesis supported?
Manufacturer information	Hypothesis 1(a)	-0.237	0.012	No
Information quality	Hypothesis 1(b)	0.249	0.109	Yes
Customer information	Hypothesis 1(c)	0.371	0.032	Yes
Information sharing support technology	Hypothesis 1(d)	0.179	0.083	Yes
Public and regulatory pressures	Hypothesis 2(a)	0.267	0.19	Yes
Environmental standards	Hypothesis 2(b)	0.756	0.47	No
Green practices	Hypothesis 2(c)	-0.091	0.021	No
Transportation planning and distribution network	Hypothesis 3(a)	0.379	0.786	No
Commodity considerations	Hypothesis 3(b)	0.576	0.947	Yes
Top management support	Hypothesis 3(c)	0.934	0.576	Yes

Table 6(b): Mediating influences

Variable name	Hypotheses	Standardized coefficient	p value	Hypothesis supported?
Transportation planning and distribution network mediated through information sharing	Hypothesis 4(a)	0.716	0.7119	Yes (marginally)
Commodity consideration mediated through information sharing	Hypothesis 4(b)	0.576	0.549	Yes (marginally)
Top management support mediated through information sharing	Hypothesis 4(c)	0.934	0.576	Yes
Public and regulatory pressures mediated through information sharing	Hypothesis 5(b)	0.23	0.157	Yes
Environmental standards mediated through information sharing	Hypothesis 5(b)	0.458	0.415	Yes (marginally)
Green practices mediated through information sharing	Hypothesis 5(c)	.012	0.23	No