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Reducing Co2 Emissions with Optimized Logistics in Super Express Way Transportation.

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Abstract- Carbon emissions from the logistics industry have been rising year after year. Correct handling of the relationship between economic development and environmental protection is of great significance to the implementation of green logistics, which is an important component of China's strategy for strong transportation. This paper focuses on the evaluation of the carbon emissions efficiency of logistics industry from a new strong transportation strategy perspective. A super-efficiency slack-based measurement (Super-SBM) model and Malmquist index are combined to evaluate the static and dynamic carbon emissions efficiency of the logistics industry.

Keywords- Logistics industry; carbon emissions; static efficiency; dynamic efficiency; super-slacks-based measuring model; Malmquist index

I. INTRODUCTION

In this context, transport management requires a decision-making choice related to the used means in terms of number and allocation, in terms of defining the best routing of its fleet, the traveled distance, and the emission rate of greenhouse gases, as well as the consumed energy amount. In this amalgam of constraints, several studies have been carried out with the objective of establishing the best allocation by using the most adequate means, which allows rapid delivery at a lower cost as well as a minimum rate in both energy consumption and CO2 emission. In this work, we will study the distribution and delivery of products for two different companies that adopt the same fleet of vehicles. This fleet is owned by a company that provides logistics and transport services. The objective of this work is to offer a logistics chain in a circular economy (closed loop) by combining the transport of the two studied networks, taking advantage of empty returns, in order to minimize travel costs and reduce CO2 emissions.

II. RESEARCH MOTIVATION

Energy and environmental issues has become the focus of attention of countries around the world. The logistics industry itself is one of the larger energy consumption industries and a large carbon emissions [1] .Moreover, the construction of logistics system has been raised from the strategic level of the enterprise to the strategic level of social infrastructure. So low-carbon logistics become a new hot spot in theoretical research at home and abroad. The rational planning of logistics distribution can not only effectively reduce logistics costs and improve logistics service level, but also further promote the coordination of production and consumption, to ensure the balanced development of logistics system. Logistics distribution planning issues in the logistics service level and carbon emissions, the predecessors have the following research: In the aspect of logistics service level the logistics service level of the logistics distribution center from different angles, and then put forward the quantitative formula of the logistics service level. In terms of carbon emissions [2]. Established a integrated optimization model for freight vehicles with time window [3].This model set distance and carbon emissions as the goal, and analyzed the effect of speed on model optimization under different congestion conditions influences applied the shortest path method to study the optimization problem of sea route with time window, and reduced the carbon emission by optimizing the transportation speed [4].

Logistics Operation

In recent years, there have been many studies solving the optimization problems of supply chain and logistics that are related to design and operation. This research proposes an integrated supply model of first-mile/last-mile delivery [2]. The author describes a real-time scheduling optimization model focusing on the energy efficiency of the operation, and introduces a mathematical model of last-mile delivery problems including scheduling and assignment problems [3]. Varamath proposed modeling and optimization a three-echelon supply chain network using the particle swarm optimization to address the demand uncertainty and constraints posed by every echelon in the supply chain design operations [4]. The measurement of supply chain and logistics solutions is performed allowing the quantification of availability, flexibility, efficiency, and plasticity indicators [5].

Studies show that unmanned aerial vehicles have the potential effectiveness to reduce CO2 emissions compared to conventional transportation solutions [6]. Researchers have considered three critical environmental issues, namely the energy used in production processes, greenhouse gas (GHG) emissions from production, and transportation activities, and then presented two models (classical and Vendor Managed Inventory coordination) for a two-level closed-loop supply chain [7]. Facing the competitive global market, manufacturers are increasingly dependent on the supply chain network. As one of the strategies of the supply chain, just-in-time greatly reduces the inventory in the workflow through frequent production, which enhances the production efficiency of the enterprise [8].

III. LITERATURE REVIEW

[1] Chao Wang, Transportation CO_2 emission decoupling: An assessment of the Eurasian logistics corridor: The Eurasian logistics corridor is as important transportation hub delivering goods and services to countries along the belt and road. While greatly promoting the economic and social development of countries in the region, the corridor also presents enormous energy consumption and CO_2 emission challenges. In order to assess these demands, our study combines the Tapio decoupling model and the logarithmic mean divisia index (LMDI) to analyze the relationship between transportation sector development and CO_2 emissions. Our study shows that transportation-intensity effect is the main driving force behind CO_2 emission reductions in developed countries, while the energy-intensity effect is key to reducing transportation CO_2 emissions in developing countries. Moreover, we demonstrated that carbon- and transportation-intensity effects inhibit transportation CO_2 emissions, while the factors of economic structure and population size help to increase transportation CO_2 emission levels. Finally, our research provides an important reference for economies seeking to develop greener transportation sectors.

[2] Dongling Bai , Spatio-temporal heterogeneity of logistics CO_2 emissions and their influencing factors in China: An analysis based on spatial error model and geographically and temporally weighted regression model: As one of the ultra-large carbon emitters in China, the logistics industry plays an increasingly essential role in mitigating carbon emissions. Previous studies on logistics CO_2 emissions (LCEs) seldom considered the issue of carbon leakage from electricity and the spatio-temporal nonstationarity of factors influencing LCEs.

Therefore, using regional grid carbon emission factors, this study calculated the LCEs of 30 Chinese provinces from 2005 to 2019 and, thereafter, employed global and local spatial econometric models – Spatial Error Model (SEM) and Geographically and Temporally Weighted Regression (GTWR) model, respectively – to uncover the spatio-temporal heterogeneous impact of influencing factors on LCEs. The results suggest that: (1) The overall LCEs continue to rise, presenting significant spatial difference with an increasing gradient pattern of the "Western-Central-Eastern." (2) The LCEs show a spatial agglomeration, with high–high (H–H) and low–low (L–L) clusters as the main types. (3) Economic development level, energy intensity, and electricity consumption significantly promote the LCEs, and the intensity of the promotion presenting a downward, steady, and upward trend, respectively. (4) Population urbanization inhibits LCEs in north China, but boosts them in south China; the inhibition effect of industrial structure on LCEs, which is mainly pronounced in the provinces along the Yangtze River Economic Belt, tends to transform into a promoting effect.

[3] Bin Xu, Assessing the role of environmental regulations in improving energy efficiency and reducing CO_2 emissions: Evidence from the logistics industry: Environmental regulations are an important means for government managers to manage the environment. The motivation of this article is to investigate the influence mechanism of incentive and mandatory environmental regulations on energy efficiency and carbon dioxide (CO_2) emissions in the logistics industry. The quantile regression can estimate the comprehensive effect of explanatory variables on dependent variables, including maximum, minimum, and median. Based on the panel data of China's 30 provinces from 2005 to 2019, this paper adopts quantile regression to simulate the impact of environmental regulations on CO_2 emissions and energy efficiency.

The empirical results obtained are as follows: (1) incentive environmental regulations make a greater contribution to CO_2 emission reduction in Ningxia, Qinghai, and Hainan provinces, due to their more aggressive levy of pollution fees. (2) Mandatory environmental regulations contribute the most to CO_2 emission reductions in the 25th-50th percentile provinces, since these provinces issue more environmental decrees. (3) Incentive environmental regulations produce a greater influence on the energy efficiency in the 50th-75th, 75th-90th and upper 90th percentile groups, due to their greater R&D investment. (4) Mandatory environmental regulations have a greater impact on energy efficiency in Xinjiang, Heilongjiang, and Yunnan provinces. The findings can provide empirical support for the government to formulate effective environmental policies.

[4]Ahmed Zainul Abideen, Collaborative insights on horizontal logistics to integrate supply chain planning and transportation logistics planning – A systematic review and thematic mapping:The growth of digital platforms and information sharing in the supply chain and logistics arena has considerably improved cross-departmental and inter-organizational collaboration. A competitor backs another competitor to support their transportation and logistics

activities for mutual benefit and growth over several echelons.

On that note, there is a need for a solid horizontal collaboration framework within the supply chain network to ease the collaboration between transportation logistics and supply chain planning. This study has integrated a systematic review of past literature and a bibliometric analysis of the acquired data set. Most relevant keywords were used in the keyword search covering all the major databases. From the final data set, various insights on how collaborative supply chain and transportation network design, profit-sharing, inventory bundling, and distribution, vehicle routing, and transport planning should be designed to attain optimal horizontal collaboration. The findings also portray the future research prospects on horizontal collaboration, practical research gaps, and related enablers within supply chain planning with a conceptual framework.

[5] Lichao Zhu, Comparative evaluation of CO_2 emissions from transportation in countries around the world:It is important to objectively assess whether the transportation CO_2 emissions (TCE) in individual countries are at low levels from the perspective of fairness. Previous studies have focused on directly comparing TCE or TCE per capita (TCEPC) in different countries and in different years, which may generate biased results, because each country has its own demographics and development status. To address this, this study establishes an evaluation framework that considers the heterogeneities of population, affluence, and technology in different countries in different years to provide benchmarks for evaluating the rationality of TCEPC fairly. Results from 115 countries from 1990 to 2019 show that population factors impact TCEPC more significantly than affluence and technology factors. In addition, TCEPC normally progresses from a rational low stage, to a non-rational medium-to-high stage, and then to a rational high-to-medium stage. Currently, most developed countries are at the third stage, while most developing countries are at the second stage.

[6] Yuting Zhu, Which strategy among avoid, shift, or improve is the best to reduce CO_2 emissions from sand and gravel aggregate transportation?:Sand and gravel aggregate (SGA) transportation accounts for over 30% of the freight volume in China, which is greater than that of any other cargo; low-carbon development can effectively promote the decarbonization of freight transportation. This study presents a four-step evaluation method to assess CO_2 emission reductions in freight transportation; the proposed method helps determine the relationship between the policy, CO_2 emission reductions, demand, and mode market share. Using Beijing as a case study, this paper estimates the potential of reducing CO_2 emissions from SGA transportation under various scenarios. The scenarios are set based on the avoid, shift, and improve strategies; the results of the Beijing case indicate that the CO_2 emission for SGA transportation is 920.86 kt, which is approximately 1% of the total CO_2 emissions in Beijing. The maximum reductions in CO_2 emissions that can be achieved using the avoid, shift, and improve strategies are 0.92 kt (0.1% of total), 560.52 kt (60.9% of total), and 78.59 kt (8.5% of total), respectively. The shift strategy is confirmed to be the most realistic and cost-effective approach for reducing CO_2 emissions from SGA transportation. In addition, the implementation of subsidy policies is discussed. Marginal abatement costs under the subsidy scenarios are higher than 224 CNY/t, which is higher than the price in the Chinese carbon trading market.
[7] Peter Wild, Recommendations for a future global CO_2-calculation standard for transport and logistics

A true global CO_2 emissions standard is still not available. EN16258 is currently the most internationally accepted standard for transport and logistics. Moreover, most emission standards have been developed by associations for a single mode of transport or for specific regions (e.g., North America). This research suggests recommendations for a global standard for all modes of transport based on EN16258 for freight/logistics transportation. First, the most relevant standards and methods are addressed and explained. Based on ISO IWA 16, they are then compared and combined into a single overview. A case study of the introduction of CarbonCare (emission calculator) and its global transport customers were taken into account to incorporate practical guidelines for a blueprint. Finally, the blueprint is discussed with experts from all modes of transport, culminating in recommendations not only for transport operation but also for harmonizing warehousing, cooling and transshipment - incorporating simplicity, accuracy, flexibility and feasibility.

[8] Jiehui Jiang, Regional multimodal logistics network design considering demand uncertainty and CO_2 emission reduction target: A system-optimization approach: This paper investigates an interesting regional multimodal logistics network design problem with CO_2 emission reduction target and uncertain demands in the context of urban cluster development. From the perspective of system optimization, a regional logistics network involves a centralized logistics authority and a centralized carrier, where the logistics authority concerns the regional logistics network configuration in terms of the number, location and scale of logistics parks and the subsidies of rail transportation links, and the carrier's decisions include the choice of transportation route for each logistics demand. Given a determined logistics demand pattern, this multi-stakeholder decision making problem is first formulated as a bi-level programming model followed by its equivalent mathematical programming with equilibrium constraints (MPEC) to depict the leader-follower behaviors. To capture the risk aversion level of the logistics authority in uncertain demand environment, an improved adjustable robust optimization method is

proposed, including an individual control parameter and providing an exact expression of the maximum satisfaction probability. Computational results and related impact analysis demonstrate that the proposed models and solution methods are effective, which can provide the beneficial theory basis and practice guide for the green and sustainable development of regional logistics.

[9] Natthapong Nanthasamroeng, Transborder logistics network design for agricultural product transportation in the Greater Mekong Subregion:This research aimed to design a transportation model for the international trade of agricultural products between Thailand, Laos, and Cambodia, known as the Great Mekong Subregion (GMS). Agricultural products are transported from a farmers' cooperative to a foreign end market. The mathematical models GA, DE, and VaNSAS were developed to determine the optimal mode of transportation. The objectives of the proposed methods are to (1) maximize the total profit for the entire agricultural chain and (2) minimize the makespan or the arrival time of the containers to the end market in order to maintain the freshness of the agricultural product. The computational result shows that VaNSAS produces a 100 % optimal solution for small-size problem instances, while DE and GA produce a 63.63 % and 72.72 % optimal solution, respectively. For large-size problem instances, VaNSAS shows a profit that is higher than that of DE and GA by 10.53 % and 8.96 %, respectively, while it shows a makespan that is lower by 9.57 % and 7.20 %, respectively.

[10] Francisco Saldanha-da-Gama, Facility Location in Logistics and Transportation: An enduring relationship:This article aims at contributing to the celebration of the 25th Anniversary of Transportation Research Part E: Logistics and Transportation Review (TRE). It provides an overview of the role of Facility Location in Logistics and Transportation highlighting the contribution of TRE to such an enduring relationship. Several conventional problems are revisited showing that the three above fields have been intertwined for a long time. Nevertheless, the role of Facility Location has become even stronger in the past decades due to challenges posed by new technological developments together with a fast economy globalization and a strong increase in environmental concerns. This has called for the study of more complex problems and the development of comprehensive mathematical models leading to major advances in areas such as reverse and green logistics, humanitarian supply chains, and multimodal transportation, to mention a few. These and other related topics are discussed. Hedging against uncertainty has gained much practical relevance and thus it will be much in focus throughout the paper. Several current trends and future challenges are thoroughly discussed. These include but are not limited to the steps already made and those still missing for paving the way from Industry 4.0 to Industry 5.0, as well as the challenges posed by data-driven decision making in the Era of big data.

IV. APPROACH

This capstone aims to design transportation distribution network scenarios that reduce the carbon emissions of MMTN's activities that meet both global carbon emissions reduction targets as well as customer demand. In addition, the research hopes to assess the trade-offs of reducing carbon emissions to transportation cost and on-the-road delivery time. To optimize a carbon-efficient network design, three key objectives were included in the model: carbon emissions, delivery time, and variable transportation cost. There are several key trade-offs when one variable is maximized over the others. For instance, less carbon intensive long-range vehicles, such as trains, are much slower than carbon intensive airplanes.

How does the carbon intensity of a shipment differ for each scenario? How should the company choose one mode of transportation over the other for certain lanes? What is the extent to which transportation by rail, water or air make economic sense? Additionally, how does the utilization of alternative-fuel vehicles such as electric trucks and biofuel planes impact the total carbon emissions of the transportation network? This project developed a model using Green Facility Location Problem (FLP) to minimize these objectives, and used the ε-constraint method to generate Pareto frontiers that quantified the trade-offs. Additionally, to account for, analyze and determine the reduction targets of MMTN's transportation carbon footprint, the Global Logistics Emissions Council (GLEC) Framework and Science-Based Target Initiative (SBTi) tools have been utilized.

V. PROBLEM DESCRIPTION

In this work, we focus on transportation problems related to the distribution networks, which remain very complex since many decisions must be taken by integrating various constraints depending on the characteristics of, the type of transported goods, the quantities involved, their destination, means of transportation used in terms of capacity and number, environmental impact, etc. The approached work is made up of two parts, the direct shipment part, for products delivery and distribution, and the reverse logistics part, for the collection and recycling of waste.

Part 01: Direct shipment
The objective of this part is to develop an algorithm which ensures the allocation of transport vehicles according to the demand, for a distribution network that is composed of a central warehouse supplying several distribution centers geographically dispersed in different cities. Each distribution center is supplied by the central warehouse with uncertain and varied demands over a given time

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horizon. The delivery of products from the central warehouse to the distribution centers is carried out using means of transport of different sizes with limited and well-defined capacities.

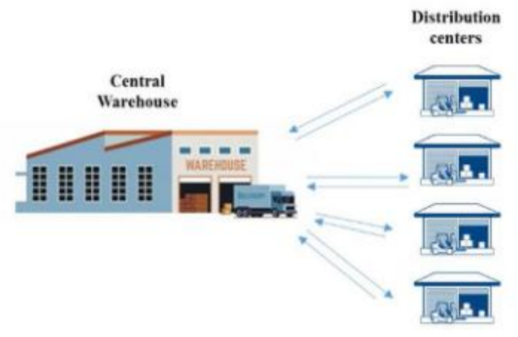

Fig. 1. Illustration of the distribution network using direct shipment.

Each vehicle has a fixed cost of use, a variable cost that depends on the transported quantity and the traveled distance, an energy consumption, and a CO2 emission rate. Other costs that can be added to this kind of network were not considered in this study, such as loading and unloading costs, just to simplify the initial study.

Part 02: Reverse logistics

The second part concerns reverse logistics for a collection network made up of a recycling center and several collection points. Recovery is carried out using a fleet of vehicles of different capacities which is responsible for recovering the quantities intended for the treatment center, as shown in the following figure:

Fig. 2. Illustration of waste recovery network using reverse logistics.

VI.CONCLUSIONS

This paper also has several limitations. Because data from the logistics industry are not always available, the data from transportation, warehousing, and postal services were used as a substitute, which may have led to inaccurate data. Data on CO_2 emissions from the logistics industry cannot be obtained directly from the relevant authorities, so we used the consumption of various fossil fuels to estimate the CO_2 emissions from the logistics industry. Therefore, the data may have caused biased estimations of the results, which is a common weakness of empirical studies. In future studies, the changes of the carbon emissions efficiency of the logistics industry in the pilot regions will be continuously tracked, and the effects of the implementation of China's strategy for strong transportation will be evaluated through data comparisons over five years or even longer.

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