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Theme: “ Electrified and Smart Transportation”

西南交通大学

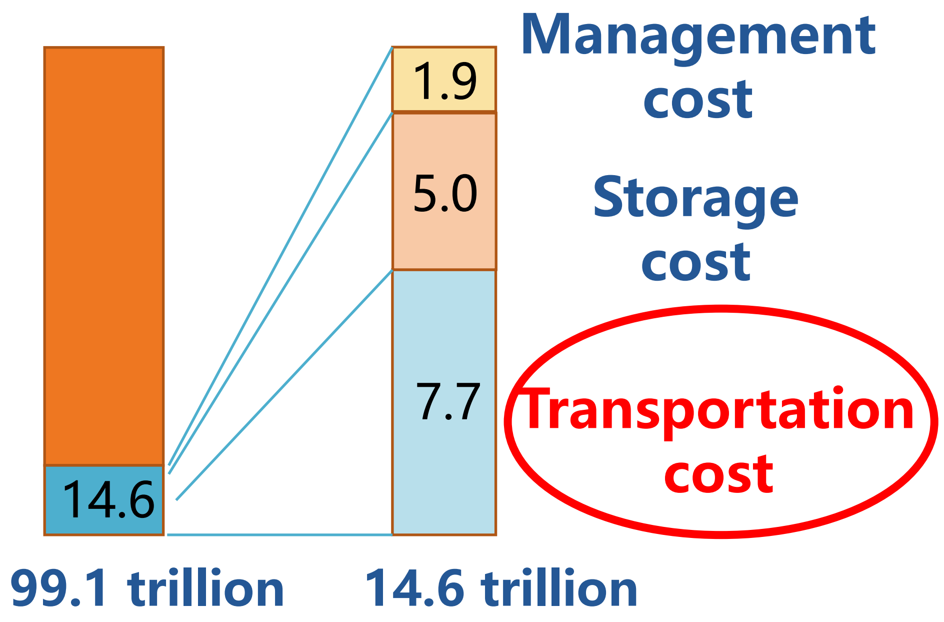
Freight Big-Data Implementation for Smart Logistics Evolution in China

Xiaobo Liu, Ph.D.
Southwest Jiaotong University
2022-02

Logistics in China

Logistics is the most fundamental industry in China

China 's GDP about ￥99.1 trillion in 2019, the total cost of logistics (about ￥14.6 trillion) accounted for GDP 14.7%, while Europe/US 8%. If the Chinese logistics costs reached same level, ~~saving will be approximately ￥6.5 trillion in 2019。~~



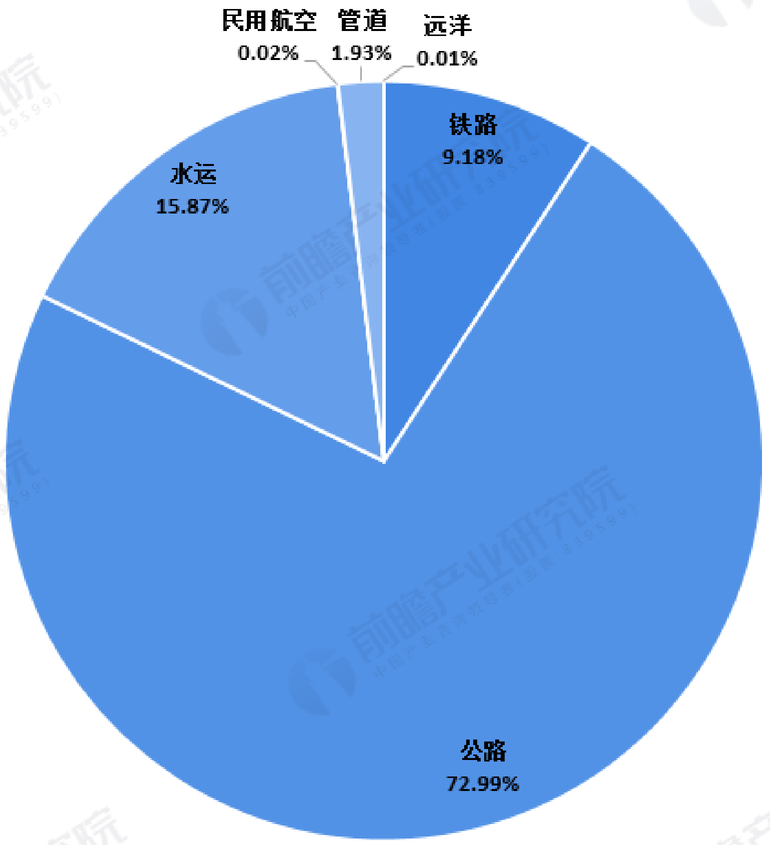
Military in GDP	1.9%
Education in GDP	4%
Logistics in GDP	14.6%

Transportation Modes

Roadway：

(Freight Volume Rank 1、Freight Turnover Rank 2)

图表2：2019年各种运输方式货物运输量所占比重图(单位：%)

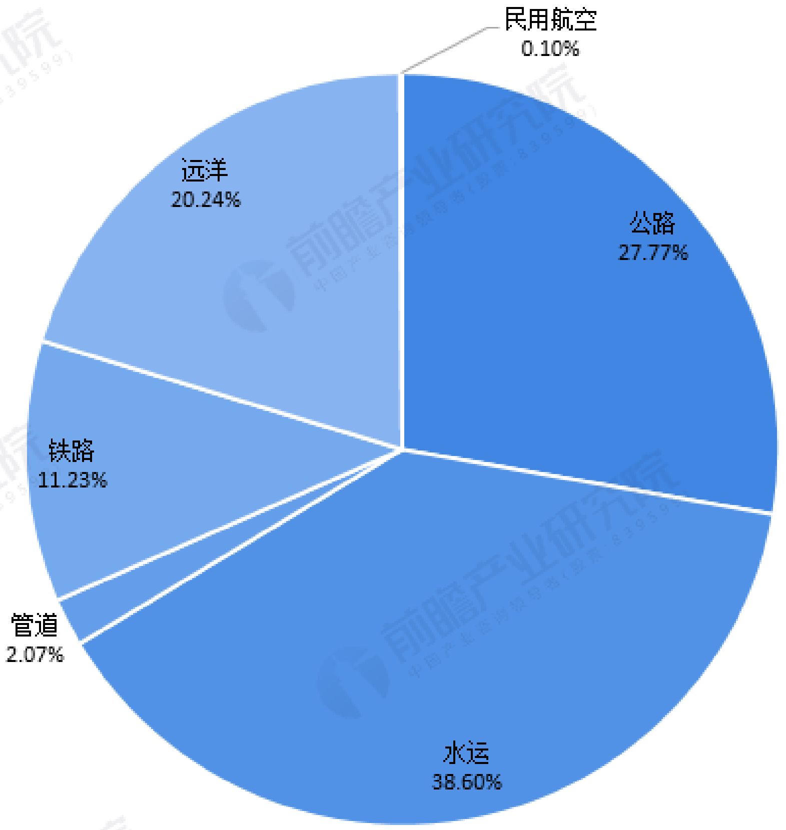


资料来源：国家统计局 前瞻产业研究院整理　　@前瞻经济学人APP

Waterway：

(Freight Volume Rank 2、Freight Turnover Rank 1)

图表4：2018年各种运输方式货物周转量所占比重图(单位：%)



资料来源：国家统计局 前瞻产业研究院整理　　@前瞻经济学人APP

Largest Road Freight Market in the world

The **largest** road freight market

- US logistics market GDP8%, $1.4 trillion
- China logistics market GDP14.6%, $1.83trillion US road freight market $0.7 trillion
- China road freight market $0.75 trillion

Road Freight Market

5 trillion RMB

Road Freight Turnover

7.1 trillion ton kilo
(3trillion ton kilo-railway)

Truck ownership

More than 25.2million

Daily average mileage of a truck

less than 300 km, 58km/hour

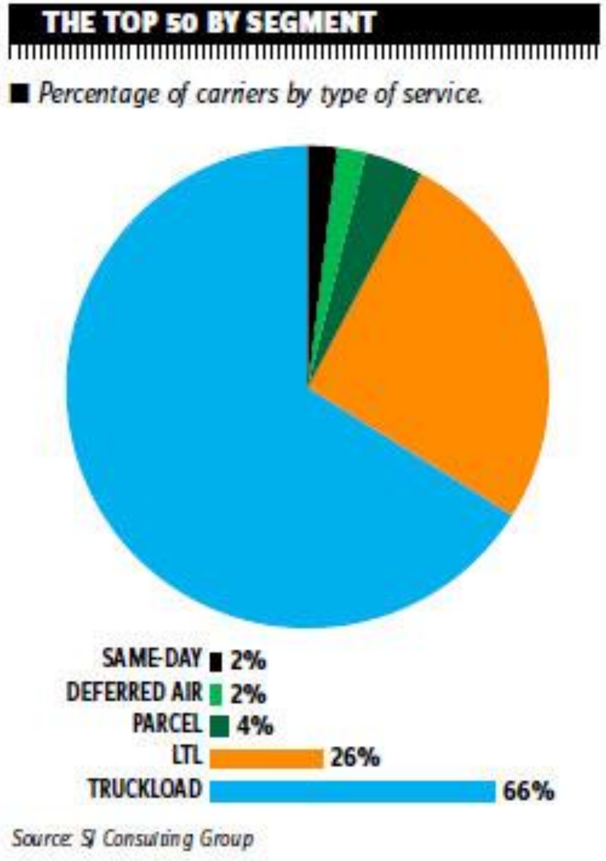
The proportion of self-employed

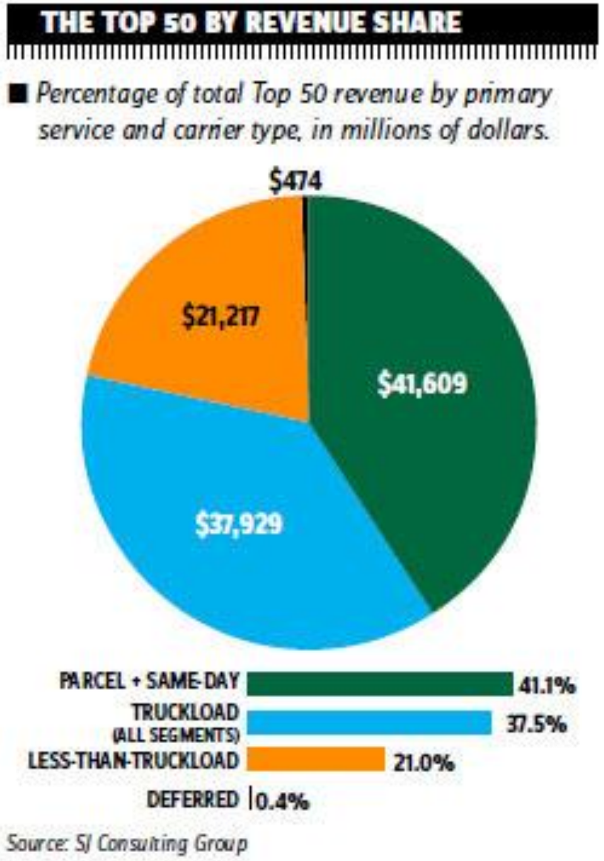
85%

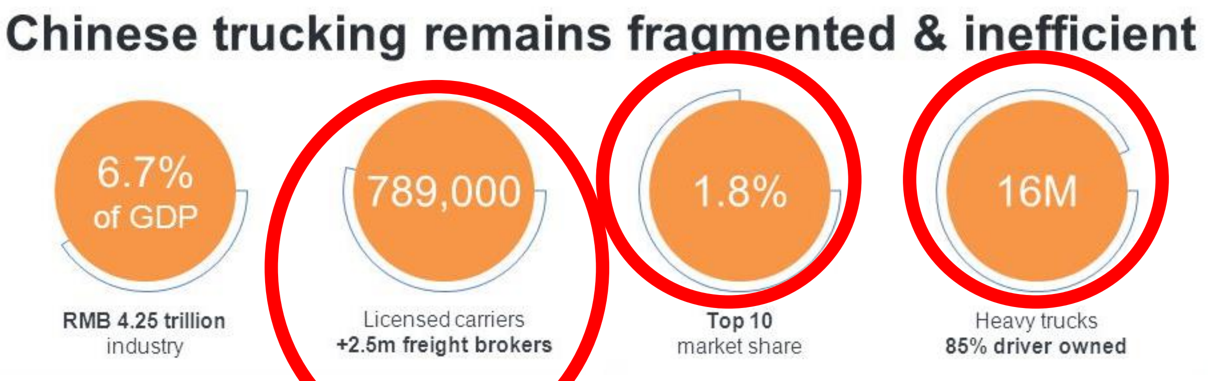
Average number of vehicles per company

1.6

Low Efficiency of Road Freight







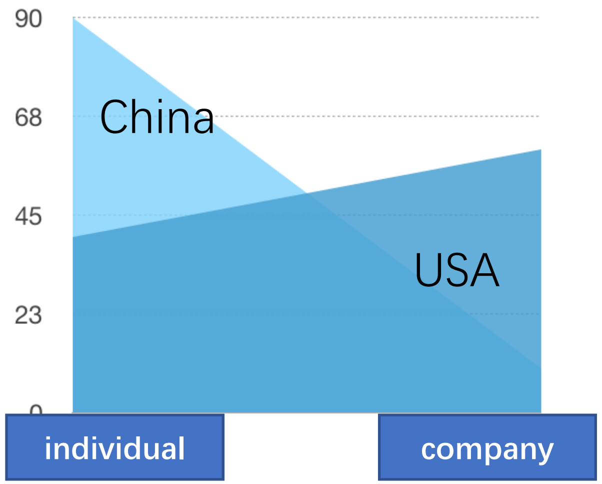
No organization
No collaboration
No Optimization

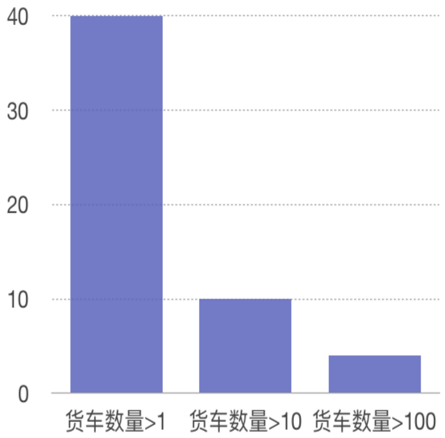
Highly Fragmented Carrier

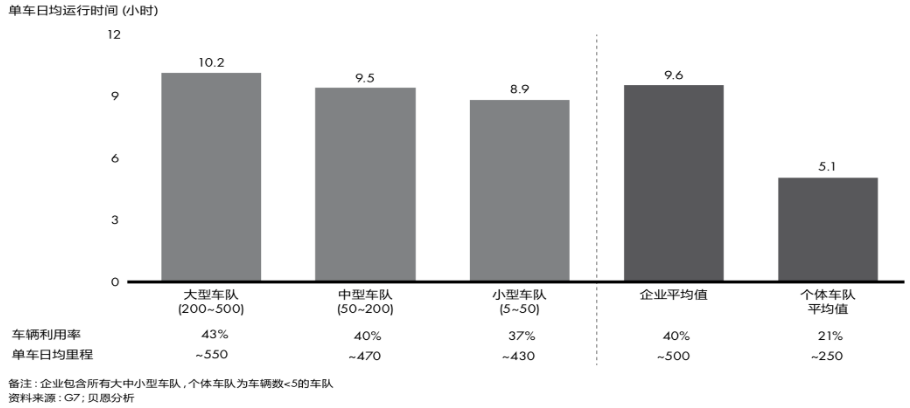
disorderly competition and waste of capacity

Low Efficiency of Road Freight

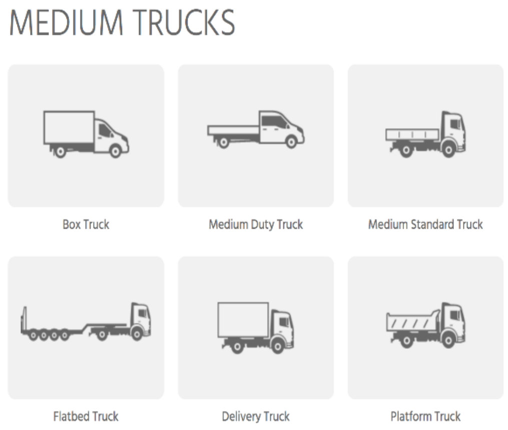
Issue 1 Fragmented and low-level standardization

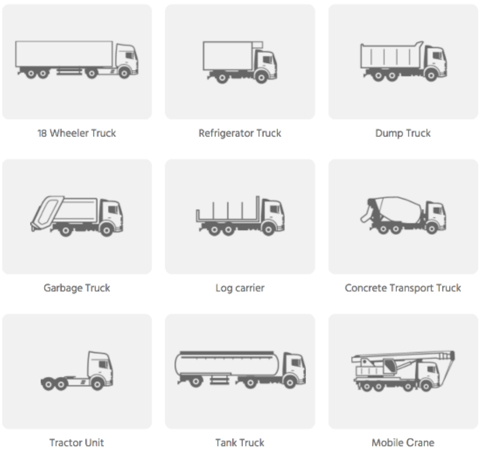






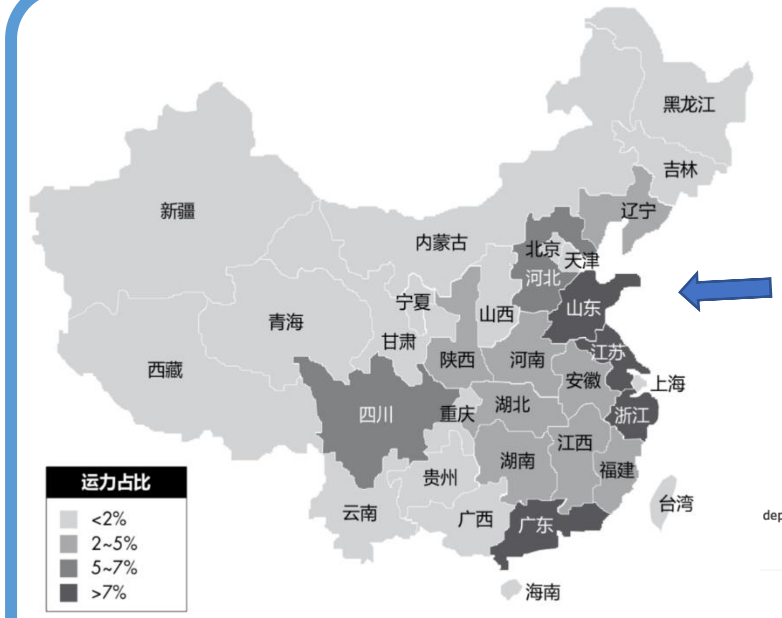
- ➢ **Highly fragmented carriers**
- ➢ **Low Vehicle Utilization Rate due to the lack of organization and collaboration**
- ➢ **Low-level standardization**





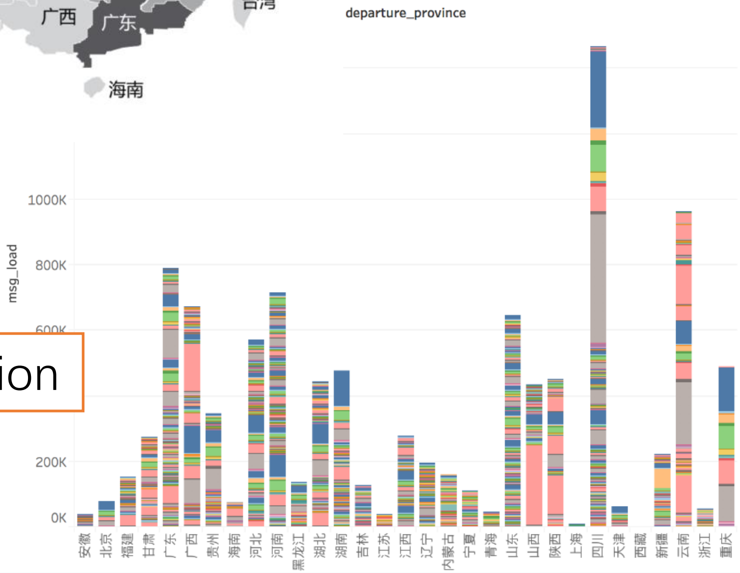
Low Efficiency of Road Freight

Issue 2 Hard to Match for truck and cargo



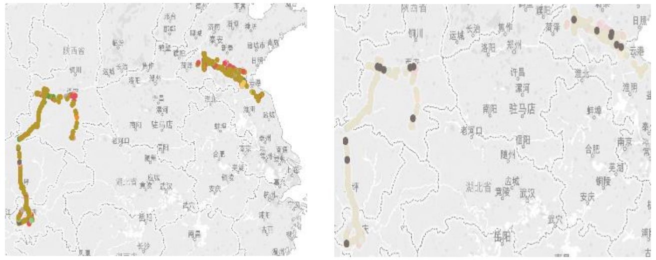
资料来源：G7；贝恩分析

Supply distribution



Demand distribution

- ➢ No pricing system (different from railway), hard to negotiate for Carrier and Shipper
- ➢ Lack of real-time intelligent allocation of logistics resources, 40% empty truck
- ➢ Lack of real-time intelligent route guidance and additional services such as refueling, automobile repair and parking



Trajectories indicates that trucker intend to familiar area

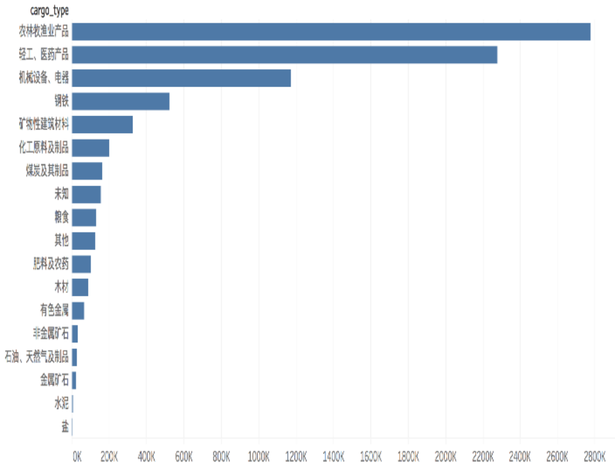
Low Efficiency of Road Freight

Issue 3 Lack of effective infrastructure

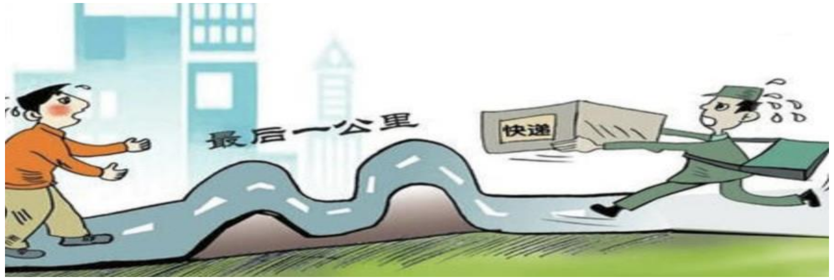
- **Point**: The traditional facilities only provide poor service; Lack of cargo handling, lack of vehicle pick-up, maintenance, parking and other functions
- **Line**: Toll service is inefficient
- **Network:** The layout of logistics facilities cannot guarantee economic service

Low Efficiency of Road Freight

Issue 4 Lack of Planning

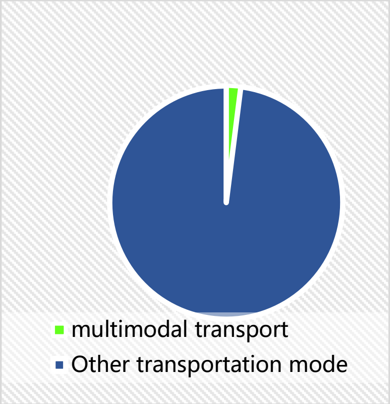


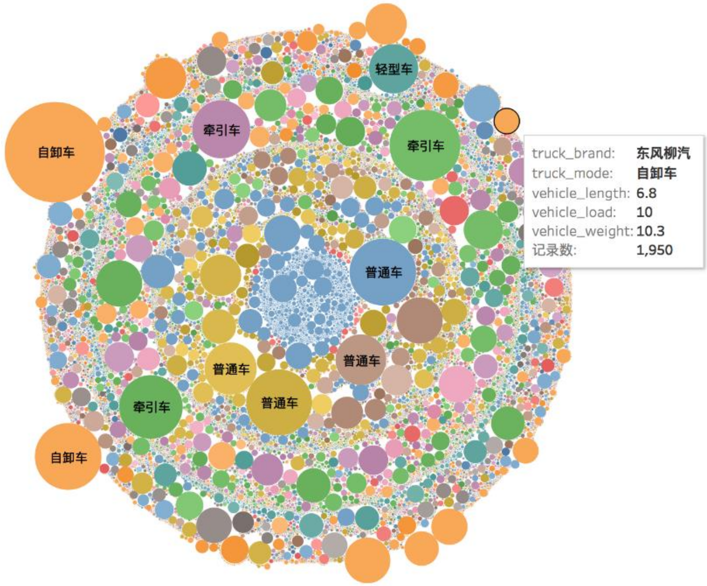
- ➢ Lack of national-level freight industry planning and coordination due to fragmented truck companies
- ➢ The threshold of freight industry is low, resulting in extra supplier capacity.
- ➢ Lack of planning for urban freight delivery, resulting in high cost in the last mile.



Low Efficiency of Road Freight

Issue 5 Lack of multi-modal transport





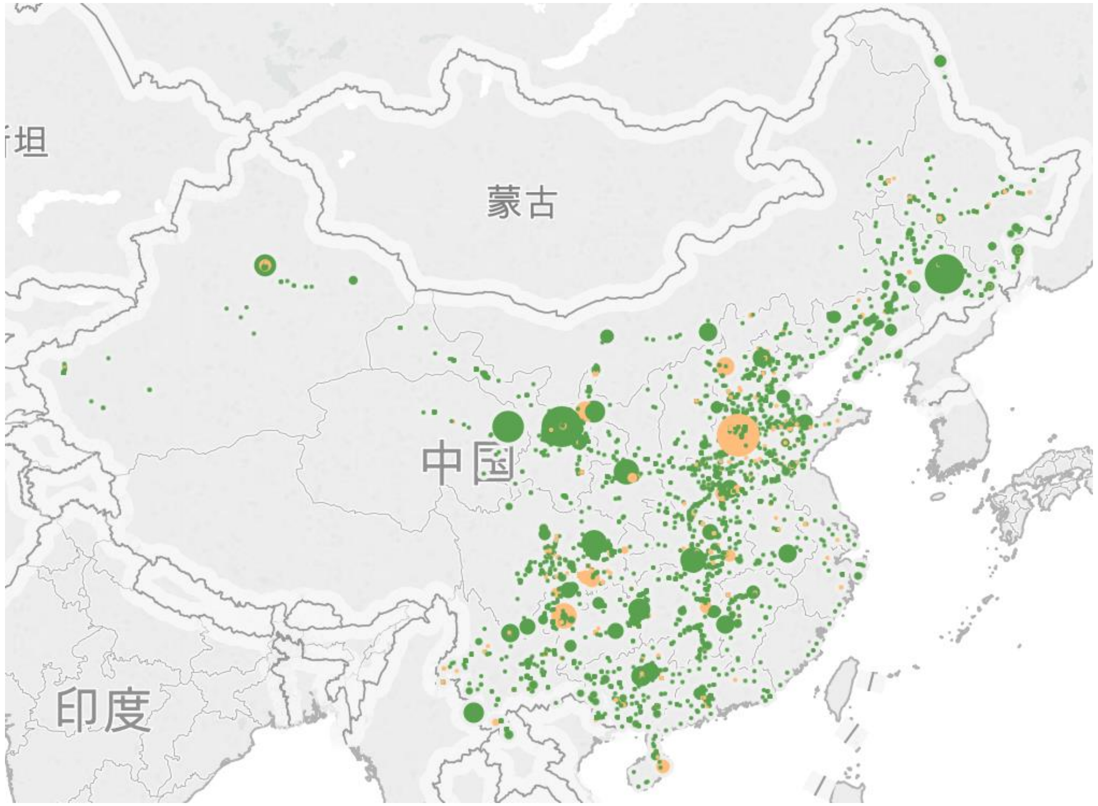
•Distribution of vehicle type

•The proportion of Semi-trailers extremely low

- The proportion of multi-modal transport is low (2% in China, 40% in the US, and 35% in Europe)
- Low rate of connection/transfer service (China1%，US/europe70-80%)
- Semi-trailer occupies a small proportion in the truck market

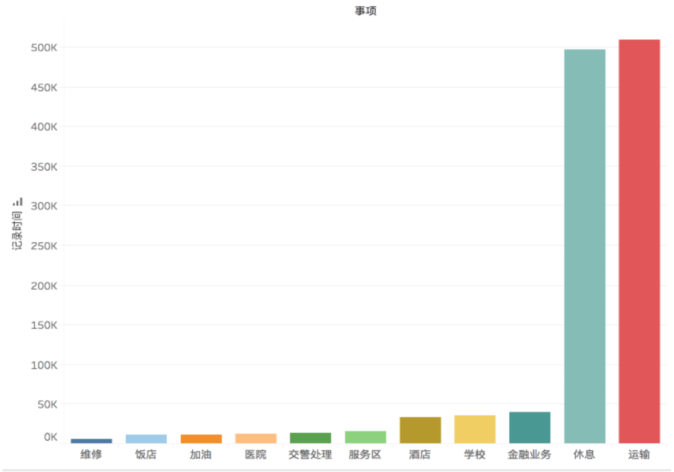
Low Efficiency of Road Freight

Issue 6 Lack of professional service to trucker



全国公路货运服务热点

Individual trucker need to take care of all in addition to transport, such as bank, mortgage, insurance, administrative



司机公路货运时间分布

Internet + Logistics Platform

1985，Europe

Teleroute®

Wolters Kluwer

Transport Services

2006，USA

COYOTE.

2011，China

2017，USA

Big Data finally Breaks the dilemma by quantifying the relationship between the demand and supply. Thus, cargo, truck, driver, dispatch, price could be optimized to improve the efficiency of trucking industry.

Massive data pool

Full life-cycle

- trucker
- Truck
- Cargo
- Market
- Financial services

High precision

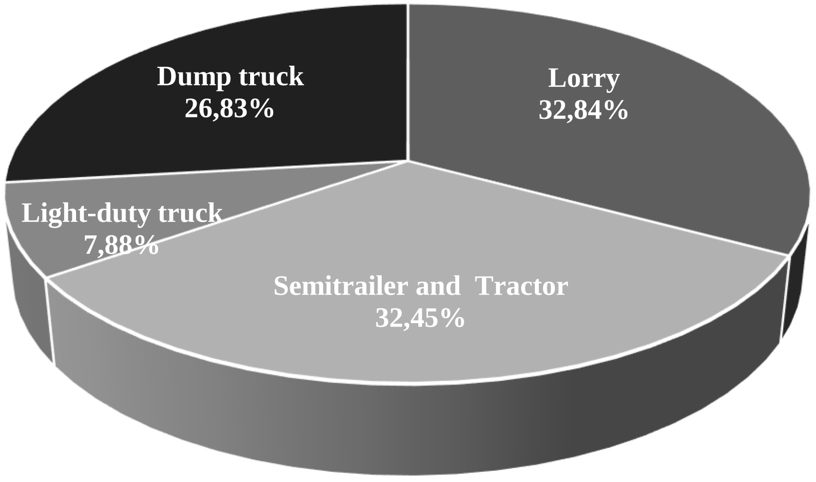
- Behavioral data
- Trajectory data
- Cargo Source data
- Logistics park data
- Transaction data

Big Data

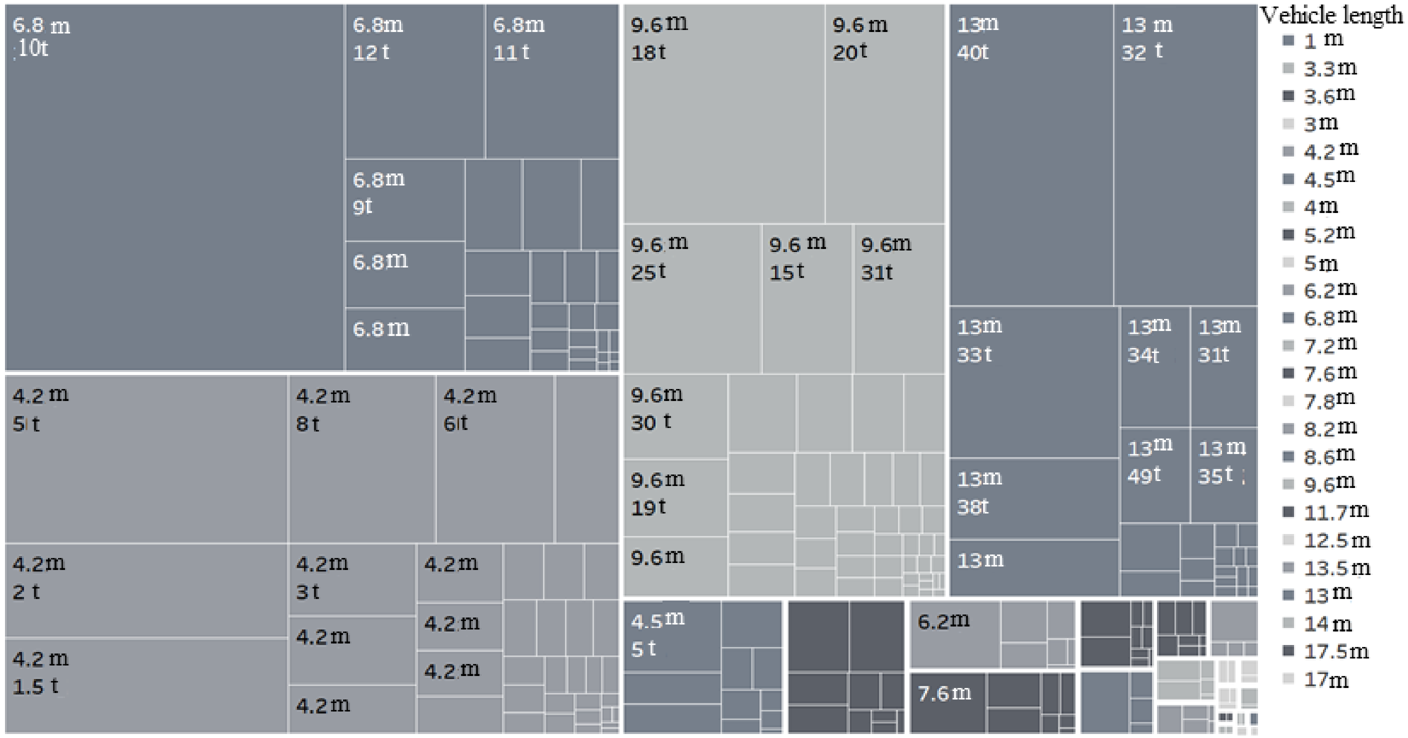
Multi-dimension

- Logistics
- Information flow
- Products flow

Distribution by Truck Type



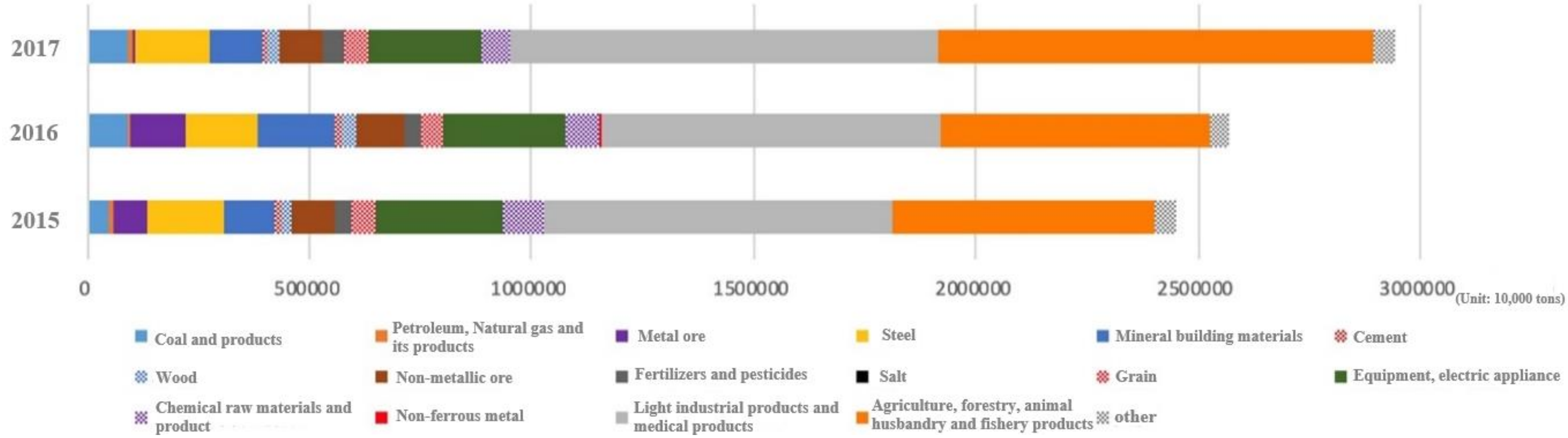
Truck Type



Truck type distribution by length-load combination

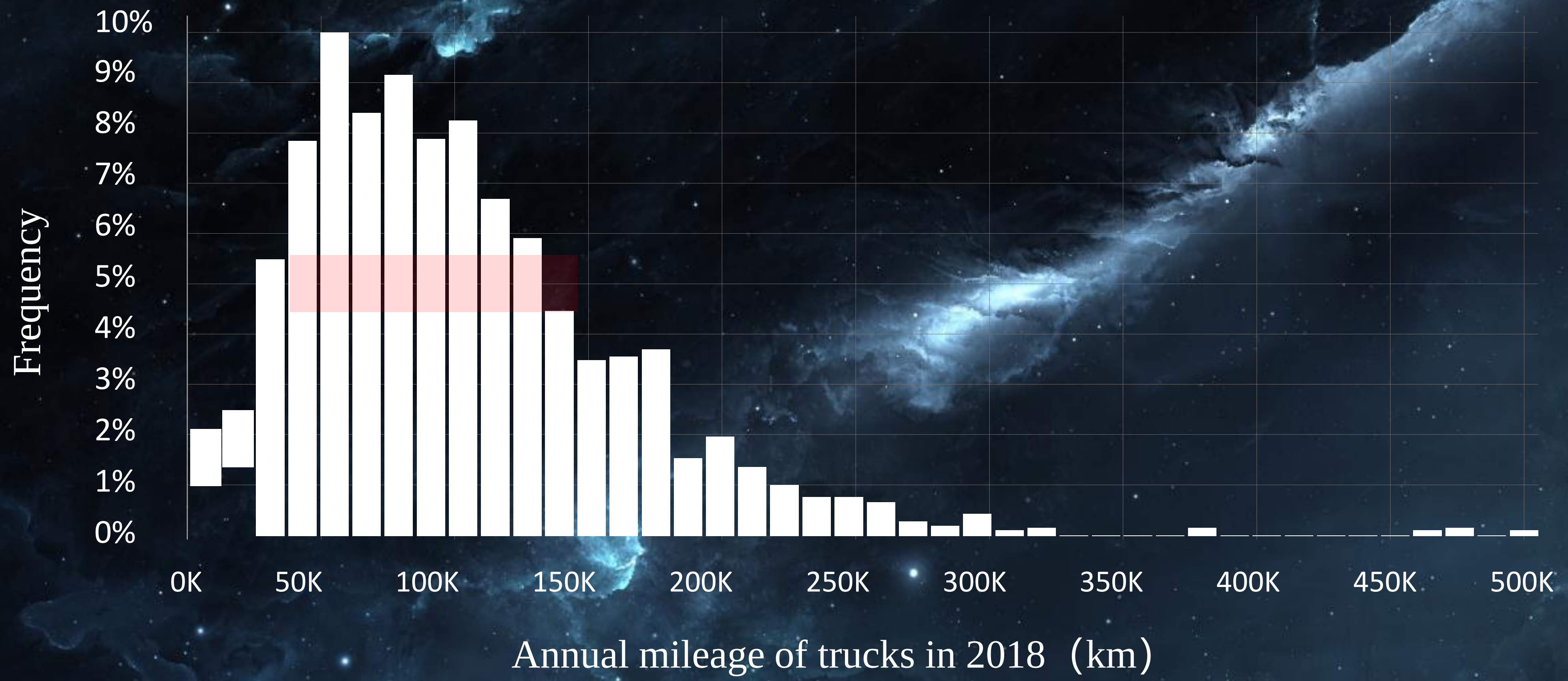
Mode division standard： GB 20997-2015 *Limits of fuel consumption for light duty commercial vehicles*、GB 30510-2014 *Fuel consumption limits for heavy-duty commercial vehicles*

Cargo composition



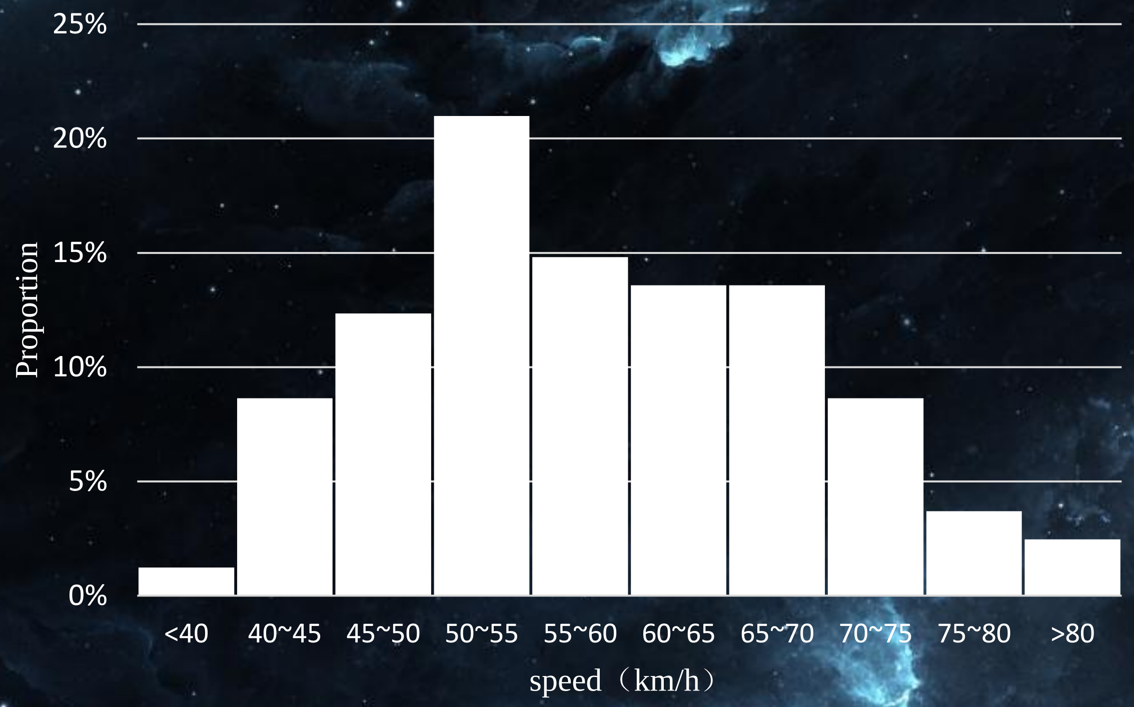
Cargo type composition from 2015 to 2017

➢ Mileage distribution by frequency

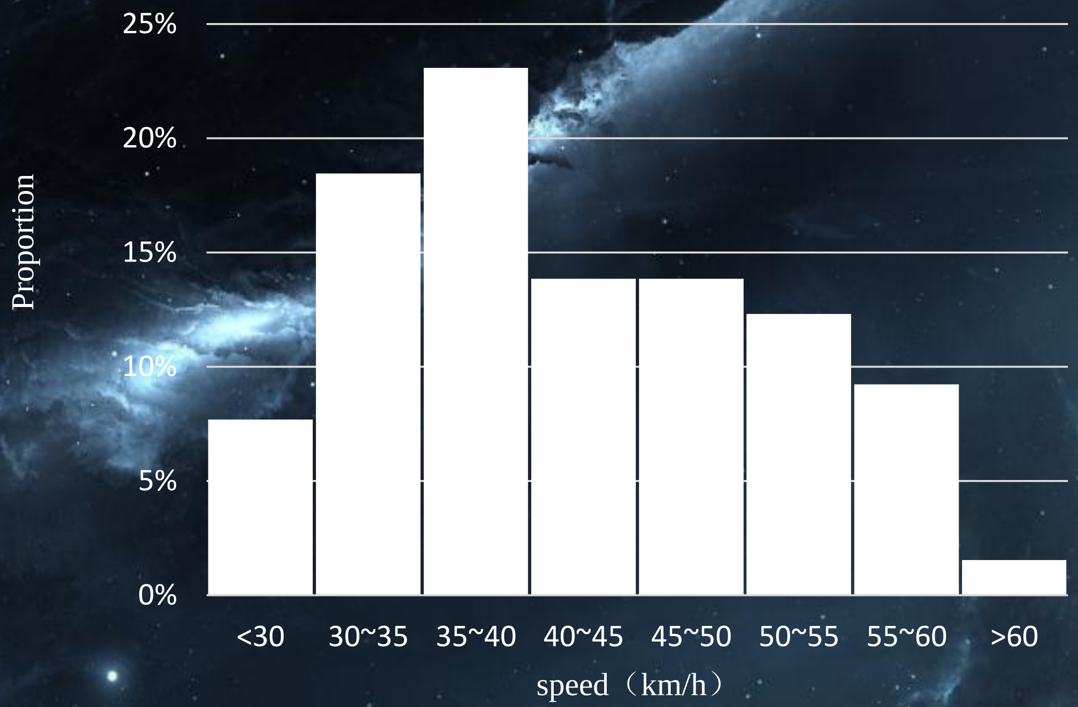


In 2018, the average mileage of trucks in China is 107,332 km, the maximum mileage is 498,458 km, the trucks with annual mileage from 50K to 150K km account for 59%.

Truck speed in different regions

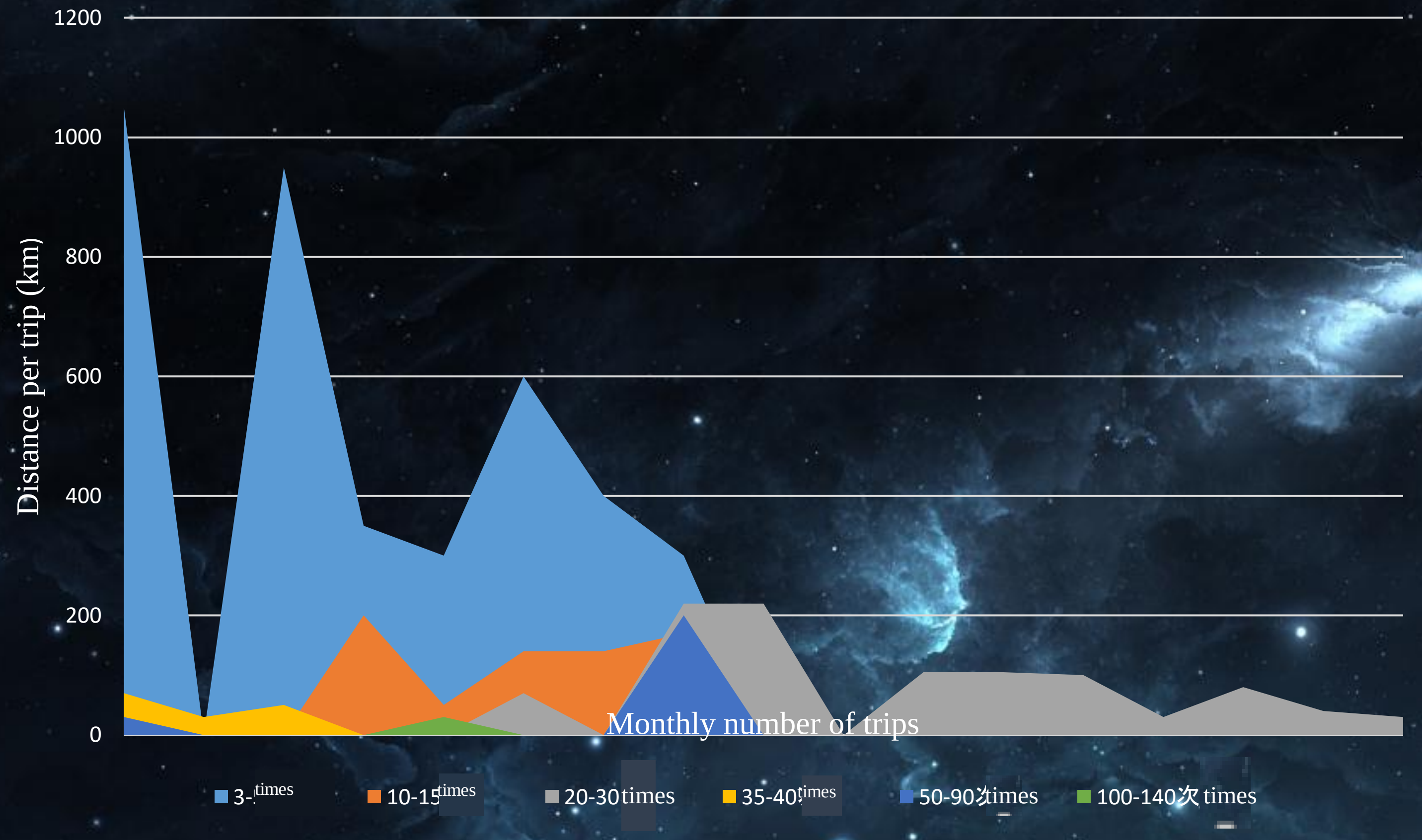


Beijing-Tianjin-Hebei region

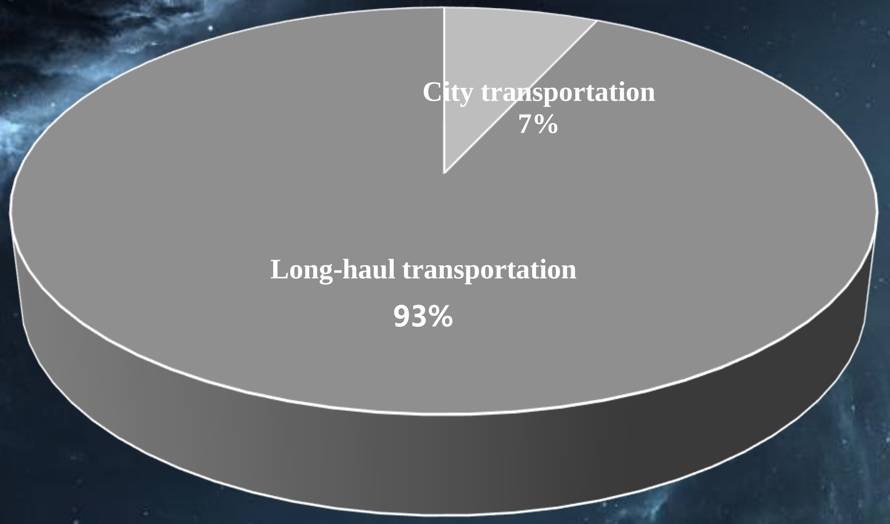


Southwest region

Freight preference characteristics



Distance Distribution by Trip Frequency



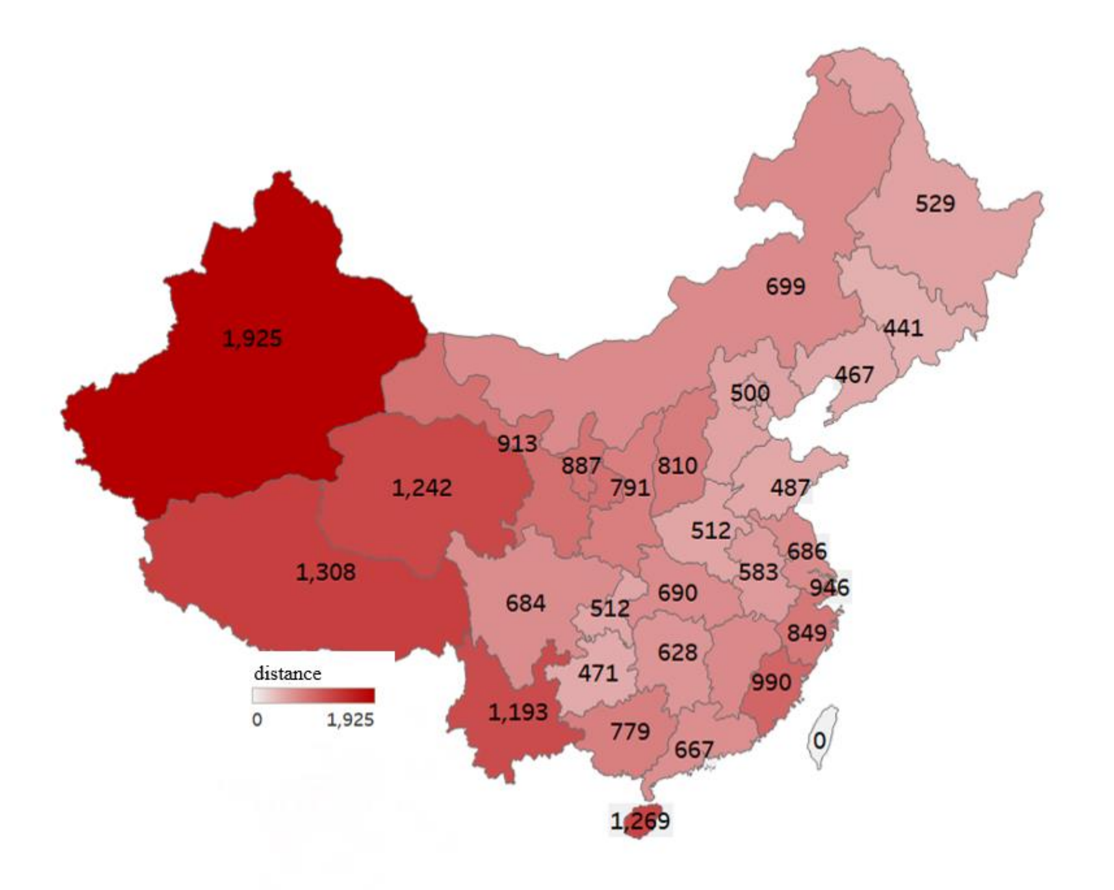
Distance preference

➢ Distance distribution by Cargo

Average load-distance by cargo types

- The average load-distance of agriculture, forestry, animal husbandry and fishery products was the longest, reaching 1076km.
- The average load-distance of cement is the shortest, which is 334 km.

Distance distribution by departure area



- The average distance of trucks departure from Northwestern China is 700km-900km;
- The average distance of trucks departure from coastal areas is 600km-700km;
- The average distance of trucks departure from Northeastern and Central China is 450km-500km.
- most of the trucks in remote areas carried out long-distance transportation, with an average distance of about 1200 km- 2000 km;

Critical impact factors include the origin of the goods, the length of the truck.

Based on 2017 data

Key Technologies

Optimal resource allocation and dispatching optimization

- **Caogo Distribution – where are they?**
- **Driver– Individual behavior and choice**
- **Truck Distribution– Where are they?**
- **Pricing- system optimization**
- **Dispatch – “machine broker”**

Predictability of Truckers

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Whereabouts of truckers: An empirical study of predictability☆

Mi Gan[a,b,c,d], Yu (Marco) Nie[c,*], Xiaobo Liu[a,d], Daoli Zhu[b]

[a] School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, Sichuan 610031, China
[b] Sino-US Global Logistics Institute, Shanghai Jiaotong University, Shanghai 200030, China
[c] Department of Civil & Environmental Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208, United States
[d] National Engineering Laboratory of Integrated Transportation Big Data Application Technology, Southwest Jiaotong University, Chengdu, Sichuan 610031, China

ARTICLE INFO

Keywords:
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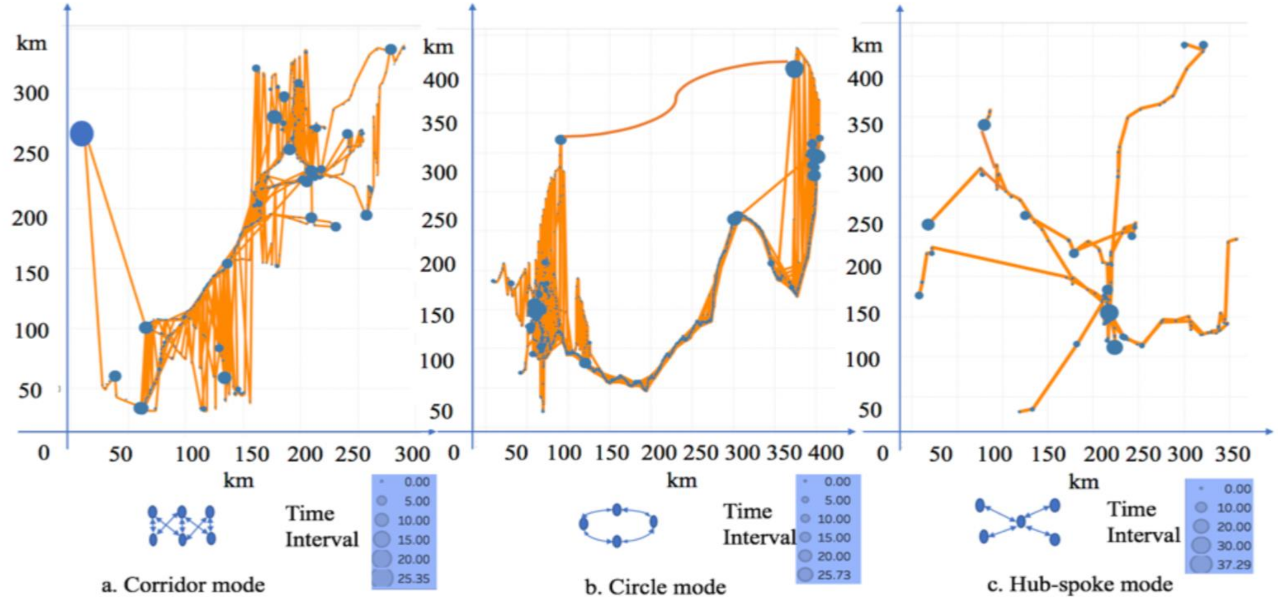
Regularity
Whereabouts
Entropy
On-line freight exchange

ABSTRACT

This study examines the predictability of a truckload trucker's whereabouts, using a GPS trajectory data set from about 1000 active users of an on-line freight exchange (OFEX) platform. To describe a trucker's whereabouts, two different location mapping schemes are proposed. The first divides the entire study area into rectangular grids using a simple geographic rescaling method and treats each grid as a unique location. In the second scheme, a location type (LT) is first assigned to each GPS point, using Point Of Interest (POI) information. Then, each GPS trajectory is converted to a trajectory of LT data. We then process both types of trajectory data, grid-based and type-based, to develop various entropy and predictability measures. We find that the whereabouts of truckers possess strong regularity, but are substantially more difficult to predict than that of an average person. Specifically, the predictability of truckers' next location on the grid map peaks at 83%, about 10% percentage point lower than that reported in the literature. Surprisingly, predicting the type of the location that a typical trucker may visit the next is even more difficult, with a predictability around 81%. Findings from this study could help guide the development of algorithms for predicting truckers' next visit location and the type of the location.

1. Introduction

Trucking is a massive industry that accounts for about $700 billion in revenue in the United States (TA, 2015). The size of the industry in terms of revenue is about the same in China, where trucks move 31.5 billion tons of freight a year, roughly three-quarters of the total freight tonnage (Song, 2017). The trucking industry is highly fragmented. According to TA (2015), more than 90% of the carriers in the US operate six or fewer trucks. In China, 85% of heavy trucks are owned by small for-hire carriers, with each having an average of 1.6 trucks (Li, 2016). Consequently, this market is very competitive and not particularly profitable, especially for individual owner-operators, who have neither much bargaining power nor access to valuable network-wide information. The rise of online freight exchange (OFEX) platforms[1] offers a novel approach to consolidating the industry. This new technology brings individual truck owner-operators (hereafter referred to as truckers for simplicity) and shippers together to share information and to provide various value-added services. One of its most important functions is quickly matching the most suitable loads with truckers to improve operation efficiency. In order to properly recommend loads to truckers in real-time, the platform often needs to predict their



- The regularity of trucker's mobility patterns is strong, both temporally and spatially.
- The main behavior of truckers is to travel across cities, or to rest in residential areas, and they also spend a lot of time in financial and government business.

Future swarm robotics in road freight

Swarm and Evolutionary Computation 62 (2021) 100845

Contents lists available at ScienceDirect

Swarm and Evolutionary Computation

journal homepage: www.elsevier.com/locate/swevo

ELSEVIER

Capturing the swarm intelligence in truckers: The foundation analysis for future swarm robotics in road freight

Mi Gan [a,b], Qiujun Qian [a,b], Dandan Li [a,b], Yi Ai [c], Xiaobo Liu [a,b,*]

[a] Department of Transportation and Logistics, Southwest Jiaotong University, 610031 Chengdu, PR China
[b] National Engineering Laboratory of Integrated Transportation Big Data Application Technology, Southwest Jiaotong University, 610031 Chengdu, PR China
[c] School of Traffic, Civil Aviation Flight University of China, 618307 Guanghan, PR China

ARTICLE INFO

Keywords:
Swarm Intelligence
Prediction
Trucker Trajectory
Machine learning

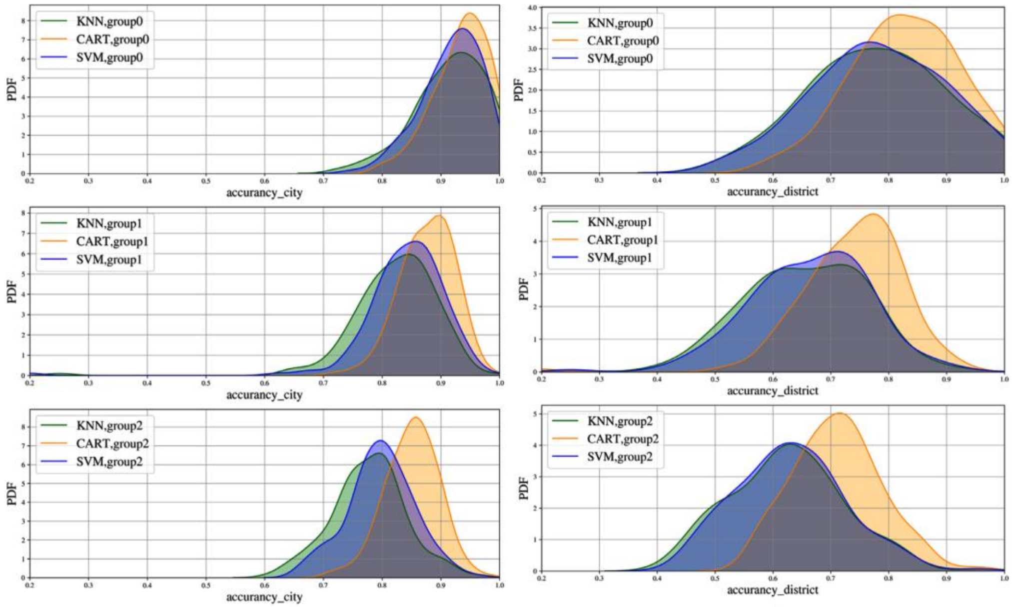
ABSTRACT

A group of individual truckers can be regarded as a swarm intelligence system without central management. With the development of autonomous driving technology, trucker groups will be replaced by driverless vehicles. At that point, a swarm of truckers will become a swarm robotics system. Therefore, considering the design and control of an efficient swarm robotics system, it is essential to investigate the properties and model the behaviors of a swarm of truckers in advance. In this study, we probe the characteristics of both individual truckers and a swarm of truckers using trajectory data of truckers. First, the trajectory data were map matched based on the geographic scale of cities and administrative regions. Then, the properties of the division of labor, pattern formation, and swarm synchronization were obtained through an analysis of the spatiotemporal distribution of radius of gyration, travel distance, and the number of visited places. Because predicting the next visit locations of individuals of a swarm is a measure for modeling swarm behaviors, the prediction model can be used to predict future swarm robotics (driverless trucks) behaviors. Thus, we apply several machine learning models to predict the next locations of truckers. The results show that there are common characteristics and routines embodied in the behavior of the truckers; the swarm shows consistency and regularity. Moreover, the peak predictability of the entire group reached 94%, indicating that our model can predict the behavior of groups and individuals. Our findings provide basis supporting the future efficient swarm robotics system.

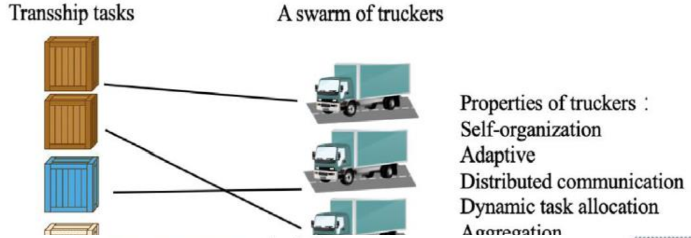
1. Introduction

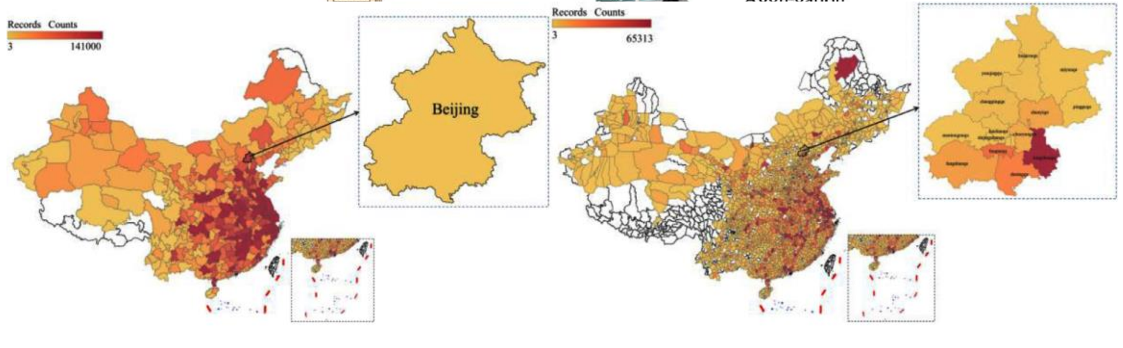
Swarm robot technology aims to design a group of robots not dependent on any external infrastructure or any form of centralized control. In a swarm of robots, the collective behavior of the robots is caused by the local interactions between robots and their environment. The design of the robot group follows the principles of swarm intelligence (SI). These principles facilitate the implementation of fault-tolerant, scalable, and flexible systems. Swarm robotics (SR) seems to be a promising approach when different activities have to be performed simultaneously, high redundancy and lack of a single point of failure are required, and the infrastructure of centralized control robots cannot be established technically. Examples of profitable missions using swarm robotics include mine clearance, search, and rescue, planetary or underwater exploration, and surveillance [1,2]. In the future transportation and logistics industries, there are many systems that need to be designed using swarm robotics, such as autonomous vehicle systems, autonomous aerial vehicle cargo systems, and warehouse Automated Guided Vehicle (AGV) systems. Some scholars have proposed that swarm intelligence is the key to the realization of driverless vehicle technology [3]. Thus, the analysis of swarm intelligence of a group of subjects in the transportation system could provide a solid basis for the design, control, and management of the corresponding swarm robotic system.

In this study, we considered a swarm of truckers in the road freight system of China as the research subject. In China, road transportation accounts for 78% of the total freight volume, and the market size has exceeded CNY 5 trillion, ranking first in the world [4]. Trucks are an important part of the road transportation system and a major contributor to fuel consumption and road transportation emissions. Among the more than 30 million truck drivers in China, less than 10% of the drivers belong to professional fleets of enterprises, and more than 90% are self-employed/individual drivers. Self-employed/individual truck drivers (hereafter referred to as truckers) operate individually and interact only with other local truckers and local environment. In contrast to the top-down organization and control of for-hire or fleets of trucks, truckers organize to accomplish local road freight tasks using a bottom-up approach without global information and central control. Thus, the efficiency of road freight system is difficult to optimize by central integration or task dispatching algorithms. Compared with the complex composition of freight tasks in the road freight market of China, the



a *b*





(a) (b)

Price Prediction for Roadway Freight

Volatility of the Freight Rate

Hindawi
Mathematical Problems in Engineering
Volume 2020, Article ID 5386402, 15 pages
https://doi.org/10.1155/2020/5386402

Research Article

Modeling and Prediction of the Volatility of the Freight Rate in the Roadway Freight Market of China

Wei Xiao,[1] Mi Gan ,[1,2,3] Hongling Liu,[1] and Xiaobo Liu[1,2,3]

[1]*School of Transportation and Logistics, Southwest Jiaotong University, No. 111 Erhuanlu Beiyiduan, 610031 Chengdu, China*
[2]*National United Engineering Laboratory of Integrated and Intelligent Transportation, Southwest Jiaotong University, Chengdu, Sichuan, China*
[3]*National Engineering Laboratory of Integrated Transportation Big Data Application Technology, Chengdu 611756, Sichuan, China*

Correspondence should be addressed to Mi Gan; migan@swjtu.cn

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The trucking sector is an essential part of the logistic system in China, carrying more than 80% of its goods. The complexity of the trucking market leads to tremendous uncertainty in the market volatility. Hence, in this highly competitive and vital market, trend forecasting is extremely difficult owing to the volatility of the freight rate. Consequently, there is interest in accurately forecasting the freight volatility for truck transportation. In this study, to represent the degree of variation of a freight rate series in the trucking sector over time, we first introduce truck rate volatility (TRV). This investigation utilizes the generalized autoregressive conditional heteroskedasticity (GARCH) family of methods to estimate the dynamic time-varying TRV using the real trucking industry transaction data obtained from an online freight exchange (OFEX) platform. It explores the ability of forecasting with and without reestimation at each step of the conventional GARCH models, a neural network exponential GARCH (NN-EGARCH) model, and a traditional forecasting technique, the autoregressive integrated moving average (ARIMA) approach. The empirical results from the southwest China trucking data indicate that the asymmetric GARCH-type models capture the characteristics of the TRV better than those with Gaussian distributions and that the leverage effects are observed in the TRV. Furthermore, the NN-EGARCH performs better in in-sample forecasting than other methods, whereas ARIMA performs similarly in out-of-sample TRV forecasting with reestimation. However, the Diebold–Mariano test indicates the better forecasting ability of ARIMA than the NN-EGARCH in the out-of-sample periods. The findings of this study can benefit truckers and shippers to capture the tendency change of the market to conduct their business plan, increase their look-to-buy rate, and avoid market risk.

Prediction Bwt-Route Correlations

IEEE Access
Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

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Short-Term Truckload Spot Rates' Prediction in Consideration of Temporal and Between-Route Correlations

WEI XIAO[1,2,3], CHUAN XU[1,2,3], HONGLING LIU[1], HONG YANG[4], AND XIAOBO LIU[1,2,3]
[1]School of Transportation and Logistics, Southwest Jiaotong University, Chengdu 610031, China
[2]National United Engineering Laboratory of Integrated and Intelligent Transportation, Southwest Jiaotong University, Chengdu 610031, China
[3]National Engineering Laboratory of Integrated Transportation Big Data Application Technology, Chengdu 611756, China
[4]Department of Computational Modeling and Simulation Engineering, Old Dominion University, Norfolk, VA 23529, USA

Corresponding author: Chuan Xu (xuchuan@swjtu.edu.cn)

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ABSTRACT Truckload spot rate (TSR), defined as a price offered on the spot to transport a certain cargo by using an entire truck on a target transportation line, usually price per kilometer-ton, is a key factor in shaping the freight market. In particular, the prediction of short-term TSR is of great importance to the daily operations of the trucking industry. However, existing predictive practices have been limited largely by the availability of multilateral information, such as detailed intraday TSR information. Fortunately, the emerging online freight exchange (OFEX) platforms provide unique opportunities to access and fuse more data for probing the trucking industry. As such, this paper aims to leverage the high-resolution trucking data from an OFEX platform to forecast short-term TSR. Specifically, a lagged coefficient weighted matrix-based multiple linear regression modeling (Lag-WMR) is proposed, and exogenous variables are selected by the light gradient boosting (LGB) method. This model simultaneously incorporates the dependency between historical and current TSR (temporal correlation) and correlations between the rates on alternative routes (between-route correlation). In addition, the effects of incorporating temporal and between-route correlations, time-lagged correlation and exogenous variable selection in modeling are emphasized and assessed through a case study on short-term TSR in Southwest China. The comparative results show that the proposed Lag-WMR model outperforms autoregressive integrated moving average (ARIMA) model and LGB in terms of model fitting and the quality and stability of predictions. Further research could focus on rates' standardization, to define a practical freight index for the trucking industry. Although our results are specific to the Chinese trucking market, the method of analysis serves as a general model for similar international studies.

Implementations

Objects / Prospective	people	truck	cargo	Logistics Park	Financial services
From the national prospective	Policy : **Cost reducing and efficiency increasing** **Multimodal transport** **Energy saving and emission reduction**				
From the enterprise prospective	Profit : **Supply and demand forecast, Cost analysis, Pricing strategy, Vehicle matching, Transport Capacity Integration, system optimization, Financial services**				

Intelligent Logistics

An update of
Industrial Model，

A Re-organization of
Logistics Procedure

THANKS

Questions?

xiaobo.liu@swjtu.cn
Xiaobo.liu@gmail.com