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BRIEFING

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CHINA GREEN FREIGHT ASSESSMENT

ENABLING A CLEANER AND MORE EFFICIENT FREIGHT SYSTEM IN CHINA

BACKGROUND

The China Green Freight Assessment provides an in-depth evaluation of the road freight system in China, including the new truck sales market, the market penetration of fuel-saving technologies, the operational characteristics of transportation companies, and the institutional framework of the trucking sector.

China is currently undergoing an environmental crisis. Large metropolises struggle with air quality and controlling vehicle emissions, while the country is actively seeking options to reduce climate emissions through investments in cleaner and more efficient methods to produce energy, transport people and goods, and manufacture products. The transportation sector is responsible for a sizeable share of air pollution and climate emissions in China, the world's largest vehicle market since 2009. Heavy-duty vehicles (HDVs), the backbone of China's freight system, represent an effective target for emissions control. Although HDVs make up just 10% of total vehicle fleet in China, they emit over 80% of particulate emissions that contribute to local air pollution and negatively impact public health and consume 65% of on-road fuel and CO_2 emissions.[1]

1 Kodjak, D., *Policies to reduce fuel consumption, air pollution, and carbon emissions from vehicles in G20 nations* (ICCT: Washington, DC, 2015), https://www.theicct.org/publications/policies-reduce-fuel-consumption-air-pollution-and-carbon-emissions-vehicles-g20.

Prepared by: The ICCT contracted the China Automotive Technology and Research Center (CATARC) to conduct the *China Green Freight Assessment, Project Report* on which this briefing is based. Funding for this research was generously provided by the United States Environmental Protection Agency. All references, charts and tables in this briefing, unless noted otherwise, are taken from the assessment. The full report can be accessed at: https://www.theicct.org/publications/china-freight-assessment

Not only is the freight sector responsible for the lion's share of transportation emissions, but it is also highly inefficient. The high number of individual owner-operators, lack of drop-and-hook operations, and the relatively small number of logistics operators increase the number of shipments and distance required to transport goods. Despite government initiatives to improve freight efficiency, a good share of bulk commodities are still transported by trucks, many of which are overloaded and not properly maintained.

This assessment of freight in China provides insights on truck characteristics, technology, and operations in order to highlight the most adequate technologies and strategies to make freight cleaner and more efficient.

ROAD FREIGHT MARKET

China is currently the second largest consumer of oil worldwide (12.5%), of which 55% is used for transportation.[2] Freight in China is primarily moved by trucks (Figure 1) and represents half of transportation energy use. Among the reasons underlying the dominance of road freight are its ability to facilitate door-to-door delivery, flexibility, current road infrastructure, and the allocation of rail infrastructure primarily to high-speed passenger trains.

Road freight will likely remain the dominant way to transport goods in China, but more efficient and cleaner modes such as freight rail could have a more prominent role in the future. Tianjin, Weifang and other port cities have banned transporting coal by diesel trucks. As a vast majority of trucks have diesel engines, this is expected to increase the share of railway freight in the future and increase freight system efficiency as a result, since railways consume less energy than trucks on a ton-kilometer basis. In 2016 alone, rail transport of cargo containers, motor vehicles, and bulk cargo has increased by 40%, 53% and 25%, respectively. Express package delivery using high-speed trains has also been in use since October 2016 as an alternative to the aviation express delivery market.

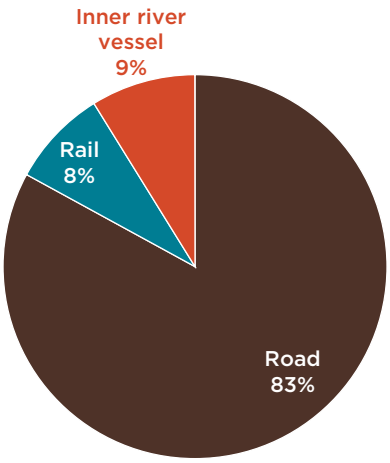


Figure 1. Freight mode shares in 2016
Source: Ministry of Transportation, Statistic Communique on the Development of Freight Industry 2016; China Fortune Press, China Logistics Development Report, 2016-2017

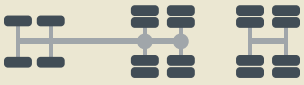
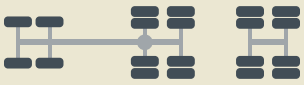
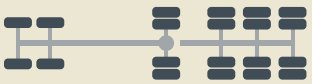
New regulations are attempting to resolve China's truck over-loading problems. National vehicle dimensions and maximum loading standards released in 2016, commonly referred to as "9.21" regulations, established new limits for gross vehicle weight (GVW), as illustrated in Table 1. Enforcement actions are now conducted against illegal retrofitted and over-loaded trucks, and non-standardized vehicles are being phased out of the market. This increased demand for heavy-duty trucks by 36% in 2016. Over-loading regulations have also encouraged the shift of large-volume cargo, such as coal and motor vehicles, to rail.

2 International Energy Agency, "World Energy Balances" (2017), https://webstore.iea.org/world-energy-balances-2017-overview.

Table 1. Over-load determination standards for trucks

Axle	Vehicle type	Figure	GVW limit after 9.21 (tonnes)	GVW limit before 9.21 (tonnes)
2-axle	Straight truck		18	20
3-axle	Center axle tractor-trailer		27	30
	Articulated vehicle			
	Straight truck		25	
				
4-axle	Center axle tractor-trailer		36	40
			35	
	Articulated vehicle		36	40
	Full trailer vehicle			
	Straight truck		31	
5-axle	Center axle tractor-trailer		43	50
				
	Articulated vehicle			
	Articulated vehicle		43	
			42	
	Full trailer vehicle		43	
				

Table 1. Over-load determination standards for trucks

Axle	Vehicle type	Figure		GVW limit after 9.21 (tonnes)	GVW limit before 9.21 (tonnes)
6-axle	Center axle tractor-trailer			49	55
				46	
				49	
				46	
	Articulated vehicle			49	
				46	
				46	
	Full trailer vehicle			49	
				46	

Notes

1. For 2-axle trucks, the total mass of truck and cargo shall not exceed the GVW on the vehicle license.
2. Except for driving axle, 2-axle vehicles, 3-axle vehicles, semi and full trailer tractor-trailers, the GVW limits shall decrease by 3 tonnes for decreasing every two tires.
3. For trailers and tractor-trailers that install tires with nominal transect width of no less than 425mm and straight trucks and tractor-trailers that install tires with nominal transect width of no less than 445mm, the GVW limit shall not be decreased.
4. For vehicles that are equipped with double-wheel and air suspension at each side of the driving axle, the GVW for 3-axle and 4-axle straight trucks shall be increased by 1 tonne; for 4-axle articulated vehicles that are equipped with double-wheel and air suspension at each side of the driving axle and have a distance between the two axles of semi-trailers ≥1800mm, the GVW limit shall be 37 tonnes.
5. For vehicles that are not listed in the table, the GVW shall be determined based on the prescriptions of "*Limits of dimensions, axle load and masses for motor vehicles, trailers and combination vehicles*" (GB 1589-2016).

Individual owner-operators represent over 60% of roughly 8 million road freight carriers in China (Figure 2), compared to roughly 1.5 million road freight carriers in the United States.[3] The large number of small and individual carriers leads to fierce competition and very low operational margins, making it difficult to comply with environmental and maximum loading regulations. Thus, over-loading regulations have benefited larger carriers who can better optimize equipment capacity and control transportation costs.

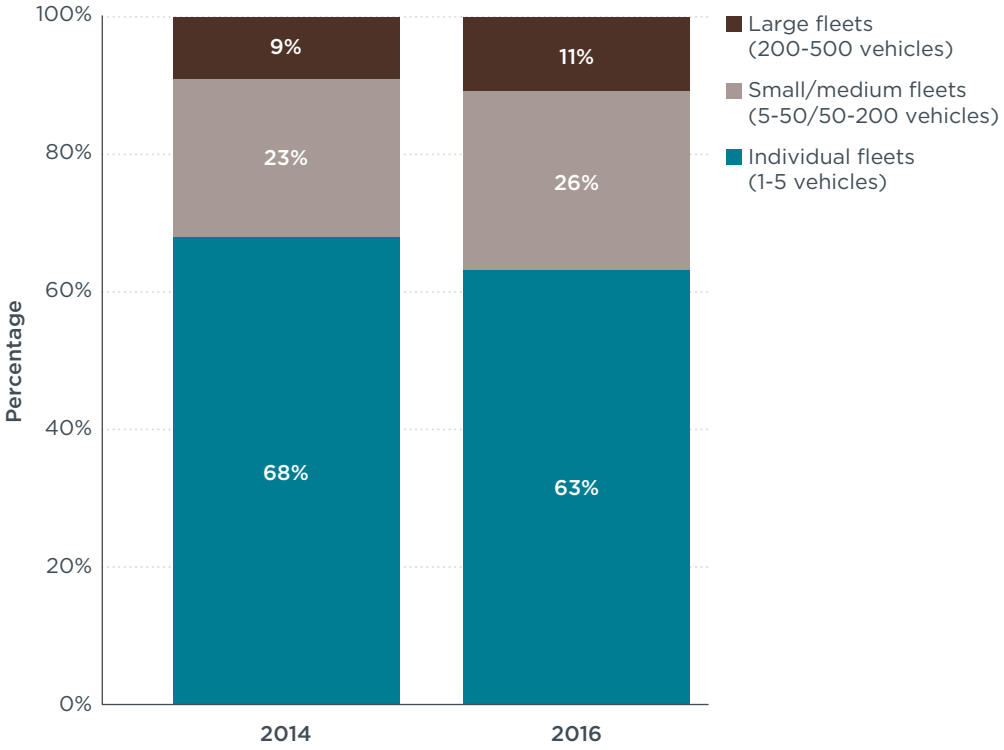


Figure 2. Proportion of Chinese truck fleet by fleet scale
Source: China Automotive Technology & Research Center, Vehicle registration data from Ministry of Public Security

The lack of more comprehensive drop and hook operations limits the efficiency of China's trucking industry. Drop and hook operations enable tractors to drop a trailer at a freight facility and pick up another trailer, thus enabling better equipment utilization (Figure 3). Drop and hook operations have been promoted in China since 2009, but they have not been widely adopted due to a lack of appropriate freight matching platforms, a lack of trust between vehicle owners, non-standardized freight stations, non-standardized truck equipment, and a low number of trailers. The ratio of tractors to trailers in China is about 1:1, while in the U.S. it is about 1:2.4.[4] Adoption can be promoted by establishing platforms for efficient freight-truck matching and creating a trailer rental program.

3 United States Department of Transportation, Federal Motor Carrier Safety Administration, "Motor Carriers Summary Report" (2018), http://ai.fmcsa.dot.gov/SMS/Tools/Reports.aspx.

4 Ben Sharpe, Nigel Clark, & Dana Lowell, Trailer technologies for increased heavy- duty vehicle efficiency: Technical, market, and policy considerations (ICCT: Washington, DC, 2013), http://www.theicct.org/sites/default/files/publications/ICCT_HDVtrailertechs_20130702.pdf.

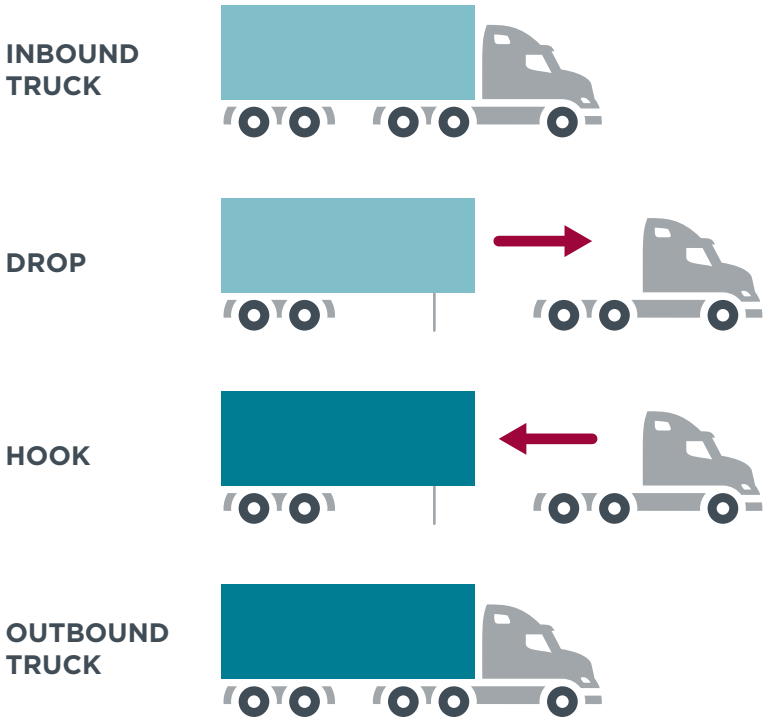


Figure 3. Drop and hook operations

Truck brokerage firms and freight truck matching platforms are in their infancy stages but have the potential to increase truck efficiency by building electronic information platforms that enable better coordination and matching of loads and truck equipment.

The rapid growth of e-commerce is increasing demand for express parcel delivery, making freight orders more fragmented. As more orders in regional distribution networks move directly from station to door, carriers face more challenges to consolidate loads and improve freight system efficiency.

TRUCK TECHNOLOGY AND CHARACTERISTICS

Heavy-duty vehicle production has fluctuated in recent years following the introduction of new vehicle emission standards and over-loading regulations (Figure 4). In anticipation of the implementation of China IV emission standards, truck production peaked in 2013, after which it fell due to lower economic growth in 2014 and 2015. Truck production increased by 36% in 2016 following the over-loading regulations.

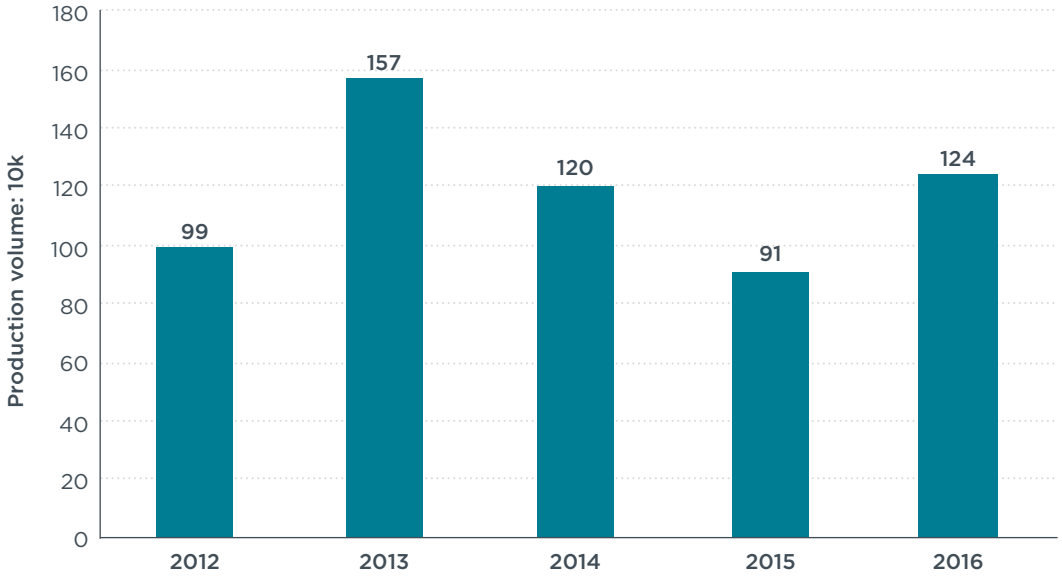


Figure 4. Production of heavy-duty freight trucks in China in 2012–2016
Source: China Automotive Technology & Research Center (CATARC, 2017a). Production volume data from database of CATARC

Although straight trucks still dominate China's truck market, tractor trailers are gaining market share (Figure 5). The increase in express deliveries put pressure on the logistics system efficiency, thus increasing demand for tractors relatively to straight trucks.

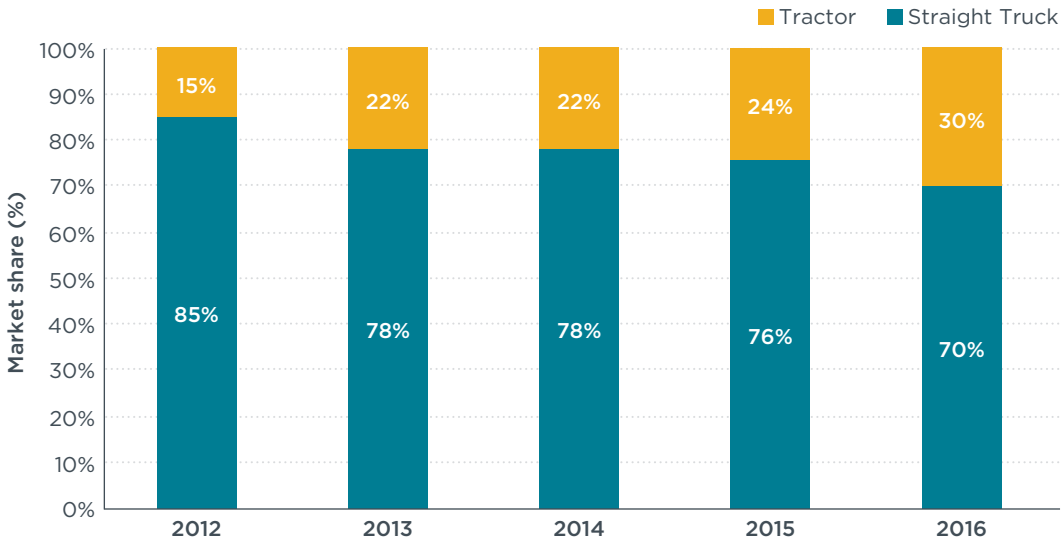


Figure 5. Share of heavy-duty trucks by vehicle segment in 2012-2016
Source: China Automotive Technology & Research Center, Vehicle registration data from Ministry of Public Security

Diesel is still the major fuel used by heavy-duty freight trucks in China (Figure 6). Although electric trucks still represent a very small share of nationwide straight trucks, the market for battery electric urban delivery vehicles has been growing rapidly (Figure 7). Since 2014, the relative decline in diesel prices have reduced the market share of natural gas engines from 4% to 1% in 2016. However, the implementation of

China V emission standards boosted sales of natural gas tractors after 2016, since they don't require the use of urea solutions.

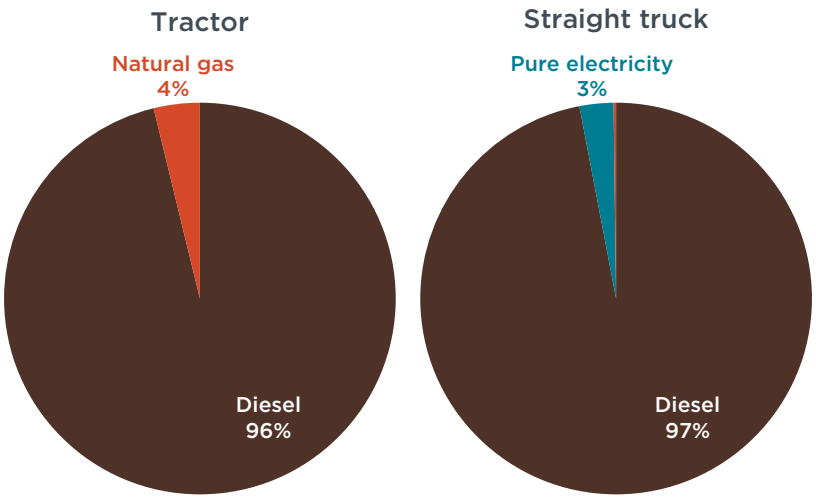


Figure 6. Fuel shares by vehicle segment in 2016
Source: China Automotive Technology & Research Center, Vehicle registration data from Ministry of Public Security

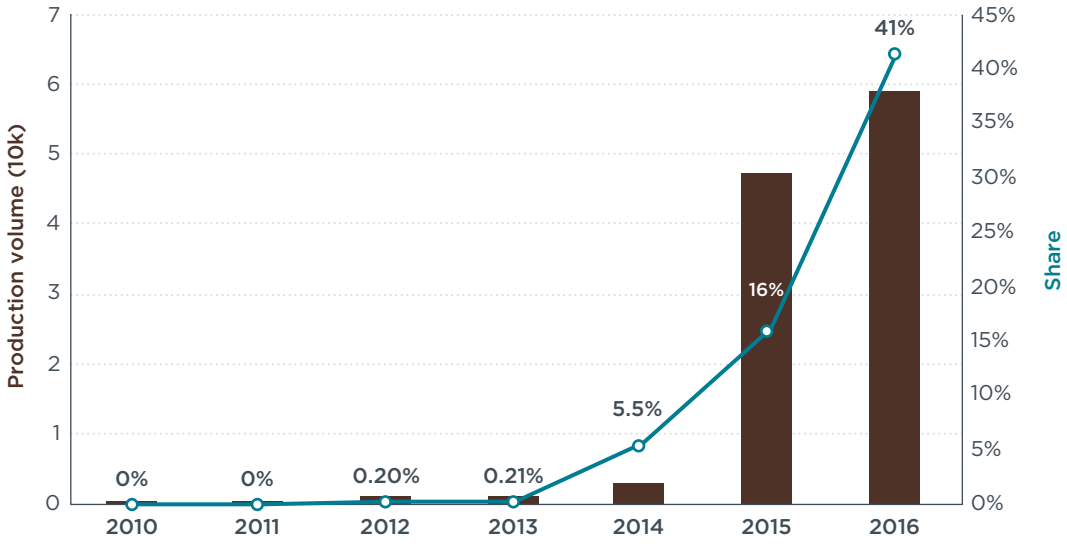


Figure 7. Production and share of vehicles over 3.5 tonnes out of the total battery electric delivery vehicles
Source: China Automotive Technology & Research Center, Production volume data from database of CATARC

The market for tractors and straight trucks is dominated by six manufacturers, who represent over 80% of the market, while the market for engines and trailers shows less consolidation (Figure 8).

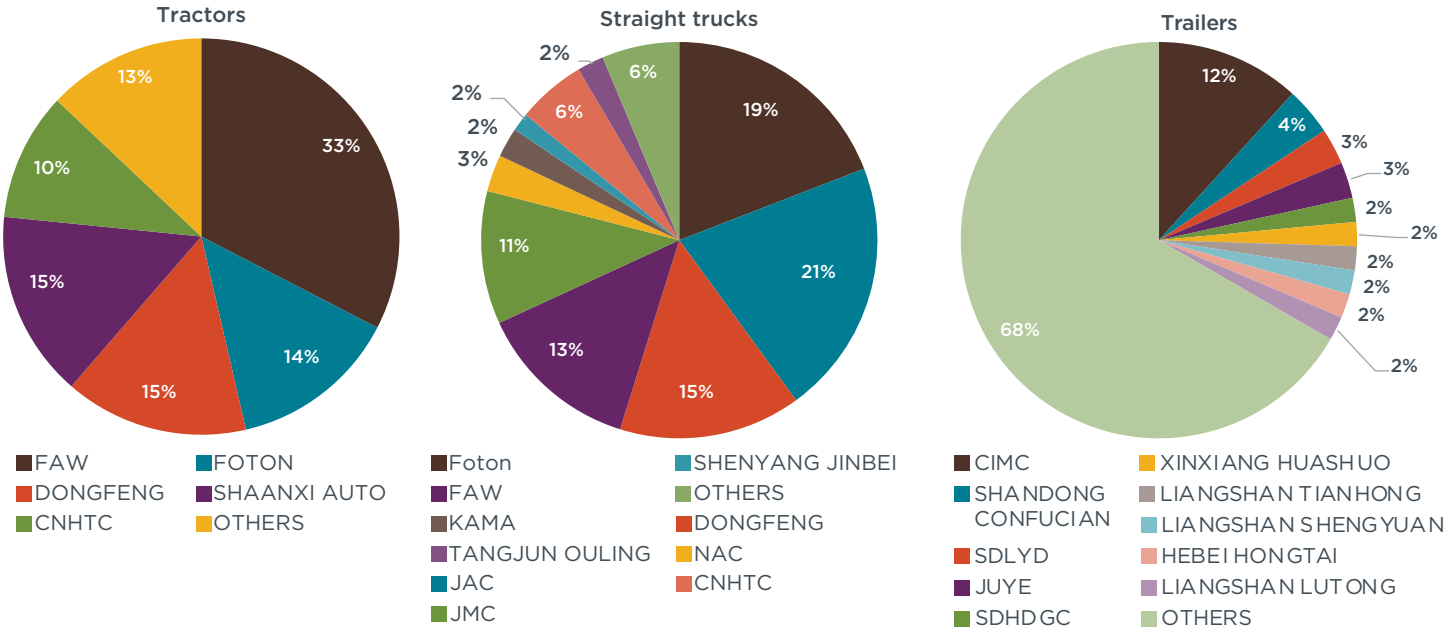


Figure 8. Market shares of tractors, trailers and straight trucks in 2016
Source: China Automotive Technology & Research Center, Production volume data from database of CATARC; China Automotive Technology & Research Center, Vehicle registration data from Ministry of Public Security

Tractors and engines have become larger and more powerful, driven by over-loading regulations and logistics needs (Figures 9-11). Enforcement against over-loading has significantly reduced the market share of 6x2 driveline configurations because of their lower payload allowance.

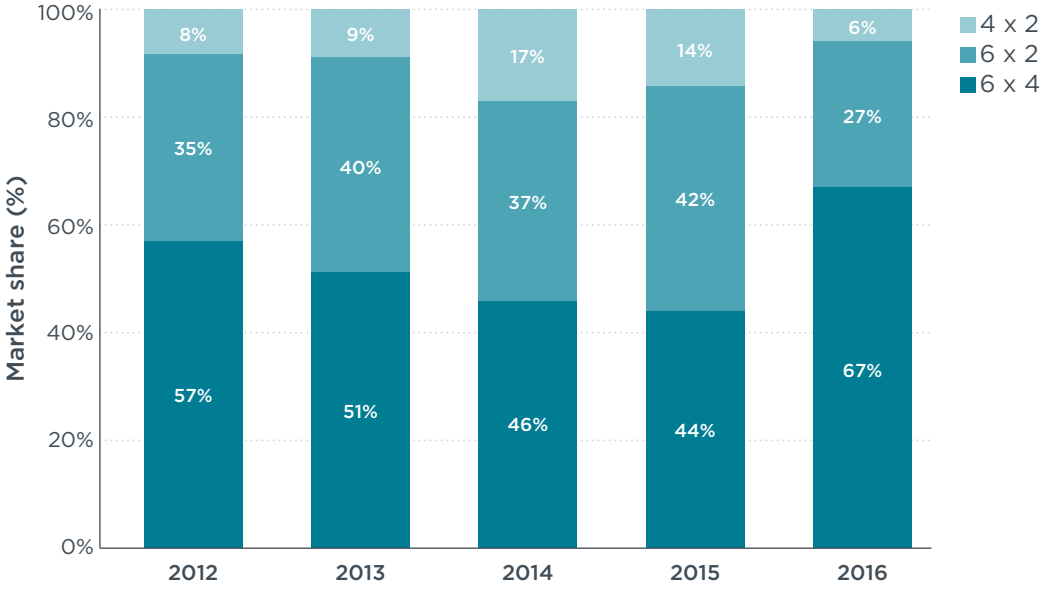


Figure 9. Market share of tractors by driveline configuration in 2012-2016
Source: China Automotive Technology & Research Center, Production volume data from database of CATARC

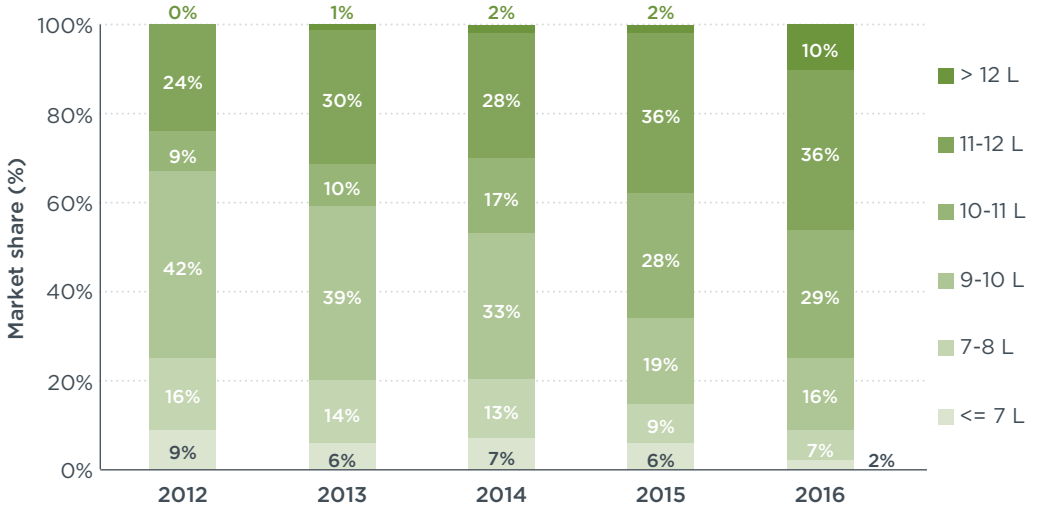


Figure 10. Market share of tractors by engine displacement in 2012-2016 *Source: China Automotive Technology & Research Center, Production volume data from database of CATARC*

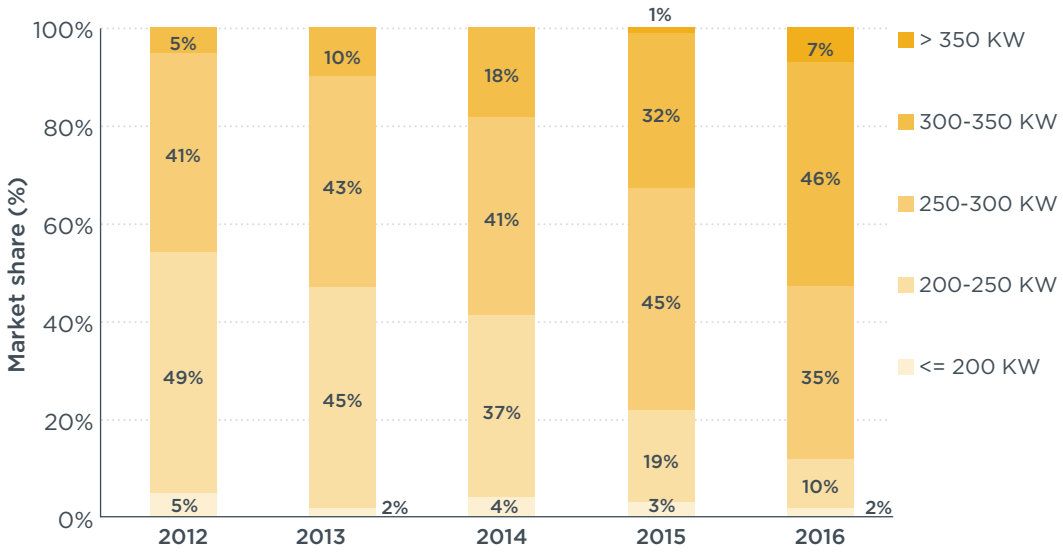


Figure 11. Market share of tractors by engine power rating in 2012-2016
Source: China Automotive Technology & Research Center, Production volume data from database of CATARC

Trailer production roughly tripled in 2016 after the implementation of over-loading regulations (Figure 12). However, despite this increase, the trailer market is still relatively small for the size of China's trucking market.

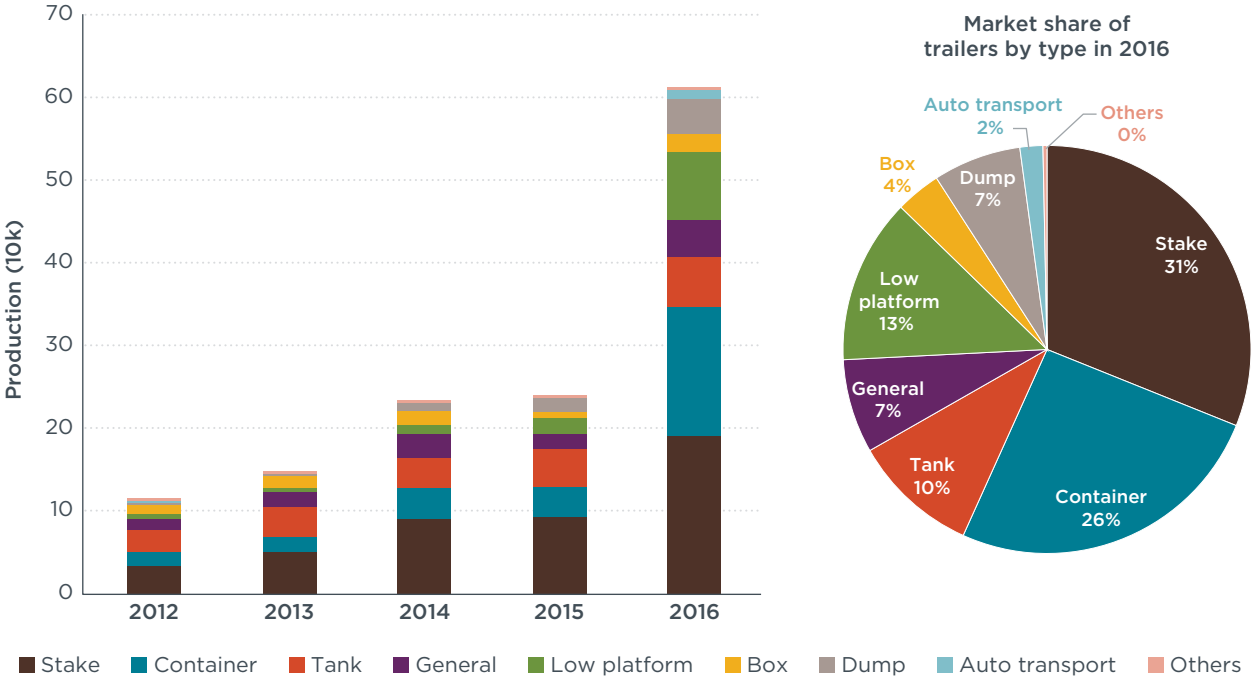


Figure 12. Trailer production and market shares in 2012-2016
Source: China Automotive Technology & Research Center, Production volume data from database of CATARC

There is a wide diversity in straight truck configurations, with the most common being a 4 x 2 with less than 4.5 GWV, which drivers are still able to operate with a commercial light-duty vehicle (C1) driver license (Figure 13).

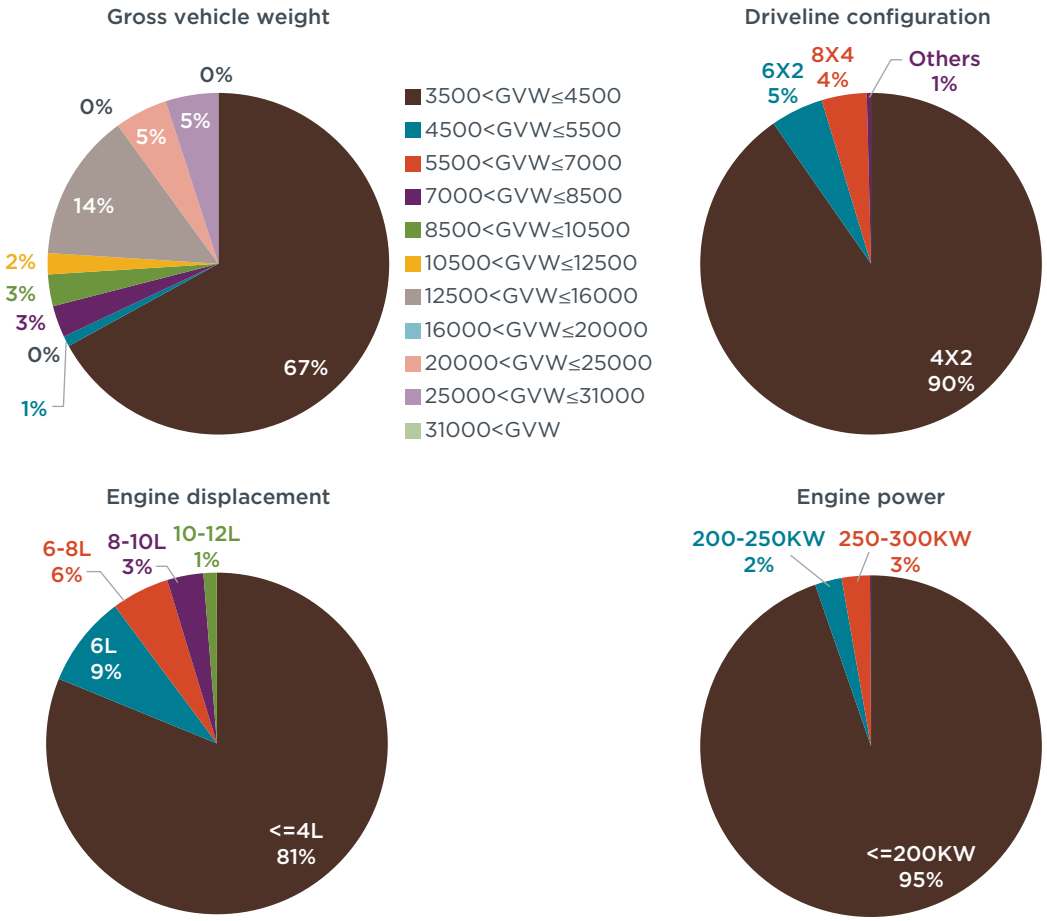


Figure 13. Straight truck configurations in 2016
Source: China Automotive Technology & Research Center, Production volume data from database of CATARC

TRUCK FUEL-SAVING TECHNOLOGIES

There are two separate and independent fuel consumption standards for HDVs in China which drive the use of more advanced truck technologies. Standards by the Ministry of Industry and Information Technology (MIIT), illustrated in Figure 14, are applicable to all HDVs with GVW of more than 3.5 tonnes, whereas standards by the Ministry of Transportation (MOT) are only applicable to commercial operation vehicles. Compliance with fuel consumption standards requires a combination of technology strategies, including powertrain optimization, light-weighting, aerodynamic devices, low-rolling resistance tires, and electric drive technologies.

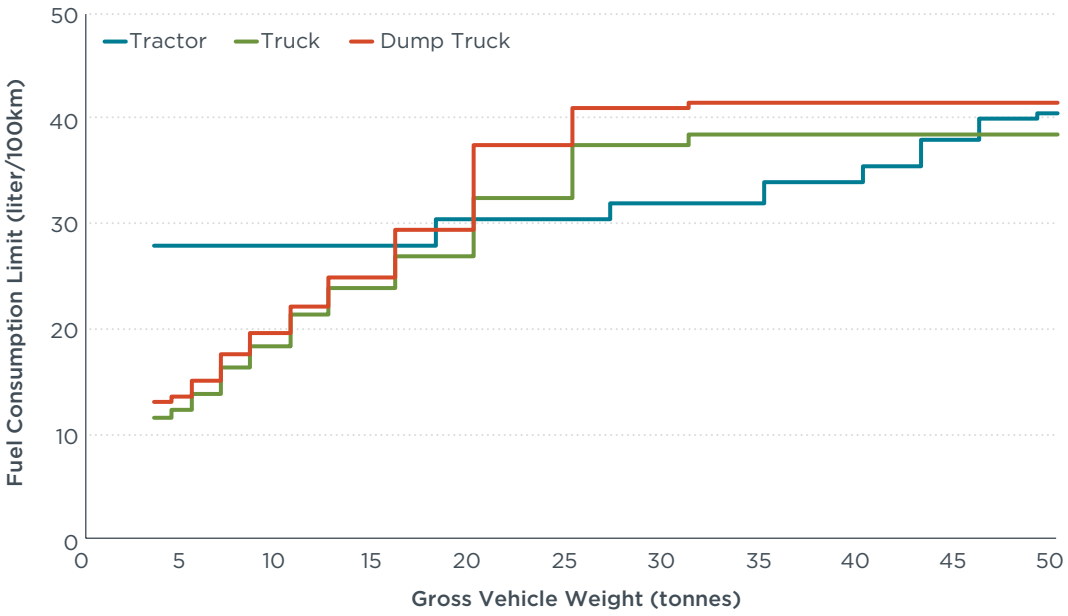


Figure 14. MIIT Stage 3 fuel consumption limits for tractors, straight trucks, and dump trucks.

In terms of powertrain optimization, there is a clear trend towards larger, more powerful engines and smaller rear-axle ratios to enable engine operations at lower speeds and to optimize fuel economy. In contrast to other markets such as U.S. and Europe, where the trend has been to downsize/downspeed, Chinese manufacturers have opted to upsize/downspeed since baseline engines are relatively small compared to those in other markets.

Vehicle weight is strongly correlated with fuel consumption; therefore light-weighting is a key strategy to improve truck efficiency. On average, truck fuel consumption drops by 5.2% with a 10% reduction in truck weight. Examples of Chinese manufacturers' strategies to reduce truck weight include lighter powertrains (engine, gearbox and rear axles), lighter suspension systems, and the use of aluminum fuel tanks and trailers.

Vehicle aerodynamic drag is directly proportional to the square of speed, and thus vehicle fuel consumption increases substantially at higher speeds. Because average speeds are not sufficiently high in China to justify the additional cost to redesign tractors to improve its aerodynamics, few manufacturers have opted to invest in such technologies. Side skirts that improve trailer aerodynamics have also had limited penetration in the market because of relatively low speeds and safety regulations.

Low rolling resistance and single-wide tires can also improve truck efficiency but have had small penetration due to limited information and safety concerns. Large trucking fleets have replaced bias tires with radial tires, which can reduce fuel consumption by 5% under similar loads and driving conditions based on local measurements.

Aftermarket installation of wind deflectors and radial tires are the primary fuel-saving technologies being implemented by fleets and individual carriers. Almost all trucks in China have been equipped with wind deflecting devices because of their relatively low cost. Some carriers have begun to install no-idle air conditioners that enable climate control through an independent battery that prevents truck idling.

The Chinese government has promoted new energy vehicles as a solution to reduce local air pollution and fuel consumption. A combination of large purchase subsidies, strict driving restrictions on combustion diesel engines, and the development of charging infrastructure have been the main drivers for increased sales of battery electric urban delivery vehicles. It is likely that electric trucks will replace 3.5-4.5 tonne diesel trucks in the near future.

TRUCKING OPERATIONS

The Ministry of Public Security (MPS), MOT and the State Administration of Work Safety (SAWS) operate a non-public platform that tracks real-time vehicle mileage to prevent over-speeding and accidents to improve road and driver safety. Based on data from the China Federation of Logistics and Purchasing, Figure 15 summarizes annual driving mileage for different market segments.

The number of daily operating hours is one of the key drivers of operational efficiency and trucking profitability. Large fleets operate their vehicles for almost twice as long as individual fleets, which currently average just above five hours per day (Figure 16).

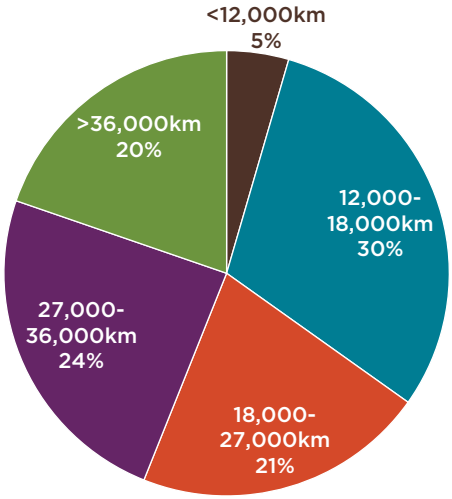


Figure 15. Annual average driving mileage of road carriers in 2016

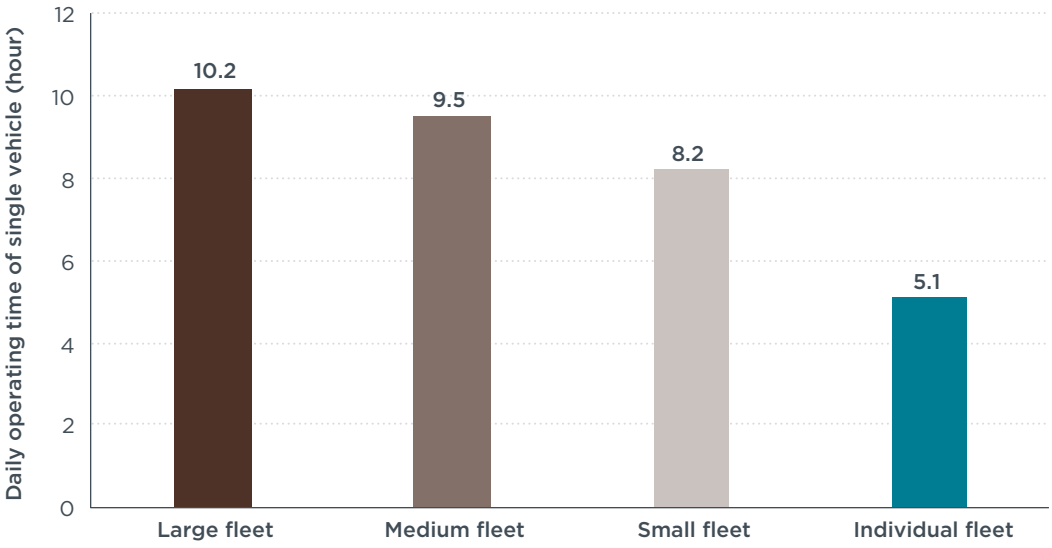


Figure 16. Daily operating hours and vehicle occupation rate of road carriers in 2016

The driving speed of freight vehicles in China is relatively low when compared to other countries. The average speed of long-haul freight vehicles is about 60km/h while urban delivery vehicles travel at approximately 30-40km/h.

Road tolls and fuel represent more than half of total trucking operating costs. Based on a survey by the China Federation of Logistics and Purchasing, fuel consumption

contributes to a quarter of total operating costs and thus represents a key concern for fleets and individual carriers (Figure 17). Some large carriers monitor fuel consumption and driver performance through intelligent management systems, while small and medium fleets implement fuel quotas.

Although driver training is regarded as a cost-effective fuel-saving strategy, driver eco-driving training programs in China are still scarce. The lack of professional training organizations is the main barrier to scaling up such programs.

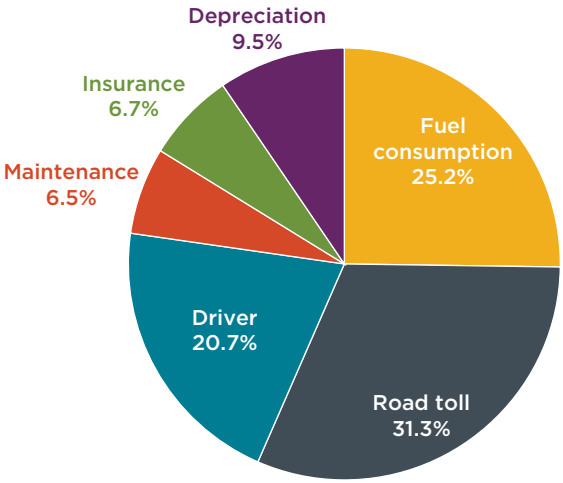


Figure 17. Cost breakdown of self-owned road carriers in 2016

The key factor that influences vehicle purchase decision for large carriers is the total cost of ownership, including vehicle failure rates, time between overhaul, and after-sales service. For individual carriers, fuel consumption is the key factor that influences the final purchase decision. Other factors include brand, safety, durability and cab comfort. (Figure 18).

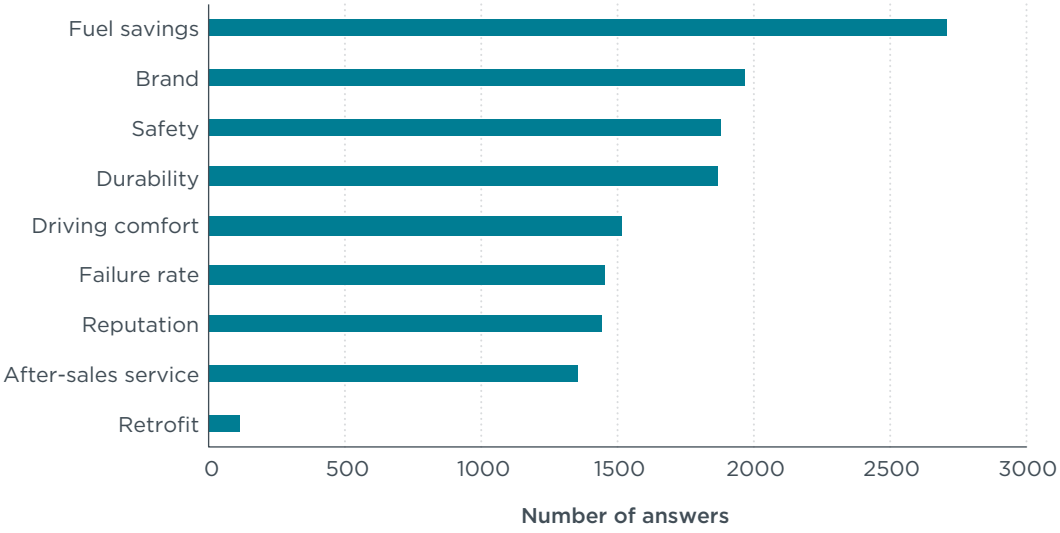


Figure 18. Decision criteria for truck purchasing

TRUCKING INSTITUTIONAL FRAMEWORK

Several government agencies in China are responsible for regulating different parts of the trucking sector (Table 2). The Ministry of Transport (MOT) is the major administrative department, and other relevant governmental departments include the National Development and Reform Commission (NDRC), Ministry of Industry and Information Technology (MIIT), Ministry of Ecology and Environment (MEE/MEP),[5] State Administration of Taxation (SAT), Ministry of Public Security (MPS), and Ministry of Commerce (MOC).

5 Ministry of Ecology and Environment was previously known as Ministry of Environmental Protection

Table 2. Administrative responsibilities of road freight management departments

	Production/Construction	Operation	End of Life
Trucks	**NDRC.** Investment qualification approval of motor vehicle industry **MIIT.** Approvals of production qualification, type approval, fuel consumption and conformity of production (COP) **MEE/MEP.** Establishing vehicle emission standards and vehicle pollution prevention and control	**SAT.** Collecting vehicle purchase tax and setting tax rate; management of freight enterprises' qualification of issuing VAT invoice **MPS.** Vehicle registration, violation determination and enforcement, driving qualification of drivers, traffic accident prevention and liability determination. **MOT.** Freight enterprise assessment, road transportation operation approval, vehicle operation approval, determination and enforcement of the actions of freight vehicles and freight enterprises for violating freight transportation regulations, determination and enforcement of the actions of freight vehicles for violating road regulations, fuel consumption management on business operation vehicles.	**MOC.** Vehicle circulation and scrappage (including second-hand vehicles)
Roads	**MOT.** Responsible for road construction	**MOT.** Responsible for road maintenance, establishing highway tool fee collection standards and management	

As shown above, MOT is in charge of road construction and maintenance, highway toll standards and management, carrier certification, vehicle efficiency standards for truck manufacturers, and fuel consumption management of road freight enterprises. The Ministry has implemented a series of programs to improve freight system efficiency, including the promotion of a drop and hook program, truck brokerage pilots, regulations to control truck over-loading, promotion of natural gas and new energy vehicles, as well as the China Green Freight Initiative (CGFI).

CGFI is a voluntary green freight program coordinated by the China Road Transport Association, supported by MOT's Research Institute of Highways, Clean Air Asia, and the Energy Foundation China. The main objectives of CGFI is to reduce information, technology, and financing barriers towards the adoption of fuel efficiency technologies and strategies. The initiative has participated in technology testing and promotion, drop and hook pilot programs, promotion of natural gas vehicles, driver training activities, and recognition of sustainability leaders through industry benchmarking.

POLICY RECOMMENDATIONS

The China Green Freight Assessment identified challenges, momentum, and potential for technology and operational strategies to improve the freight system efficiency in China. As illustrated in Figure 19, a cleaner and more efficient freight system should rely on strategies that optimize freight activity (Avoid), shift freight to the cleanest and most energy efficient modes (Shift), and improve the environmental and energy performance of vehicles and fuels (Improve).

Strategy type		Priorities in China	
AVOID	Optimize freight activity through better network design and equipment configuration		Drop and hook operations and trailer rental market
			Truck brokerage and freight matching platforms
SHIFT	Shift freight to the cleanest and most energy efficient modes		Increased share of rail transport
IMPROVE	Improve the environmental and energy performance of vehicles and fuels		Adoption of truck fuel efficiency technologies
			New energy vehicles, especially in urban delivery
			Eco driving training

Figure 19. Green freight strategies in China

In order to optimize freight activity, MOT and four other agencies jointly released a policy to promote "drop and hook" transportation in 2009 and have since issued additional supportive policies. Because progress remains slow compared to other regions, the following recommendations should be implemented to support the further adoption of "drop and hook" operations: (1) the development of the truck brokerage market to increase system efficiency and reduce empty backhauls; (2) the development of electronic freight matching platforms to link shippers, truck brokers, and carriers; and (3) the development of trailer rental platforms to address safety concerns and reduce purchase costs.

In order to shift freight to the cleanest and most efficient modes, China has restricted the use of diesel trucks to transport coal in some regions, which may increase the share carried by rail. In order to facilitate the move to cleaner transport modes, China should also develop a long-range logistics plan to evaluate future trade flows and identify high-density freight corridors where rail investments are needed. In addition, China should develop a thorough evaluation of barriers, opportunities and impacts of mode shift strategies on fuel consumption and emissions, ideally leveraging international best practices and identifying their applicability in China.

Finally, with respect to strategies to improve the environmental performance of vehicles and fuels, the government should continue to invest in a combination of regulatory programs, market-based initiatives and fiscal instruments. More stringent fuel efficiency standards can drive the introduction of the most cost-effective truck technologies for the new fleet, while a well-implemented green freight program such as the China Green Freight Initiative, can encourage the introduction of aftermarket technologies (e.g., aerodynamic devices, low resistance tires, idle reduction devices) on the legacy fleets. Agencies can also promote alternative fuels such as natural gas and electric vehicles to reduce the energy consumption and emissions in the freight industry. Electric vehicles are currently seen as a compelling solution to replace diesel urban delivery vehicles below 4.5 tonnes. Finally, eco-driving training is regarded

worldwide as a cost-effective strategy to improve fuel efficiency of the entire truck fleet, and China should deploy such programs more broadly.

In addition to these strategies, China should leverage existing platforms to share best practices about energy efficiency technologies and operational practices through analysis of real-world usage data. The China Green Freight Initiative could be leveraged to create case studies for investments in truck and logistics efficiency, and to serve as a platform for sharing industry best practices.