

## **The Impact of Trucking Back-Haul in the Sustainable Supply Chain Management**

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### **Abstract**

The main objective for any business is profit making, through increasing the revenue and/or reducing the cost. The Empty trips for the longer travel distances considered to be inefficient performance in transportation cost analysis. The interest in sustainable supply chain management has been growing rapidly over the years. Any successful organization seek to minimize negative environmental emissions impact on their community. One way to increase efficiency in transportation is to increase the fleet utilization through the addition of backhaul routes. Backhaul trucking is a transportation method to reduce empty truck-miles by having drivers haul loads on trips back to their home terminal and considered to be one of the least expensive approaches to improve the transportation costs. The revenues generated from the backhaul trips reduced the logistics cost, and impact on decreasing the environmental emissions by decreasing the CO<sub>2</sub> emissions. also, affect the social style of the drivers. This paper will examine the impact of Backhaul on the sustainable supply chain practices on its environmental and economic aspects. This paper aims to review systematic literature on the relationships between Backhauling and SSCM. Finally, a qualitative approach will be conducted through semi-structured interviews with experts from the logistics and supply chain fields to investigate the current situation of Backhauling in Egyptian market.

**Keywords:** Back-Haul Network Size; Back-Haul Trip; Sustainable Supply Chain Management; Logistics Fright cost; Truck's productivity.

## 1. Introduction

Sustainability has become a widely researched topic academically and practically. The increase in analysis concerning sustainability is dated back to the 1980's wherever the Burtland Commission outlined sustainability as 'development that meets the wants of this while not compromising the flexibility of future generations to fulfill their needs' (World Commission on environment and Development, 1987). this can be thought of the foremost adopted and infrequently quoted definition of sustainability. However, sustainability means that variety of various things looking on the attitude in question. El-Said (2018) outlined that a sustainable firm is defined by presently and for the predictable future having the ability to provide and deliver its product and services while not inflicting depletion or degradation to individuals, planet, or profit.

Transportation is considered as one of the most important logistics activities; Although of its importance, it has been neglected in the existing literature (Santos et al, 2021). within this neglected standing of the transportation analysis, the limitedly explored empty trips problem is also explained in other key words; empty running, load factor and fill rate (Rogerson, 2017; Shi et al., 2017). The Empty trips for the longer travel distances are not economical nor effective performance in transportation analysis. The empty trips problem in as simply can be defined as the fully or partially empty truck movement in the logistics distribution process. These are all inefficient trips due to the costs are resulted without any potential revenue (Leclerc, 2021). the empty trip is considered as non-value-added practice that is caused by the inefficiency of the trucks capacity utilization which mean that is wasted method in transport process and will not impact on customer value added. the target for a carrier is to achieve the complete utilization of its out their empty area. supported similar arguments, the severity of the matter has additionally been highlighted in recent discussions (Santos, 2020).

The technique of this paper is to use systematic literature review approach of the period from the year 2014 to the year 2021 to scan the previous studies of the relationship between Backhauling and the environmental aspect of SSCM. The objective of that is to know the literature gaps.

## 2. Literature Review

### 2.1. Sustainable Supply Chain Management

#### 2.1.1. SSCM Definition

Sustainability today's in its developmental stage; therefore, there is not a single definition encompassing all facets of that term. El-Said et al. (2018) discuss that there are many divergent definitions of Sustainability have been presented which depend on the field and the scope of the research such as in operations management, engineering science, operations management, and social science. The drivers of understanding the sustainability are to understand that the factor of economic or profit that focuses from organizations is no longer sufficient and that

organization is required to take the factors of environmental and social responsibilities into its consideration to remain competitive and survive in today's market.

## 2.1.2. SSCM Aspects

El-Said et al. (2018) presented that the Sustainable supply chain management is the integration of the environmental and social aspects with the economic dimension. The interest in sustainable supply chain management has been growing rapidly over the years. There are three different aspects of sustainable supply chain management that have been addressed by researchers over time: environmental aspect, economic aspect, social aspect.

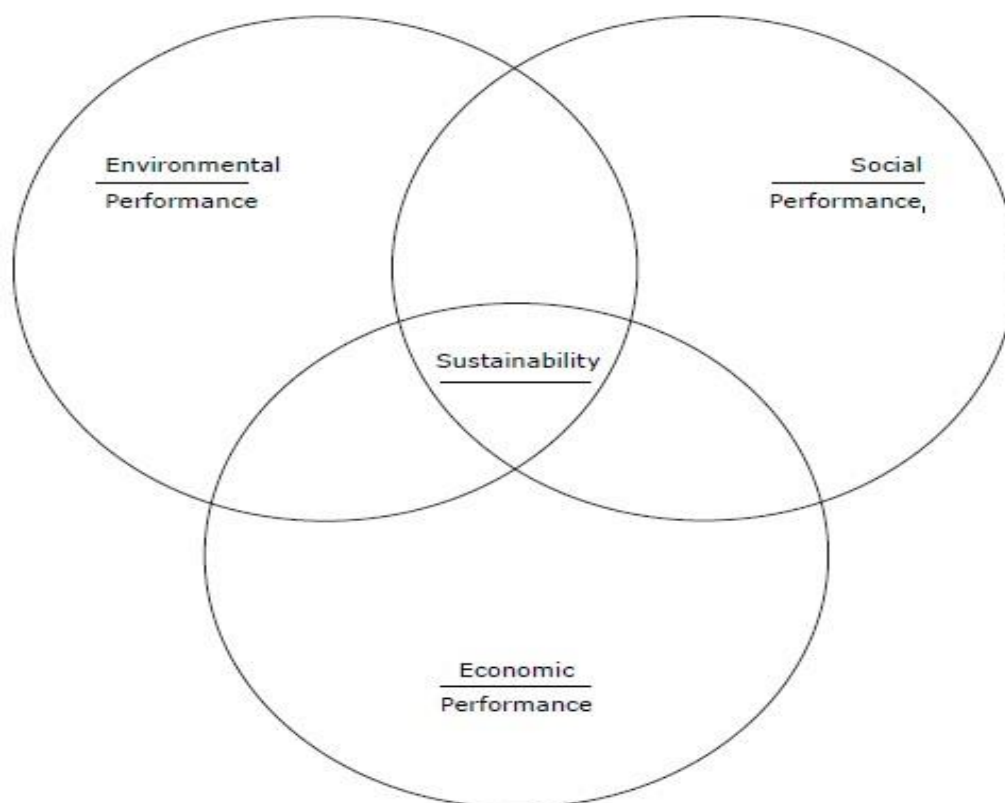


Figure 1. Aspects of Sustainability

Source. Elsaid, Ahmed Tarek, 2018

### Environmental Perspectives

The environmental aspect in sustainable supply chain management is about how to conserve the environment that organization is working in. The Egyptian Environmental Law provides for the protection of the environment and firms that violate the law are subjected to law enforcement.

Researchers found that the techniques for optimal use of energy in manufacturing results in a substantial decrease of carbon emission by minimizing energy consumption to the minimum

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(Bevilacqua *et al.*, 2014). The amount of diesel fuel consumed for truck applications is approximately 200 grams/ kWh (assuming 50% efficiency). The mass of diesel fuel is approximately 850 grams/liter. The amount of CO<sub>2</sub> emissions produced by diesel fuel is 2.668 kg/liter (Santos *et al.*, 2010).

## Economic Perspectives of SSCM

The main objective for any business is profit making. Traditionally, the economic perspective of sustainability was mainly focused upon by firms; however, lately the environmental and social aspects have gained impetus even though it is challenged to be able to measure them. The economic perspective is about the optimize the utilization of the natural resources to attained a high return on investment. To ensure improvement for a longer term and maintain firm's economic stability. In order to attain economic sustainability, some critical factors such as collaborative relationships through optimized logistics support and profitability need to be addressed (Dubey *et al.*, 2016).

## 2.2 Truck's Productivity

When the trucking utilization rate improved and transportation efficiency is increased, the potential cost reduction could be significant (Copley, 2020). Trucking operation efficiency is affected by a variety of constraints, such as fleet size, delivery time operation mode, industry regulation on driving hours and detention time. The increasing demand for transportation and moving goods is putting shippers and carriers on continuously critical situation to improve their operational efficiency. This requires more efficient in supply chain management practices which required collaboration between all parties in the supply chain. Ergun, Kuyuzu and Savelsbergh (2007) describe that traditionally, shippers and carriers have respectively and independently focused on reducing their own internal operation cost by improving efficiencies. Ergun *et al.* also describe that more recently; they have come together focusing on improving system-wide collaboration to drive down system-wide cost and be able to share these cost savings. Previous studies suggested that the use of high productivity freight vehicle for transportation as it would minimize the cost of transportation by 33.5 percent and also its impact on the environment (Karha *et al.* (2021); Lee and Wu (2014)).

Ninikas, G. and Minis, I. (2020) addressed that the vehicle productivity is a newly introduced term that encourages the available fleet to complete as much of the known work as early as possible. The author suggested that; The vehicle productivity can yield higher with backhauling method, and that improvement reaches up to about 15% of more dynamic orders served.

Truck productivity can be measured by the quotient:

(Loading volume) x (utilization rate) divided by (fuel consumption) x (time needed for the transport). Time is distance divided by speed.

## **Loading capacity x average speed / fuel consumption x distance**

The higher the payload and the higher the transport speed and the lesser the fuel consumption and the lesser the transport distance the higher is the efficiency of the productivity (Sung-Keun et al., 2020).

Kim, Hassall (2018) discussed the impact of backhaul transportation method on truck's productivity in the article "Safety and Productivity Observations on a Billion Kilometers of Travel by Australian Trucks Using the „Performance Based Standards“ Schemes", the author argued that backhaul has direct impact on productivity, the productivity saving achieved around 33% kilometer. As the cost per kilometer by vehicle type are known then the kilometers saved can be measured directly as financial benefit.

### **2.3 Analysis of Vehicle Routing Problem with Backhauls towards Sustainability**

The Vehicle Routing Problem with Backhauls (VRPB) focusing on sustainable aspects, environmental, economic, social. Also, collaboration and reverse logistics. This section describes and discusses this term.

For the majority of vehicle routing problem with backhauls presented in previous studies, the solution of that problem was focused on minimizing costs by minimizing the distance. Accordingly, as CO<sub>2</sub> emissions and fuel consumption are depending on the distance of dispatching. therefore, minimizing the distance indirectly reduce both emissions and fuel. Most of the previous studies and practical applications of the vehicle routing problem with backhauls focus on the costs savings by performing inbound and outbound trips together and neglect the quantitative assessment of the impact of transportation on the environment and society. From economic perspective, Leclerc (2020) investigated the impact of Backhaul method in reducing transportation cost and developed a vehicle routing with backhaul planning tool to minimize the transportation costs by used the CPLEX, AMPL and Python to build mixed integer linear programming model, also, compared the effect of planning for different time periods (yearly versus weekly when studying the impact of backhaul on transportation cost. the findings of that study suggested that it is an attractive option to use backhauls even if the planning period is short because the yearly planning resulted in 42% savings transportation cost and the weekly planning resulted in 36% savings in transportation cost.

The first studies that investigated the environmental impact of a vehicle routing problem with backhauls were addressed in Ubeda et al. (2011). The authors investigated the effect of different strategies of transport on the operation profitability and environmental. The authors named these strategies as: Backhauling, Re-scheduling, and Green optimization deliveries.

The two first strategies formularized the vehicle routing problem for minimizing the distance and the third strategy relies on formulating the vehicle routing problem for minimization the

CO<sub>2</sub> emissions. In all three strategies, the emissions are estimated based on the distance and distance-based emission factors. The Mole and Jameson's method is used to solve the vehicle routing problems the Nearest distention by using algorithm to solve the vehicle routing problem.

From the three strategies studied, backhauling provides the highest reduction of the total trip distance: more than 15%. The results of this case study establish that:

- Backhauling increases the truck's productivity, therefore, the vehicles efficiency increases. - Increasing the backhauling rate leads to an increase in both economic benefits and reduces the environmental negative impacts.

Induce higher economic benefits (lower costs and reduce CO<sub>2</sub> emissions), the time of reload in the vehicle during mixed trips are not considered in this study. Nevertheless, this extra time may lead to a drastic increase in the total time required to complete a route.

Santos (2020) addressed that the vehicle routing problem with backhauls allowed reductions up to 20% in the total distance and up to 25% in CO<sub>2</sub> emissions and saving up to 30% in the total costs in comparison with the traditional vehicle routing problem.

Internal prices discuss with the entire prices with fuel, drivers, vehicles and tolls. External prices comprise each environmental (climate amendment and air pollution) and social impacts (noise and accident rate). The matter considers totally different kind of fuels and is resolved with a Clarke and Wright savings heuristic extended by the authors to incorporate the power to perform with a heterogeneous fleet. With a case study, the authors show that together with backhauling is often a stronger strategy than perform individual incoming and outward-bound routes. They additionally conclude that considering social and environmental impacts ends up in selecting the less waste material vehicles if a heterogeneous fleet is considered within the routing downside (Santos, 2020).

## **2.4. Systematic Literature Review of the relationships between Backhauling and SSCM**

This section presents the systematic literature review of most relevant articles that focused on the relation between the variables; Backhaul Trucking service and trucks' productivity and the environmental aspect of sustainable supply chain management during the period from 2014 till 2021. A systematic review has been carried out on seven published papers from 2014 to 2021. articles spanning 7 years of research published in English-language, peer-reviewed journals for covering most of studies in that topic. and the aim from that part is to get the gap in literature which need to be studied to advance an understanding of the impact of trucking back-haul in the sustainable supply chain practices through the truck' productivity.

Table 1: Systematic Literature Review of the relationships between Backhauling and SSCM

Year Of Pub.	Title	Author	Aim	Methodology	Findings	Further studies
2021	A green lateral collaborative problem under different transportation strategies and profit allocation methods.	Maria Joao Santos, Sara Martins, Pedro Amorim, Bernardo AlmadaLobo	Examine a lateral collaboration between a leading retailer, 3rd party logistics service provider and several producers	a case study in the food supply chain to investigate three collaborative strategies.	Savings of 26% in fuel consumption and 28% in operational costs.	Social concerns, for example, the impact of the equity of working hours among drivers on their performance and motivation.
2021	Impacts of Road Infrastructure on the Environmental Efficiency of High-Capacity Transportation in Harvesting of Renewable Wood Energy	Teijo Palander, Stelian Alexandru Borz and Kalle Karha	Investigate the impact of highcapacity transportation in Reducing the environmental emissions by backhauling transportation method	- Data of wood transportation from the enterprise resource planning system between 6 July 2018 and 19 August 2020, 152 vehicles - Quantify Fuel Consumption and the index of environmental efficiency.	The reduction in average fuel consumption between 52% and 70% in backhauling transportation was 18.88%. In this respect, CO2 emissions were reduced by 4.52 g t × km-1, achieving 19.48 g t×km-1.	Recommended to study the seasonal problems
2021	Sustainable supply chain management and its effects on the performance of sugar	Panya, K. O., 2 Ochiri, G., Achuora, J., and Gakure, R. W.	Investigated the effect of green procurement strategies (included the green logistics activities such as backhaul	180 questionnaires from of sugar companies in Kenya used SPSS and Microsoft word tools to examine the	Positive significant relationship between green procurement and performance of	- Expand the scope by study other industries such as cement - Using qualitative methods to

	subsector in Kenya.		transportation approach).	relationship between the variables.	sugar sub-sector in Kenya.	come up with findings for comparison with the findings of this study.
2020	“Towards solving a robust and sustainable. Vehicle Routing Problem with Backhauls” PHD thesis.	Maria Joao Martins Dos Santos	Minimize the total routing costs minus the total revenue collected at backhaul customers by developing mathematical models and solution methods for the vehicle routing problem with backhauls.	Methodological approach based on following four steps: material collection, descriptive analytics, category selection and material evaluation.	Vehicle routing problem with backhauls allows reductions up to 20% in the total distance and up to 25% in CO2 emissions and saving up to 30% in the total costs in comparison with the traditional vehicle routing problem.	Investigate the impact of NOx as one of environmental aspects.
2019	Environmental Impacts of Reusable Transport Items: A Case Study of Pallet Pooling in a Retailer Supply Chain.	Riccardo Accorsi, Giulia Baruffaldi, Riccardo Manzini and Chiara Pini.	investigate the impact of reverse logistics in environmental sustainability targets.	- case study in Italy and conducted data collection from companies’ Enterprise Requirement Planning Systems. - Calculated the logistical and environmental KPIs by a tailored GIS-driven decision support tool.	Reverse logistics reduced distance traveled of the truck by 65% and pollutant emissions by 60%.	Recommended to study the impact of reverse logistics approach on optimizing trucks productivity and cost reduction.

2017	Horizontal collaboration in freight transport: concepts, benefits, and environmental challenges.	Adrian SerranoHernandez, Angel A. Juan, Javier Faulin and Elena PerezBernabeu	Present a literature review of transportation horizontal collaboration practices and analyze the main benefits of these practices in sustainability economic and environmental aspects.	Analyze the horizontal collaboration at three levels; the strategic, tactical, and operational levels.	Horizontal collaboration practices represent an efficient approach of reducing transportation freight cost and promote best practices for environmentally friendly.	Modeling and solving of realistic freight transport logistics scenarios including time evolving and stochastic inputs.
2014	Horizontal cooperation in vehicle routing problem with backhauling and environmental criteria	Angel A. Juan, Javier Faulin, Elena Perez Bernabeu, Nicolas Jozefowicz	Examines different numeric examples to quantify saving costs and reduction in CO2 emissions that can be attained from backhaul Horizontal cooperation.	Developed a metaheuristic algorithm developed by Juan et al. (2011) to solve three numerical tests for three benchmark instances.	The use of backhaul allows reducing distance-based cost in about 16% and environmental emissions are reduced by 24% on the average	Develop a metaheuristic approach for efficiently deal with routing problems with backhauling and to test this approach using a large set benchmark instance.

These previous studies in the above systematic literature could be classified in three categories:

- The First category is based on the research aim; articles investigated the impact of Backhauling in reducing the transportation freight cost, articles examined the impact of it in reducing CO2 emissions, articles studied the impact of Backhauling in both of the two sustainability aspects, articles examine the using of backhauling to maximize the vehicle productivity, articles studied the impact of reverse logistics in sustainable supply practices and articles studied the impact of the horizontal collaborative strategies in sustainability.
- The second category is based on the research methodology; algorithms, linear programming, MS excel and equations to quantify the reduction of cost, fuel, and CO2.
- The third category is based on research findings; there is a common finding of all these studies which strong relationships between Backhauling method and truck's productivity and sustainable supply chain management. the findings of these previous studies showed that the higher of backhauling result in higher rate of truck's productivity which leads to

higher rate of economic and ecological benefits. which impact in reducing the transportation freight cost and allows the environmental to be green.

Based on this systematic literature review, there are three gaps in literature:

1. It has been observed that the methodology of these relevant studies used mathematically approach such as algorithms, linear programming, and equations to quantify the reduction of cost, fuel, and CO<sub>2</sub>. But none of these studies used the statistics methods to evaluate the relationship between the three variables of Backhauling, Truck“ productivity and sustainable supply chain management.
2. Second gap, there is no study of the relationships between the mentioned variable in one study in Egypt market.
3. The third gap; there is no focusing enough on the factors that influences the effectiveness Backhaul Trucking service.

### 3. Research Methodology

Research methodology is the process that helps the researcher in conducting research systematically, it can be defined as the way in which different theories, ideas and concepts are gathered so researcher can relate them to a particular topic of investigation for attain the research aim and objectives. Also, Specific methodology is necessary for the evaluation of the results of the research. Table 2 show the methods used to satisfy the study objectives

Table 2: The methods used to satisfy the study objectives

Objective	Method
Exploring the literature gaps through Scanning the previous studies of the relationships between Backhauling and Sustainable supply chain practices.	Systematic Literature review
Create Conceptual Framework by examining the current situation of Backhauling in Egypt market to Verify the validity of the previous step which results in exploring the literature gaps	Semi-Structured interview

#### 3.1. Semi-Structured Interviews

The result of the previous method “Systematic Literature review” resulted in exploring three gaps in literature; Most of previous studies methodologies depend on using linear programming and algorithms but none of these previous studies used the statistical methods for studying the relationships between the variables, Backhauling, Truck’ productivity, and sustainable supply chain management. Also, there is no focusing enough on the factors of effectiveness trucking backhaul and no previous studies investigate the relationships between the mentioned variables in one study in Egypt market.

The analysis of the qualitative study was done by using semi-structured interviews directed with academics and professionals in transportation and supply chain fields to Create Conceptual Framework by examining the current situation of Backhauling in Egypt market. Of all, 15 of the interview participants are 5 Academic Professors, 3 CEOs, and the remaining 7 are supply chain functional heads. All interviews were recorded to provide accurate rendition. The average interview time was 30 minutes, the longest interview lasted for 34 minutes and the shortest lasted for 21 minutes. The audio record was made after the participants' appraisal as it was easier for the researcher to recap the information and repeat the important parts again to extract the hidden meanings beyond their answers. All the participants answered the 8 interview questions and at the end of the interview, they were given the chance to ask any question about the research or any contribution they would like to add. These 8 questions could be classified into four Themes.

Table 3: The summary of all the 15 semi-structured interviews

Theme	Common Answers	Recommendations
The impact of back haul on trucks productivity	<ol style="list-style-type: none"> <li>1- Backhaul increase the productivity of the trucks due to increasing the loading capacity.</li> <li>2- Backhaul increase the fleet utilization through the addition of backhaul routes.</li> </ol>	<ol style="list-style-type: none"> <li>1- Not all backhauls optimize the truck productivity, it depends on other factors such as the backhaul loading capacity, time consumed between base trip unloading and backhaul source.</li> </ol>
The Economic effect of Backhaul	<ol style="list-style-type: none"> <li>1- Backhaul turn the logistics from cost center to profit center result from the revenues generated from the backhauls.</li> <li>2- Backhaul considered to be one of the least expensive approaches to improve the transportation costs.</li> <li>3- This reduction on cost can use for many uses such as increasing the company market share, profit margin.</li> </ol>	<ol style="list-style-type: none"> <li>1- Backhaul method represent a risk due to the responsibility of the products of backhaul trips.</li> <li>2- Market uncertainty decreases the importance of backhaul transportation approach.</li> </ol>
The Environmental effect of Backhaul	<ol style="list-style-type: none"> <li>1- The higher of backhaul trips, the higher of reducing CO2 emissions due to decreasing the consumption of fuel.</li> <li>2- Backhaul Trips has a positive influence on green logistics.</li> </ol>	
Factors influence the effective backhaul	<ol style="list-style-type: none"> <li>1- Trip time</li> <li>2- Backhaul network size</li> </ol>	<ol style="list-style-type: none"> <li>1- Digitalization</li> <li>2- Support of top management</li> </ol>

#### 4. Discussion

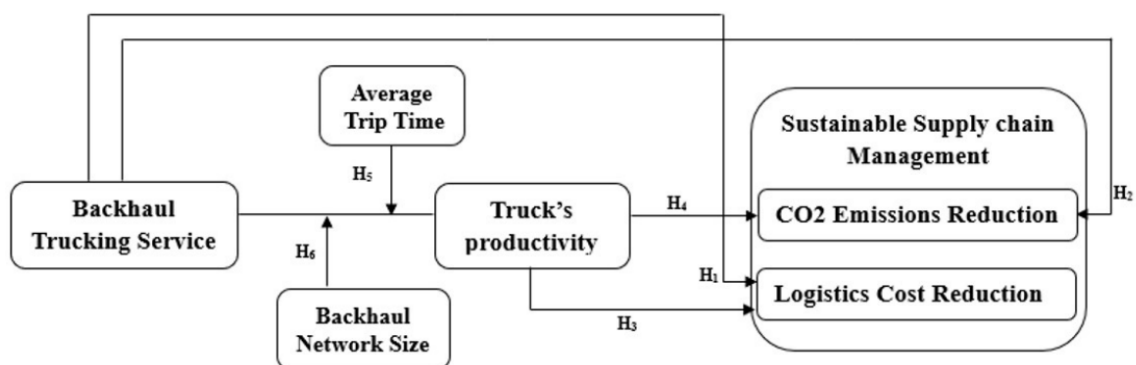
Sustainable supply chain management is the integration of the environmental and social aspects with the economic dimension. Today, initiatives and strategies that reduce cost and lead to green logistics are gaining interest. There is a common finding in systematic literature review and semi-structured interviews which is a strong relationship between Backhaul and sustainable supply chain management. The higher of backhaul trips, the higher of reducing CO2 emissions due to decreasing the consumption of fuel which lead to green logistics. Also, backhaul increase the fleet utilization through the addition of backhaul routes and has a positive impact of reducing the logistics freight cost and it can turn the logistics from cost center to profit center result from the revenues generated from the backhauls. Although Backhauling considered to be one of the least expensive approaches to improve the transportation costs, not all backhaul trips generate logistics cost reduction, there are many factors influence the effective backhaul such as trip time, backhaul network size, using Digitalization and Support of top management.

#### 5. Conceptual Framework and Hypotheses

Regarding the findings of the systematic review and Semi-Structured interview, a conceptual framework has been analyzed to propose the relations between the variables that could be investigated.

The following figure demonstrates the conceptual model for this research proposing the following relations and hypotheses that would be investigated within this study.

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Accordingly, the research hypotheses could be stated as follows:

**H<sub>1</sub>:** The Backhaul Trucking service has a significant positive influence on CO2 emissions reduction.

**H<sub>2</sub>:** The Backhaul Trucking service has a significant positive influence on Logistics cost reduction.

**H<sub>3</sub>:** Truck's Productivity mediates the relationship between Backhaul Trucking service and Logistics cost reduction.

**H<sub>4</sub>:** Truck's Productivity mediates the relationship between Backhaul Trucking service and CO<sub>2</sub> emissions reduction.

**H<sub>5</sub>:** The Average Trip Time moderates the relationship between Backhaul Trucking service and Truck's Productivity.

**H<sub>6</sub>:** The Size of Backhaul network moderates the relationship between Backhaul Trucking service and Truck's Productivity.

## 6. Further Studies

Recommended to use statistical tools to evaluate the impact of Backhauling in Sustainable supply chain practices through trucks productivity and it could be also using another qualitative method such as focus group to validate the findings of this case study.

## 7. Conclusion

The Empty trips for the longer travel distances considered to be a wasted method in transport process and are not economical nor effective performance in transportation analysis. This paper aims to find the gaps in literature through systematic literature on the relationships between Backhauling and Sustainable Supply Chain Management. Finally, a qualitative approach conducted through semi-structured interviews with experts from the logistics and supply chain fields to create the conceptual framework through investigate the current situation of Backhauling in Egyptian market.

This study reinforced the significance of backhauling in logistics practices. The high backhaul revenues will lead to high reduction in logistics freight cost. Also, will conserve the environment through reducing the carbon emissions.

The conclusion of is that there is a strong relationship between Backhauling and sustainable supply chain management through increasing the truck's productivity. the findings of these previous studies and experts showed that the higher of backhauling result in higher rate of truck's productivity which will lead to higher rate of economic and ecological benefits. which impact in reducing the transportation freight cost and allows the environmental to be green.

There are three gaps in literature; The first one is that most of previous studies methodologies depend on using linear programming and algorithms but none of these previous studies used the statistical methods for studying the relationships between the variables, Backhauling, Truck' productivity, and sustainable supply chain management. The second gap, there is no focusing enough on the factors of effectiveness trucking backhaul and the third gap is there is

no previous studies investigate the relationships between the mentioned variables in one study in Egypt market.

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