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Trucking

A Performance Assessment Framework for Policymakers

WORLD BANK GROUP
Transport

Korea
Green Growth
Trust Fund

PPIAF
Enabling Infrastructure Investment

Multi-Donor Trust Fund for
Sustainable Logistics

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Multi-Donor Trust Fund for
Sustainable Logistics

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Abbreviations

3PL	Third-party Logistics Service Provider
AASHTO	American Association of State Highway and Transportation Officials
BCO	Beneficial Cargo Owner
CFS	U.S. Commodity Flow Survey
CO_2	Carbon Dioxide
COFC	Container on Flat Car
COVID-19	Coronavirus Disease 2019
EBIT	Earnings Before Interest and Taxes
ELDs	Electronic Logging Devices
EMS	Emergency Medical Services
ESAL	Equivalent Single Axle Loads
GPS	Global Positioning System
GHGs	Greenhouse Gases
HCM	U.S. Highway Capacity Manual
HHI	Herfindahl–Hirschman Index
IFIs	International Financial Institutions
IoT	Internet of Things
IRI	International Roughness Index
ISO	International Organization for Standardization
IT	Information Technology
JIT	Just-in-time
LOS	Level of Service
LPI	Logistics Performance Index
LTL	Less-than-truckload
MECC	Marginal External Cost of Congestion
NGOs	Non-Governmental Organizations
NOx	Nitrogen Oxides
NPCT	U.S. National Private Truck Council
O-D/OD	Origin-Destination
OSOW	Oversize/Overweight
PCE	Passenger Car Equivalent
PM	Particulate Matter
ROCE	Return on Capital Employed
TL	Truckload
TOFC	Trailer on Flat Car
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VIUS	U.S. Vehicle Inventory and Use Survey
VSL	Value of Statistical Life
WTO	World Trade Organization

Executive Summary

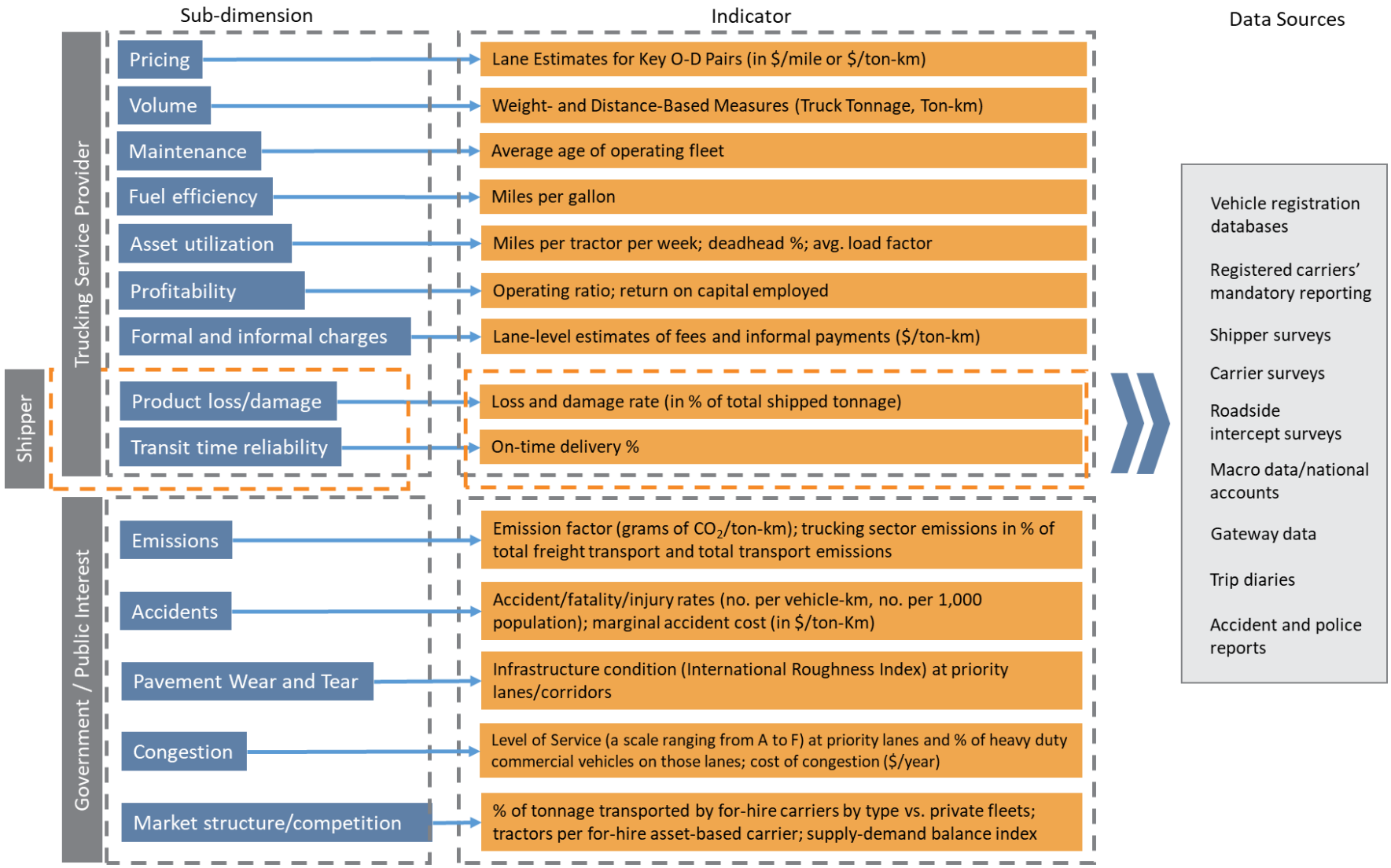
There is a global need to better understand the inner workings of trucking markets and how these relate to performance. Despite the critical role that trucking plays as a dominant mode in most countries' freight transport task, and as a key determinant of both private logistics costs and economic externalities such as transportation emissions of greenhouse gases and local pollutants, trucking markets globally, and especially in developing countries, remain insufficiently understood and under-studied. In particular, the structure and operational characteristics of trucking markets, typically complex and atomized, remain opaque to the policy makers and regulators whose role it is to assess sectoral performance and champion interventions to improve it. In particular, there is seldom an adequate frame of reference *or benchmark* to assess trucking sector policy interventions and associated outcomes in an industry that is highly context specific.

Performance measurement in the trucking industry should reflect the actors that comprise it, because "performance" means different things to different actors. This report starts from the basic definition of actors as comprising trucking service providers on the supply side, shippers and beneficial cargo owners on the demand side, and the public sector, broadly defined, on the side of the public interest that is reflected in issues of import to society at large. But it is critical to delve deeper to reflect the way trucking operations are conducted in practice, by disaggregating these main actor types into further dimensions of supply, demand, and public interest factors to arrive at a more realistic view of performance.

Trucking sector performance is determined by the commercial view of service providers, the supply chain efficiency view of shippers and cargo owners, and the economic impact view of governments and other entities in support of the public interest. The performance assessment framework proposed by this report lays out indicators than can capture these dimensions, which are often partially missing in existing trucking sector benchmarking tools. These indicators include, on the supply side: fluctuations in unit pricing; fluctuations in demand volume; average age of the national fleet; fuel efficiency of the national fleet; utilization of the national fleet, as measured by kilometers (miles) per tractor per week, percentage of empty miles driven, and average load factors; estimates of operating ratio and returns on capital employed for the industry; and incidence of informal payments. On the demand side: loss/damage rate en-route; and on-time delivery percentage. And on the public interest side: greenhouse gas emissions factor of the national fleet and sector emissions as a share of total emissions; accident and fatality rates and marginal cost of accidents; highway infrastructure condition, and congestion level of service at priority lanes (ideally complemented by estimates of the cost of congestion); and structure of competition as measured by tonnage share of for-hire services compared to private fleets, ideally complemented by sector-wide supply-demand balance estimates.

The framework and indicators proposed intend to balance practicality of implementation with comprehensiveness of coverage in light of the multiple dimensions that define trucking sector performance. The report proposes a simple framework with a limited number of indicators that can facilitate measurement at manageable cost and level of effort. The proposed prioritized set of performance indicators is summarized in Figure ES.1.

Figure ES.1. Mapping of Prioritized Trucking Sector Performance Indicators at the National Level



Source: Authors.

The natural next step stemming from this report as an opportunity for future research is the application of the proposed benchmarking framework in various country and sectoral contexts as a proof-of-concept. This would establish a baseline of indicators to better assess and compare trucking sector performance. The framework may be applied to contexts with relative data limitations/abundance, regulated/liberalized environments, low-income/high-income contexts, etc. Its relative simplicity should allow for low-cost data collection, and its structure should yield performance insights that are both useful for policy making purposes in the public interest and recognizable as accurate by industry practitioners. Collaboration in data sharing and experiences across countries could also be explored, including through regional and international entities that may facilitate this process. This process may be facilitated by an initial focused effort to test out this framework, as a proof of concept, in a limited number of countries where initial conditions, such as data availability, may facilitate implementation. Lessons can then be reflected to help extend application of this tool – or variations thereof – to more challenging contexts.

Introduction. Trucking Services: The Misunderstood Sibling

Road freight transport – which this report will refer to as trucking, for short – remains today, and for the foreseeable future, the dominant mode of inland freight transport in most countries. While relevant data are not universally available, in 2018 trucks of one kind or another moved 71% of national freight tonnage in the U.S., 77% in the EU, 77% in China, 60% in India, 60% in Brazil, 78% in Vietnam, 74% in Turkey, 75% in Mexico, 81% in Colombia, and 93% in Argentina, to name notable examples spanning several world regions and comprising high-income, upper-middle income, and lower-middle income countries alike, as well as countries with different economic geography profiles[1]. Numerous factors explain this generalized dominance. The most salient is trucking's inherent flexibility and relative itinerary simplicity compared to freight rail or waterways, particularly for short and medium length of haul shipments – whether that means accessing raw materials in the hinterland, facilitating global trade via intermodal transfer at ports, or distributing merchandise to stores, food to supermarkets, or life-saving medicines to hospitals.

From a systemic perspective, trucking plays a critical role alongside rail, air, marine, and pipeline transportation in facilitating the movement of goods throughout the supply chain. A well-functioning trucking industry is essential to create reliable and resilient supply chains by either enabling the door-to-door connection of goods and markets or providing last-mile access to rail intermodal yards, marine ports, airports, and fuel terminals. For this reason, practically all supply chains rely on trucks at some stage – and typically at many or most stages from conveying raw materials through to delivering finished industrial and consumer goods (Table 1).

Table 1. Examples of the Role of Trucking Throughout the Supply Chain

Extraction	• Agricultural Products -> Markets • Aggregates -> Cement Plants • Forestry Products -> Lumber Mills
Manufacturing	• Base Metals -> Manufacturing Plants • Machinery -> Manufacturing Plants • Car Parts -> Assembly Plants
Distribution	• Food Products -> Food Terminals • Shoes and Dresses -> Distribution Centers • Electronics -> Specialized Stores
Retail / E-Tail	• Food Products -> Restaurants • Consumer Goods -> Stores • Parcels -> Homes and Businesses

Source: Authors.

[1] Data for the EU, India, Brazil, and Turkey are expressed in ton-km, which makes the reported trucking sector shares even more remarkable, as average lengths of haul of truck-based shipments tend to be shorter than those of other modes. Market share statistics were obtained from World Bank research, based on data from the American Trucking Associations (ATA); Eurostat; National Bureau of Statistics of China; NITI Aayog and Rocky Mountain Institute (2018), *Goods on the Move: Efficiency & Sustainability in Indian Logistics*; ILOS consulting; General Statistics Office of Vietnam; Turkish Statistical Institute; and the Ministries of Transport of Mexico, Colombia, and Argentina, respectively.

The flexibility of trucking spans several dimensions, including routing, timing, access (geographic penetration), and products that can be transported (Table 2). Consideration of these flexibility attributes is critical when evaluating modal choice. They make trucking, as a mode, particularly well suited to the operational complexity of modern supply chains, which are frequently multinational, multimodal, time-definite, and/or network-like rather than linear (Box 1). For example, even in situations where rail freight service between origin and destination is direct and seemingly less financially costly to a shipper than trucking in terms of out-of-pocket *transportation* costs, the additive impacts of issues like schedule inflexibility, intermodal transfers, and limited resiliency against linehaul delays could result in higher *logistics costs* compared to trucking, where the latter include inventory carrying costs in addition to transport costs alone.

Table 2. Four Dimensions of Trucking Services Flexibility

Flexibility of Routing Trucks can usually provide *door-to-door* connectivity, whether on their own or in connection with other modes in multimodal itineraries.	Flexibility of Timing Trucks are not bound by *Fixed Schedules*.
Flexibility of Access Trucks can often access *rural or remote sites* where other modes are unavailable or uneconomical.	Flexibility of Products Transported Trucks can be configured with many types of trailers, facilitating the transport of a wide range of commodities.

Source: Authors.

There are other characteristics of trucking that make it a particularly appealing mode choice. The ease with which shippers, particularly small and medium enterprises, can engage trucking service providers on the demand side, as well as the relative ease with which, in most contexts, owner-operators or fleet owners can participate in trucking service provision –formally or informally– on the supply side, increases trucking accessibility with low entry barriers and high impact on immediate job and income creation. On the other hand, this also makes trucking, as a sector, prone to fragmentation, supply-demand mismatches, and informality. In addition, some countries still engage in the subsidization or low-/non-taxation of diesel fuel, which makes operating costs apparently not very onerous. Finally, the immediacy and visibility of roads and highways in the daily lives of taxpayers tend to influence governments' budgetary and public investment decisions in favor of road sector infrastructure funding.

While trucking services, through their flexibility, are an enabler of shipper-level logistics efficiency, they also expose economies to several drawbacks that have posed policy challenges in the international experience. First, trucking services generate negative externalities, such as road accidents, trunk infrastructure wear-and-tear, and emissions of greenhouse gases (GHGs) and local pollutants, at per ton-km rates largely exceeding those of higher-capacity modes like rail and inland waterway transport[2]. These costs are generally not internalized, or at best are only partially internalized, in private/financial transportation costs. Second, trucking services contribute to road congestion, especially in urban areas. This is another form of externality that, in addition to generating costs to society, reduces the efficiency

[2] See, for example, U.S. Government Accountability Office (2011), "Surface Freight Transportation: A Comparison of the Costs of Road, Rail, and Waterways Freight Shipments That Are Not Passed on to Consumers."

of trucking services themselves and often exposes them to restrictive regulations, such as truck bans in demarcated areas or road types, either permanently or during certain periods of time, which partially limit operational flexibility. In low- and middle-income countries in particular, the fragmented and often informal nature of trucking services makes the vulnerable to the incidence of informal payments to regulators or the police, which increase logistics costs, undermine safety, and reduce the attractiveness of truck driving as a profession.

Trucking brings together many different types of actors—shippers and cargo owners, trucking service providers, ancillary service providers, and regulatory agencies and other entities of government. These actors have specific strategic, supply chain, commercial, and/or non-commercial objectives, motivations, and time-horizons. They are linked together through business, operational, or regulatory interactions rooted in entity-specific decision making. Depending on the actor, the intention—not always attained—is for these interactions to result in economic and/or financial value creation.

Despite its general preponderance in countries' national transport tasks and in determining national (and shipper-level) logistics costs, measuring the performance and impact of the trucking industry has proven a lingering challenge in the international experience. First, data unavailability is a typical limitation: sectoral data is rarely complete or representative, typically lacks disaggregation, and it is difficult to collect even with the increasingly common deployment of electronic logging devices (ELDs) or the use of mobile phone-based data gathering

Box 1. Trucking: the 'Invisible Hand' of Supply Chains

What do companies such as Walmart (big box retail), Halliburton (oil and gas), Zara (fashion apparel), Novartis (pharmaceuticals), and Alibaba (e-commerce) have in common? Their revenue streams and lines of business are vastly different from one another, but they each rely on trucking as a critical element of their supply chains to operate successfully.

Walmart specializes in stocking thousands of its name-branded stores with low- to mid-value manufactured goods, consumer packaged goods, and produce sourced from all over the world – all ultimately delivered by trucks. Halliburton on the other hand moves millions of dollars of highly specialized, mission-critical oil field services equipment – often characterized as oversized and overweight by road transport standards – in and out of the field to enable oil and gas exploration and production under significant economic time pressure. As one of the world's largest pharmaceutical companies, Novartis relies on the assurances of temperature-controlled expedited trucking services to ensure that biological substances – controlled inputs into the manufacture of drugs – and the finished pharmaceuticals are moved securely and in a timely manner. Fashion company Zara delivers merchandise by truck twice a week like clockwork to over 2,000 stores around the world in more than 90 countries. The thousands of merchants, wholesalers, businesses, and customers connected by online marketplace and mobile commerce platform Alibaba ultimately rely on trucking services to complete online transactions, often struck a world away. Each of these corporate giants, and many thousands of smaller business like them fuel a modern global economy that would not function without trucking services and truck freight networks.

Yet, by the unique nature of their operations, each of these companies uses trucking in different ways. Walmart and Halliburton own large fleets of their own tractors and specialized trucks. Meanwhile, Novartis contracts with expedited services providers such as DHL's specialized life sciences division to ensure that the World Health Organization's "Good Distribution Practices" are achieved in transporting pharmaceuticals from manufacturer to customer, which includes temperature-controlled trucking, warehousing, and shipment tracking. These backbone trucking services are accordingly just as specialized as the business and shippers they serve, conforming to meet the needs of global supply chains. The examples illustrate the versatility and flexibility—and the many manifestations of service provision—of the trucking sector.

Source: Authors.

techniques. Data gathering efforts tend to be one-off in nature, rarely sustained overtime or with little comparability across countries. For confidentiality reasons, sometimes detailed data, when available, may not be publicly released. And even in cases where data is systematically gathered and released to the public, often the output needs to be put in context and combined in ways that can assess critical elements of performance.[3] Second, there are genuine complexities in defining performance and therefore how to quantify performance, given the myriad actors and viewpoints involved, as well as the levels of assessment needed (corridor, national, regional, etc.), the externalities involved, and the extraordinary disparities across countries in relation to levels of formality and market and industry structure. Moreover, the evolution of the trucking industry is such that, behind the physical and visible complexity of fleets and cargo movements, there can be systems of intermediation in service provision, with varying levels of sophistication, that influence, positively or negatively, sectoral efficiency and performance, and help determine the sector's adaptability to specific industry and country contexts.

Therefore, systematically assessing trucking performance —in a way that can be benchmarked across countries and over time— requires a nuanced understanding of the sectoral actors, their interests, performance objectives, and constraints. In short, the organizational structure of the industry merits developing a typology that defines the actors in the trucking value chain and how they fit together as the basis for a performance assessment framework. It is also necessary to define clear prioritization criteria to make the measurement and quantification effort manageable. This is the starting point of this report. By proposing a simple yet comprehensive framework for performance measurement, the report aims to offer a monitoring and benchmarking tool for trucking industry stakeholders — in particular, policy makers and public sector agencies in oversight roles and in their capacity as industry stewards. The framework can facilitate cross-country comparisons that may galvanize reforms towards improved performance and greater sectoral transparency and contestability.

The report is structured as follows. Chapter 1 describes the organizational structure of the trucking industry in the international experience. Chapters 3 through 5 subsequently describes the interests and typical decision-making motivations for each type of actor, and what 'performance' means to each of them. Chapters 5 concludes.

[3] Global Road International Organizations, such as the International Road Federation (IRF) or the International Road Union (IRU) apparently do not make publicly available updated data on the trucking industry worldwide. At the regional and national levels these data can be accessed in a few online sources. For example, relevant information can be obtained for the European Union (Eurostat), the U.S. (Department of Transport), and several high- and upper-middle income countries such as France, Mexico, and Japan, to name a few. One notable exception is the International Energy Agency (IEA), which monitors the road transport sector with the aim of quantifying CO_2 emissions.

Chapter 1. Organizational Elements of the Trucking Industry

The trucking industry comprises three main types of actors: (i) trucking services providers, also referred to as operators or 'carriers' (the Supply side); (ii) Shippers, also referred to as beneficial cargo owners, or BCOs (the Demand side); and (iii) the public sector (the enabling side).

Trucking service providers either convey goods from origin to destination or provide an intermediary or ancillary service to the conveyance of goods. Shippers generate demand for transportation services that is unique to their circumstances as to, inter alia, volume size, economic order quantity, commodity type(s), operating requirements, supply chain stage position, and origin-destination profile. The public sector comprises various public interest actors, including local, regional, and national governments, as well as supranational bodies. They create the conditions and enabling requirements, and employ safeguards as necessary, for the provision of trucking services in the economy. They are in principle interested in demand and supply reaching an equilibrium without sacrificing other public priorities, including social and environmental policy priorities.

Are there exceptions to this three-pronged structure? There are many cases in which the triadic model becomes a dyad, for example when shippers deploy their own private fleets. In these cases, the shipper is also the trucking service provider, and the two functions are vertically arranged within the same firm.

Private fleets are an example of vertical integration, and the model exists to enhance the shipper's comparative advantage to not only produce or source goods, but also deliver them using a dedicated fleet which it owns. A variant of this model is for-hire dedicated asset provision under long-term contract, known as dedicated contract carriage, in which the transportation assets (tractor and driver – the concept of a 'seated truck' – often including the trailer in the case of semi-trucks) are owned/controlled by another firm, but available to the shipper as if they were a dedicated fleet (Box 2). There are usually several business reasons for shippers to organize their supply chains through private fleets and/or for-hire dedicated or non-dedicated services, and these reasons (a) typically go beyond a narrowly defined make-or-buy/outsourcing determination, and (b) are usually major drivers of performance (Chapter 2 addresses these performance perspectives). Consultations with shippers conducted for this report suggest that shippers frequently evaluate and re-evaluate their supply chains in search of the model that best suits their unique business needs, in case industry structures change or new opportunities arise.

Box 2. Private Fleets and Dedicated Contract Carriage

What are private fleets?

Private fleets refer to the operation of a trucking fleet by a company whose primary business is something other than transportation. In this case the company is not only a shipper of goods, but also the carrier. Under this model, a shipper will transport their own goods using in-house trucks and drivers, rather than relying on a separate trucking company (under contract) to provide this service, or a combination of the two approaches.

In the U.S., private fleets were the dominant segment of the trucking industry prior to deregulation of for-hire trucking services in 1980.[4] Prior to deregulation, the U.S. trucking industry was constrained by restricted entry

[4] Teske et al (1995), "Deregulating Freight Transportation: Delivering the Goods." The American Enterprise Institute. The AEI Press.

and operational freedoms, as well as price controls, with the effect of stifling the efficiency, quality, and price competitiveness of for-hire trucking companies.[5] In this environment, shippers recognized that owning and operating their own transportation systems could be more efficient than relying on heavily regulated for-hire trucking companies for a few different reasons, as discussed below.

Today, regulation in the U.S. trucking industry is focused on the social (e.g., environmental and safety) rather than economic aspects of trucking. However, private trucking continues to occupy a very significant role in the U.S. trucking industry: approximately half of all U.S. truck tonnage is moved by private fleets; the equivalent number in the EU is a somewhat lower but still significant 30%, with significant country-specific variations—in Greece, for example, private fleets account for a staggering 79% of all truck tonnage.

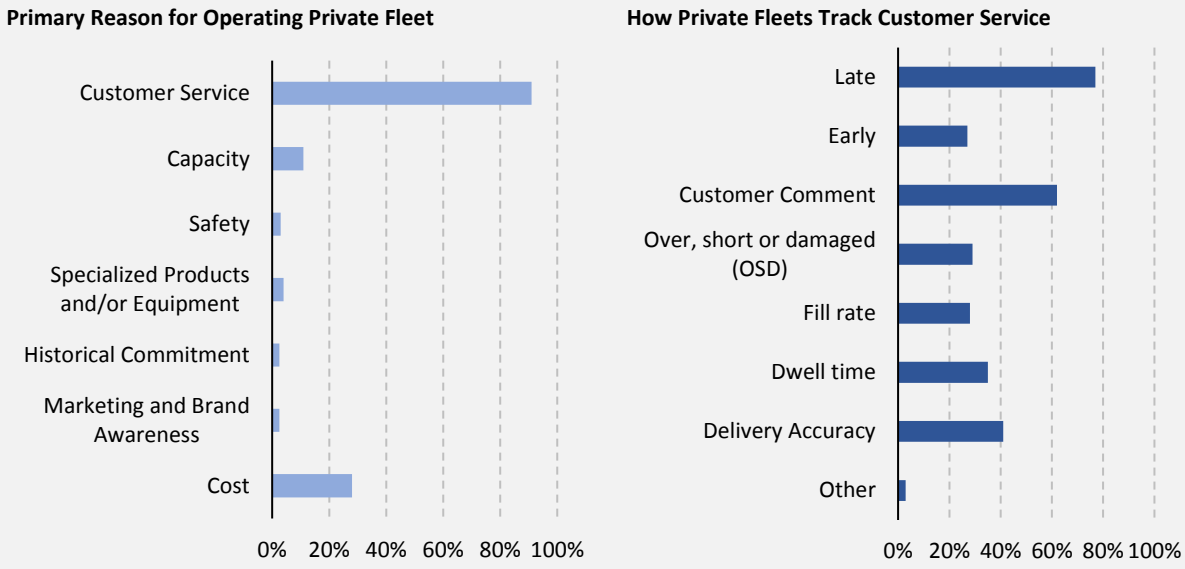
Why do shippers operate private fleets?

Private trucking offers several potential advantages for shippers. Where private trucking is advantageous, the benefits relate primarily to the control that a shipper has by virtue of managing the transportation of their own goods.

Customer service is the primary and overwhelming reason why companies choose to operate a private truck fleet, according to the most recent annual Benchmarking Survey Report conducted by the U.S. National Private Truck Council (NPTC), a national trade association representing private motor carrier fleets (Figure B2.1). Customer service is a broad concept but, as described by the NPTC, "includes attributes such as flexibility, reliability, dependability, a desire to put company employees in front of the customer, building access and security."

Specifically, the most commonly tracked performance metric related to customer service is late deliveries – with nearly 80% of respondents to the NPTC survey mentioning this as a customer service metric they track. Other common ways of measuring customer service performance include customer comments, delivery accuracy, dwell time (i.e., time waiting to load or unload), and over, short or damaged deliveries (i.e. incorrect quantity or damaged goods).

Figure B2.1. Insights on Private Fleet Deployment from the U.S. NPTC Survey



Source: Benchmarking Survey Report 2017, National Private Truck Council. Note: responses total more than 100% because respondents were provided the option of selecting multiple responses.

[5] Meyer et al (1959) *The Economics of Competition in the Transportation Industries.*

One important reason explaining the importance of customer service is that drivers employed by private fleets represent the company whose goods they are hauling. One private fleet driver describes the situation as follows: "We represent the company 24/7. We never know when we may interact with a customer or potential customer. It's all about image, and we all know that there are no retakes on the first image you make. It is imperative that that first impression be positive. For-hire fleets don't care/seem to worry about that. It's all about the next load and little more."[6]

In addition to customer service, the NPTC survey report reveals that operating costs and capacity are also important reasons why some shippers elect to operate their own fleets. These two reasons are related, since owning a private fleet provides stability and protection against the capacity crunches and rate escalations that characterize the for-hire industry in periods of high demand (e.g., accompanying economic expansions). The trade-off of this hedging mechanism is the pressure to utilize assets in support of the main business, as the fleet is not easily re-purposed to other shippers "for hire" as a one-off.

The higher standards that truck drivers for private fleets are held to are typically accompanied by higher wages as well. In general, private fleets tend to hire more experienced drivers compared to for-hire carriers and have higher retention standards relating to safety and customer service. In exchange, private fleet drivers on average receive higher wages, better benefits, and more home time compared to drivers with for-hire companies. One outcome is that driver turnover at for-hire truckload carriers tends to be far in excess of turnover at private fleets. According to one estimate, driver turnover is 98% at large truckload carriers, 82% at smaller truckload fleets, and only 11% at private fleets.[7]

Limitations of private fleets

A business model that works for one company is not necessarily going to work for another. While private fleets have advantages related to control, they also have potential drawbacks. One such drawback relates to the principle of *comparative advantage* – for many shippers, trucking (or transportation in general) are not perceived as core competencies. In other words, managers of private fleets may be well in-tune with their own operations but may not have as much visibility into general market trends and developments relating to hiring/recruiting, the complexity of modern vehicles, or fuel price volatility. Furthermore, management at these companies may not prioritize trucking as a core competency, and may prefer to outsource issues such as driver recruiting and retention (especially in strong labor markets).

The geographic characteristics of a company's supply chain also play a role in influencing whether private trucking is a company's preferred option. For example, Wal-Mart (which operates a large private trucking fleet) will often pick up shipments from suppliers to deliver to their distribution centers, thus making efficient use of otherwise empty backhauls. Increasingly, many private fleets are even starting to carry freight on a for-hire basis on backhauls to reduce inefficient empty miles.[8] However, in general difficulty securing backhauls may be a disadvantage for private fleets compared to for-hire carriers (which in addition to backhauls can have the option of finding new headhauls to a third city).

A final reason why some companies may not prefer private fleets is the upfront capital cost of purchasing new equipment (or longer-term financing arrangements) and the associated cost of tying up capital in running a transportation system as opposed to investing the capital for other productive purposes more central to the company's core business.

Dedicated Contract Carriage

Dedicated contract carriage, or dedicated trucking for short, serves as an "in between" option – one that provides many of the benefits of private fleet operations (guaranteed capacity and customer service) without many of the drawbacks (need to tie up capital or manage a trucking operation). Typically, established shippers will rate carriers

[6] Driver for a private fleet – cited in Lockridge and Harlow (2014).

[7] Lockridge and Harlow (2014), "Five Ways Private Fleets Keep Drivers Longer." *Trucking Info.*

[8] Leavitt (2013), "The future of private fleets." *Fleet Owner.*

according to key performance indicators (KPIs) and may elect to define a group of "core carriers" with which the shipper builds a long-term trusted relationship. An extension of this practice is the idea of a dedicated fleet.

Under the dedicated model, a shipper and a for-hire carrier reach an agreement whereby the parties lock-in pricing for a specified period of time, in exchange for a guarantee that the carrier will provide a certain amount of capacity over a certain period of time to match the shipper's needs, with the load factor risk fully absorbed by the shipper (i.e., the shipper pays for its dedicated contract carriage capacity irrespective of whether the equipment in question is full or empty, moving or idle). This model offers predictability for both the shipper and the carrier (albeit with the risk of locking in above- or below-market rates, as the carrier assumes the rate risk).

Many of the large for-hire carriers offer dedicated trucking as a part of their service offering. Indeed, despite the explanatory value of differentiating for-hire trucking, dedicated trucking, and third-party logistics services, the reality is that these terms describe roles more than they do actors *per se*. For example, as shown in Table B2.1 through the case of two large North American trucking companies (U.S. Xpress and Werner), carriers typically have a mix of service offerings which may include one-way and dedicated asset-based trucking, rail intermodal, truck brokerage, and logistics. When evaluated on the basis of number of tractors, 42% of U.S. Xpress's asset-based trucking activity and 58% of Werner's is dedicated trucking. A typical customer for dedicated services will be a retail distribution center or manufacturing facility.

Table B2.1. Selected Financial and Operating Characteristics of Two North American Trucking Companies, 2019

	U.S. Xpress Enterprises	**Werner Enterprises**
Annual Revenue	US$1.7 billion	US$2.4 billion
Business Segments	**Truckload:** asset-based truckload services, including one-way ("over-the-road") and dedicated services **Truck Brokerage:** non-asset based trucking services	**Truckload:** one-way truckload, dedicated, temperature-controlled. **Werner Logistics:** non-asset based transportation and logistics (brokerage, freight management, intermodal, global logistics, final mile)
Avg. Age of Tractor Fleet	1.7 yrs.	1.9 yrs.
Truckload Revenue	US$1.5 billion	US$1.6 billion
Avg. Tractors	6,439	7,969
Avg. Dedicated Tractors	2,727	4,593
Pct. Tractors Dedicated	42%	58%

Source: Authors' analysis of 10-K SEC filings.

While dedicated trucking providers are in charge of labor, equipment, and other operating costs, they may advertise the shipper's name and logo on the trailer and their drivers may wear the shipper's livery – thus giving the outward appearance of directly representing the shipper. A shipper's decision to partner with a dedicated trucking provider is thus one that relies on a good deal of trust and is made after careful deliberation and a track record of good service.

As a further scenario, a shipper may elect to operate a private fleet in some circumstances, and to use a dedicated fleet in others. Situations where this might occur include seasonal surges or when expanding into new territory. As another example, Wal-Mart transports general merchandise and dry grocery merchandise primarily through its own in-house fleet, but contracts with for-hire carriers for the majority of its perishable grocery merchandise.[9]

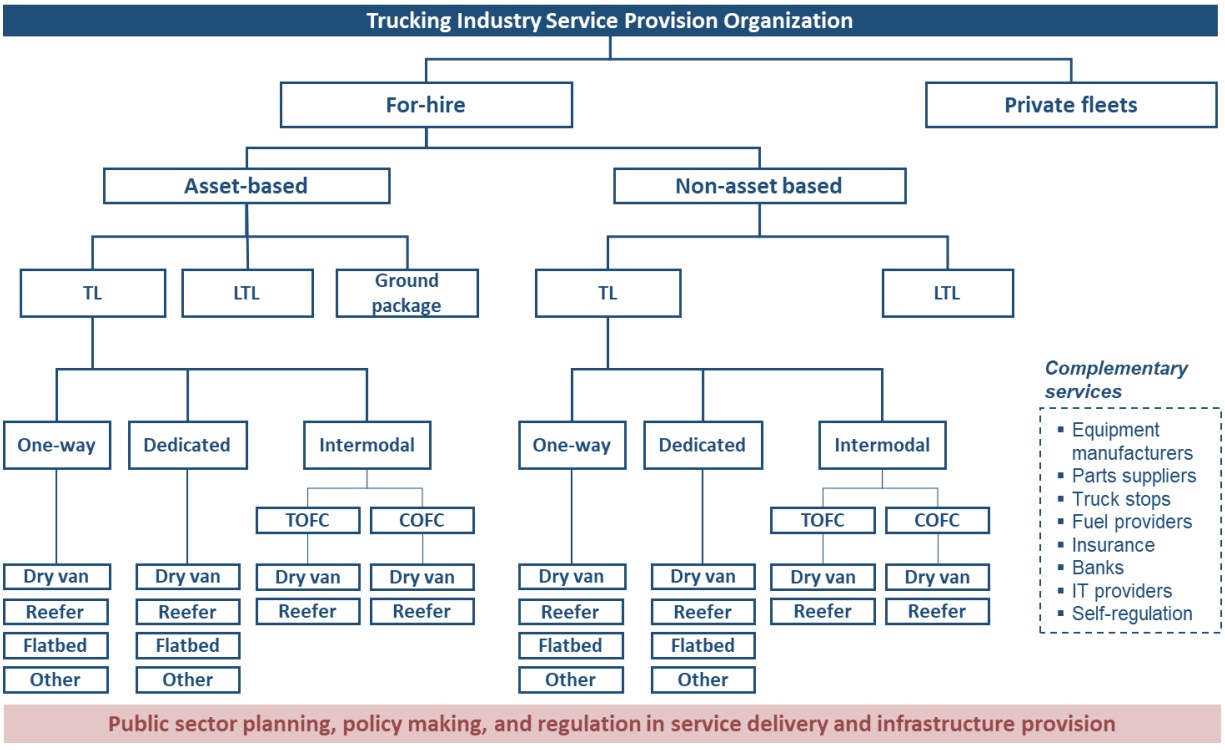
Source: Authors.

The many departures in practice from the basic model of trucking service provision, i.e. as a for-hire service to move cargo by the truckload from origin to destination, make evident that the organization of

[9] Wal-Mart Form 10-K for the fiscal year ended January 31, 2018. Filed with the SEC, available through EDGAR (sec.gov)

the trucking industry in a given economy often responds or adapts to industry- or firm-specific operational requirements. For example, two firms in the same industry may elect to use different models of trucking service provision to fulfill similar transport needs. Options can include, inter alia: private fleet operations; a long-term dedicated contract carriage arrangement; one or more long-term "core carrier" contractual arrangements for "one-way" (i.e., non-dedicated) truckload or less-than-truckload services, whether for non-refrigerated "dry van", refrigerated/"reefer", or bulk commodity "flat bed", tanker, or dump truck equipment services; non-contractual "spot market" truckload or less-than-truckload services; rail intermodal services, where a portion (the so-called 'linehaul' portion) of the journey is done via rail, with trucking moves at the first and last mile, for either ISO containers, domestic containers, or domestic trailers; "drayage" services for short-haul moves to/from maritime ports, inland ports, logistics centers, and other types of logistics clusters; a combination of any of these—or indeed something else (e.g., air-truck itineraries, waterway-truck itineraries, etc.); and they can do so either by engaging asset-based carriers directly or through non-asset based intermediaries, like truck brokerage service providers (Figure 1 illustrates this array of services in the U.S. case). International experience shows that shippers' choices as to trucking service organization, which, as shown here, go well beyond the question of modal choice, are drivers of competitive advantage at both the firm and sectoral levels.

Figure 1. Simple Representation of the U.S. Trucking Industry Service Delivery Organization



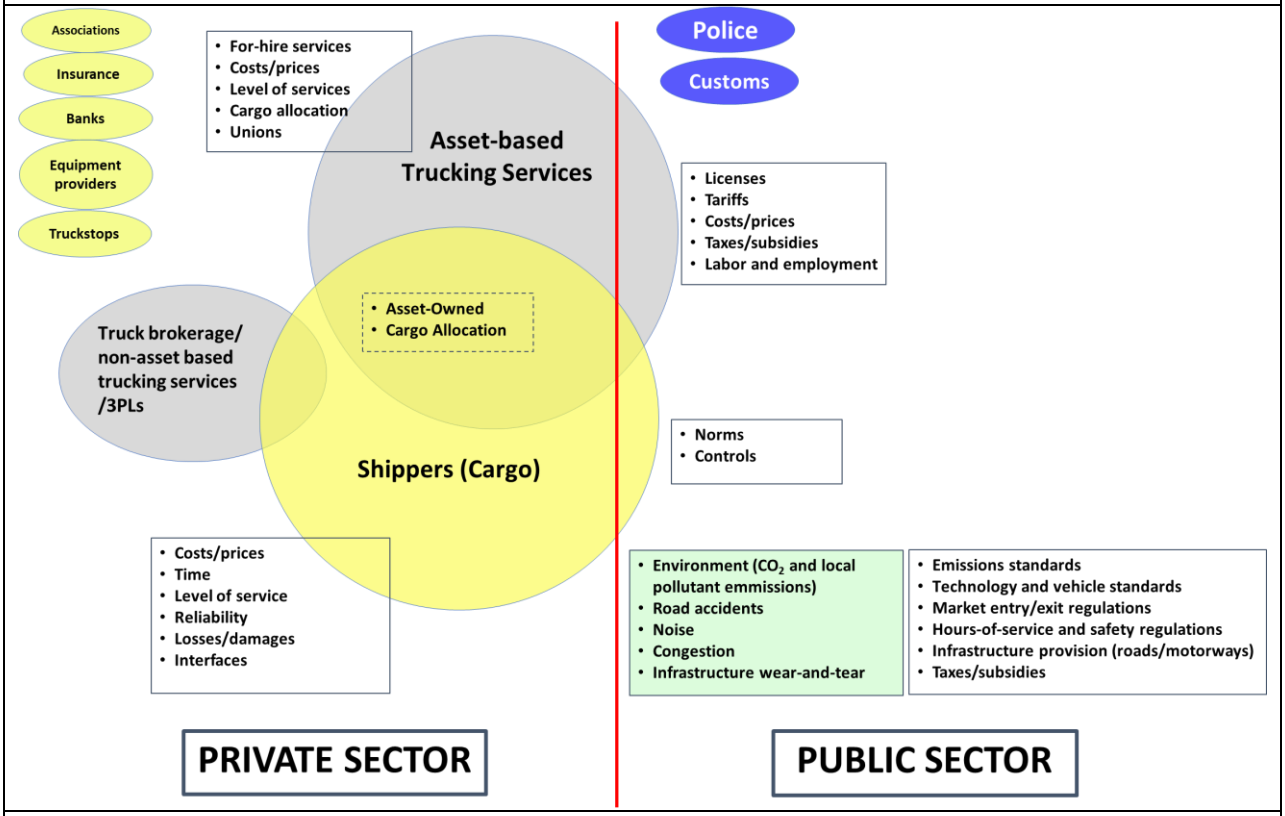
TL = truckload; LTL = less-than-truckload; TOFC = trailer on flat car; COFC = container on flat car.
Source: Authors.

The result is specialization in service delivery, with many sub-types of services, often but not necessarily provided by the same operator, to ensure that the market reaches equilibrium across the various types of trucking services demanded. Specialization is integrally linked to the versatility and flexibility of

trucking. This process, however, also increases market complexity, with potential implications for market efficiency.

While on a shipment or specific transaction basis trucking services are relatively straightforward, the nature of industry-wide relationships among actors is complex, and it is influenced and shaped by ancillary service providers on the private sector side (insurance companies, commercial and development banks, equipment providers, etc.), industry groups or associations, and on the public sector side, the police and customs administration (Figure 2).

Figure 2. Interactions Among the three Key Actors in the Road Transport Industry



Source: Authors.
Note: The boxes list a few key parameters for each of the actors.

What is the Nature of Market Equilibrium and Efficiency in the Trucking Industry?

Efficiency and market equilibrium in the trucking industry can be defined as the extent to which demand for services, of specific types and modalities, is met by adequate supply. In an 'efficient' market, shippers can find capacity across asset owners/carriers of their choice, these carriers can enter or exit the market at their discretion subject to applicable regulations, and together shippers and carriers can negotiate mutually agreed rates and terms of service, either in the spot market or contractually, in such a way as to "clear" the market (i.e., roughly matching available capacity with transportation demand). However, well-functioning competitive markets become increasingly fragmented over time, raising the transaction costs involved in matching supply and demand, particularly for small-size shippers and small truck carriers in an industry where typically small carriers are the norm. In the U.S., for example, 91.3% of all registered truck

carriers operate six or fewer trucks.[10] The result is supply-demand mismatches, which could lead to price distortions and unintended incentives on the part of both shippers and carriers.

This type of matching problem is one example of a market friction, and it creates the opportunity for firms to develop a comparative advantage as intermediaries. Intermediation in freight markets in general, and in trucking markets, has proven to be a source of efficiency in the international experience in many competitive market settings[11]. Intermediaries include truck brokers, freight forwarders, and other types of third-party logistics service providers whose main function is to match freight transport demand with supply across different types of services, service levels, and pricing. These "non-asset based" service providers generally do not own or control transport assets like trucks and trailers, but rather act as a link, often enabled by proprietary technology, between shippers with cargo to move and asset-based carriers with available capacity. To an asset-based carrier, a non-asset based intermediary is a shipper; to a shipper, a non-asset based intermediary is a carrier. In the framework proposed by this report, non-asset based entities are classified on the supply-side, as the role they play is one of consolidation and matching, thus 'discovering supply' and helping markets clear. It also follows that the source of revenue for these intermediaries (their so-called "net revenue", after deducting purchased transportation) is arbitrage, essentially exploiting the market friction by maximizing the spread between the prices at which demand (shippers) is willing or able to pay for supply (trucking services) on the one hand, and the prices at which supply is willing or able to be brought to a given lane or shipment at any given point in time.

The efficiency gains generated by intermediation in trucking markets goes beyond reductions in supply-demand mismatches to help markets clear. Intermediation has implications for other undesirable market frictions. For example, by reducing the incidence of empty miles driven through better supply-demand matching, intermediation is associated with reductions in unnecessary truck trips, fuel consumption, highway wear and tear, road accidents, and emissions of GHGs and local pollutants. This in turn is associated, all else being equal, with improved levels of profitability and return on capital employed for asset-based carriers; better health outcomes for local populations exposed to tail pipe truck emissions; and the mitigation of climate change risks. Secondly, by not being married to a fixed fleet and geographic coverage as are their asset-based counterparts, non-asset based truck carriers are able to offer the "best" available option to a shipper at any given time across numerous potential fleets and carriers, as opposed to the one or limited number of options a particular (asset-based) carrier could offer the shipper. This is another dimension of the matching done by intermediaries. While asset-based carriers are primarily focused on maximizing the utilization of their network of fixed assets, non-asset based carriers are primarily focused on minimizing logistics costs for shippers based on a wider universe of assets and routing/service options that can be deployed across the relevant supply base.

[10] This includes private fleet carriers; American Trucking Associations Economics and Industry Data.

[11] In *de jure* or *de facto* non-competitive market settings, industry entry and exist, access to cargo, and/or pricing are controlled, formally or informally, by specific parties or entities, rather than determined by supply and demand. In these cases, intermediaries between shippers and trucking service providers are the ones typically imposing the controls, making intermediation a source of market failure rather than efficiency. See, for example, Herrera Dappe et al. (2019), *Moving Forward: Connectivity and Logistics to Sustain Bangladesh's Success*, for a description of the inefficiencies generated by truck brokers in the case of Bangladesh; see also Bove et al. (2018), *West and Central Africa Trucking Competitiveness*, for a description of the distortionary role played by intermediaries, known as *coxeurs*, in West and Central Africa.

But asset-based carriers can also generate efficiency gains for their customers (and, by extension, for the industry) in various ways. Owning or controlling assets has inherent value, particularly during times of supply shortages relative to demand (for example, during peak shipping seasons). In those instances, shippers—particularly large shippers—place a premium on access to capacity as a source of competitive advantage. For this reason, long-term "core carrier" relationships between large volume shippers and a small number of select asset-based truck carriers are common and widely deployed in the high-income and upper-middle income international experience. Such long-term arrangements tend to be associated with close shipper-carrier relationships and thus better customer service.

These intangibles may reduce logistics costs or result in other ways in which shippers can generate enterprise value. In contrast, the case of small-sized shippers is markedly different, in that their lower volumes generally cannot justify a core carrier program. On the other hand, non-asset based intermediaries, by pulling demand across numerous small (and, for that matter, large) shippers, can enter into long-term, guaranteed-capacity agreements with carriers. This allows them to offer small shippers a level of access to capacity and pricing that they (the small shippers) would not have been able to attain on their own. This granular view of the industry is, for most, based on the deregulated and mature U.S. trucking industry, and with some simplification and stylization can be adjusted to other national contexts, particularly where deregulated markets exist. The EU brings the complementary trucking organization experience of a regional bloc (Box 3).

Box 3. Trucking Sector Organization in the EU

The EU trucking market is regionally integrated. The regulatory framework underpinning this integration is the road transport a*cquis communautaire*—a comprehensive set of common rules, regulations, directives, and principles governing the trucking industry, set forth by the European Commission, and to which all EU Member States must adhere. The road freight transport acquis governs the key aspects of sectoral organization across the EU, including market entry and exit ("access to the profession"), hours-of-service rules and other key safety and labor protection regulations, fair competition provisions, tailpipe emission standards, common principles for tolling, taxes, and other road user charges, weights and dimensions of equipment, and ancillary services such as parking and rest areas.

The EU's regional trucking market is deregulated, most notably, but not only, with regard to pricing and market access[\1]. Asset-based service providers (both individual manager(s) and the firms they lead) must meet certain market entry criteria, such as regarding technical competency, financial standing, legal standing, and a requirement of being physically based in an EU Member State. Provided these conditions are met, there are no market access restrictions across the EU under the acquis, which establishes a common regional market, except for certain restrictions on cabotage (specifically, carriers may perform up to 3 cabotage operations, in any Member State, within a 7-day period starting from the day of unloading of an international shipment). Within the EU there is a competitive subsector of non-asset based intermediaries which contribute to reducing supply-demand mismatches and help markets clear across the bloc.

One notable aspect of EU regulation of the trucking sector is that related to data collection. Data collection by Member States from trucking companies registered in their jurisdictions is mandatory. These data are then used by the European Commission for policymaking purposes.

[1\] Each Member State's own domestic trucking market followed a separate deregulation process, with its own pace, timing, and requirements. For example, Greece's trucking sector remained a "closed profession", with (government-controlled) access to operating licenses capped at 33,000, until landmark liberalization reform was adopted in 2010, and which is still in the process of being fully implemented. Not surprisingly, the incidence of private fleets in Greece, which were not subject to access controls, is much higher in Greece (79%) than in the EU as a whole (30%).

Source: World Bank (2016), *Road Freight Transport Services Reform: Guiding Principles for Practitioners and Policy Makers*; Lafontaine, F. and Laura M. Valeri (2005), "The Deregulation of International Trucking in the European Union: Form and Effect", *Law & Economics Working Papers*, University of Michigan Law School; National Bank of Greece; authors' research.

Chapter 2. The Supply-side: Trucking Service Providers

Supply-side actors are those that are involved in the provision of trucking services in one form or another. At the heart of the supply side are asset-based motor carriers, a term used to denote businesses that transport goods by truck on equipment they own or otherwise control. Motor carriers are far from uniform in their structure and operations, and the full supply-side ecosystem also includes many other actors beyond asset-based carriers. This supply-side ecosystem can be subcategorized into five basic archetypes:

- **Asset-based for-hire carriers.** These are businesses that (a) do not own the cargo being shipped, but rather transport cargo on behalf of beneficial cargo owners (shippers); and (b) own/lease or otherwise control all of the transport assets used to provide their services. For the purpose of this segmentation, this category includes trucking companies that employ company drivers and/or owner-operators (the latter model enables drivers who own their own truck to enter into contractual relationships with for-hire carriers). There are many different service varieties under this sub-type, including truckload services, less-than-truckload services, local drayage services, intermodal services, and dedicated contract carriage services (Table 3). Some of these services may further differentiate themselves by length of haul (e.g., regional vs. long-haul truckload), equipment type (e.g., refrigerated vs. non-refrigerated "dry van" truckload, flat-bed truckload, etc.), commodity type (e.g., edible vs. non-edible products), and operational characteristics (e.g., time-definite vs. regular service).
- **Non-asset based trucking companies and other types of third-party logistics service providers (3PLs).** These businesses generally do not own assets themselves, and therefore do not physically transport any cargo. They also do not own the cargo. However, they fill an important role by (to varying degrees) managing the flow of cargo, information, and payments between shippers and (asset-based) carriers. As stated above, often these companies serve as a single point of contact for shippers, thus effectively appearing to the shipper as the "trucking company" responsible for carrying out their trucking needs. There are many levels of sophistication, with wide variety across different geographies.

- **Private fleets.** These entities are not independent for-hire businesses but rather operational groups within larger companies, the primary business of which is something other than transportation. The distinguishing feature of this sub-type is that these companies own the physical goods being transported. Private fleets are asset-based by definition. This category can be subdivided according to stages of the production process (retailers, distributors, manufacturers).
- **Ancillary service providers.** These businesses are not directly involved in the transportation of goods but provide services that help facilitate the trucking industry. These services include fueling stations, warehousing/logistics, financing, insurance, truck stops, equipment manufacturers, maintenance/service providers, and secondary sales.
- **Commercial advocacy organizations.** These are organizations that serve to promote or advocate for supply-side businesses (as distinct from ones with a broader or general social mandate).

This 5-part categorization masks a complex web of businesses and roles. For example, the specific functions performed by a third-party logistics services provider (3PL) may vary not just across countries, but across 3PLs within a single country. Nonetheless, identifying the key primary and secondary sub-types is valuable for understanding the many interests in play (Table 3). The most meaningful features along which sub-types can be conceptually differentiated are private (vertically integrated in the shipper organization) versus for-hire trucking, and asset-based carriers versus non-asset based companies.

As another layer of industry adaptability (or "complexity", depending on one's perspective), it must be noted that the lines between some of the above actors can blur, in some cases very significantly. For example, it is increasingly common in the North American experience for 'traditional' asset-based for-hire carriers to deploy non-asset based truck brokerage divisions or business segments. This may seem counterintuitive, in that such truck brokerage divisions would contract capacity with carriers that may be direct competitors of their parent (asset-based trucking) company. Why would an asset-based carrier generate revenue for some of its direct competitors through its brokerage division? The answer typically lies in the primary importance of customer relationship control and the cost of customer acquisition. Asset-based trucking companies increasingly find that it is far more profitable to rely on a brokerage division when their own assets are unable to serve a customer—thereby preserving service and thus the customer relationship—than risk losing a customer due to unavailability of equipment. Customer relationship control is perhaps the most critical element of the supply-side of the trucking services value chain. Non-asset based carriers specialize in customer relationship management, not on asset utilization. By embracing truck brokerage, 'hybrid' asset/non-asset based carriers strengthen their own customer relationship management capabilities.

Table 3. Supply-side Actors

Primary Sub-Type	Description	Key secondary Sub-Types	Description
For hire asset-based carriers	Trucking companies that ship cargo owned by others, and own/lease most or all of their own assets (principally trucks).	Truckload (TL)	Transport full truckloads for a single customer at a time, either via contracts or on the spot market. Provides more direct service than LTL, but requires sufficient shipping volumes.
		Less-than-Truckload (LTL)	Consolidated shipments from multiple customers in the same truck – shipment includes pickup/delivery (peddle runs) and line haul components. (Similar in principle to a postal operation, but with pallets of cargo rather than mail.) Some LTL carriers serve defined local regions, while others cover wider ground. Cost-effective for small or medium-sized shipments.
		Drayage	Transport of goods over short distances, as one component of a larger multi-modal shipment. Commonly used in the maritime industry at seaports.[12]
		Intermodal	Ship intermodal containers by truck, generally as part of a larger shipment that includes rail. For example, a railroad may operate an intermodal trucking service to provide access to and from their intermodal terminals.
		Dedicated Fleets	Provide dedicated trucking services for shippers through long-term contracts that provide certainty in rates and capacity. In some cases, a fleet may only serve a single shipper. Offer many of the benefits of private fleets, but free up the shipper's capital and outsource the operations of running the fleet. Also advantageous for businesses that require specialized equipment.
Non-asset based logistics companies	Do not own their own assets but connect shippers (demand) to	Load Board Operators	Operate an on-demand freight exchange used by shippers, freight brokers, motor carriers, and other logistics companies to find freight and trucks on the spot market. Most "hands off" subtype among non-asset based companies.
		App-Based Services	New app-based services such as UberFreight have developed in recent years, serving to match freight supply and demand.
		Brokers, 3PLs and Freight Forwarders	Fulfill varying degrees of supply chain services. At the simplest, brokers are used on-demand to find capacity for shippers from a large network of trusted carriers. At the most complex, brokers (often then referred to as third-party logistics providers or 3PLs) play a strategic role in helping shippers optimize their supply chains and minimize their total logistics cost. Another related entity is freight forwarders, which typically take responsibility for optimizing and managing the logistics of international and intermodal shipments for shippers. In all of these cases, these entities do not physically transport the freight but are in charge of coordinating with the entities that do – thus easing the burden on a shipper.
Private Fleets	Trucking operations	Retailers	Large retailers may operate their own trucking fleets to deliver from distribution centers to stores. These are regular, frequent shipments that can be optimized by an in-house logistics manager. For

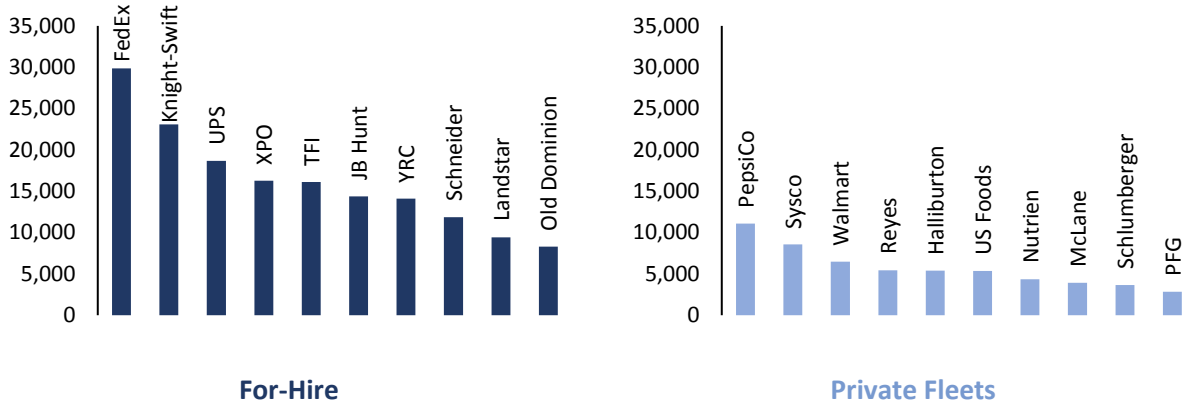
[12] A detailed discussion of the US drayage sector is included in the Transportation Research Board's Truck Drayage Productivity Guide, http://www.trb.org/Publications/Blurbs/165528.aspx.

Primary Sub-Type	Description	Key secondary Sub-Types	Description
	within larger companies , the primary business of which is not transportation		example, companies like Wal-Mart will operate their own fleet to ship pallets of goods outbound from their distribution centers to stores, as well as to pick up some inbound products from suppliers to deliver to the distribution center.
		Distributors	Distributors are intermediaries that sell to retailers or end customers. Unlike pure logistics intermediaries, distributors take ownership of the physical goods.
		Producers / Manufacturers	Manufacturers may operate their own fleets, particularly when shipping goods with very specific or specialized needs. For example, cement plants often operate their own fleet of cement trucks.
Ancillary Service Providers	Provide ancillary services to the trucking industry which support the movement of goods	Fueling Services	Gas stations that sell fuel (principally diesel) to truck fleets. Often these facilities also feature additional value-added services such as washrooms/showers, restaurants, or truck parking facilities.
		Warehousing & Logistics	Logistics services include the handling of goods, order processing, warehousing, and many other elements. These may or may not be integrated with transportation/ trucking services.
		Financing	Provide financing to facilitate the purchase of trucks – for example manufacturers, large dealerships, financial institutions or loan brokers. Access to financing can be an impediment in less developed trucking industries.
		Insurance	Provide commercial insurance to trucking fleets or drivers – requirements regarding insurance vary by country (including no requirements in some less developed industries).
		Truck Stops	Truck stops may be publicly or privately owned – public truck stops are often part of larger rest areas while private stops are often provided as value-added features by travel plazas/ fueling locations. Truck stops are important where hours-of-service restrictions limit driving times.
		Equipment Manufacturers	Manufacture trucking equipment – most significantly trucks / tractors and trailers.
		Truck Maintenance & Service Providers	Service and maintain trucks to ensure functionality, efficiency and safety.
		New & Used / Secondary Sales	Purchase and sell new and second-hand trucks to trucking fleets.
Commercial Advocacy Organizations	Promote or advocate for supply-side businesses.	Trucking Industry Associations	These organizations represent the interests of trucking companies and may also serve to educate policymakers or the public on the importance of trucking, or to conduct research on trucking issues. These organizations may have affiliates at a local or regional level.
		Ancillary Services Associations	These organizations represent the interests of a particular subset of industry participants – for example a national association of truck stop operators.
Source: Authors.			

In 2017, private fleets handled approximately half—49.5%—of total truck tonnage in the U.S.[13] Many of the largest private trucking fleets are comparable in size to the largest for-hire trucking companies. In general, comparisons at a company level based on tonnage or value are not feasible, because large shippers with in-house fleets do not necessarily release these data. However, comparisons on the basis of revenue equipment (tractors and trailers) give a good indication of the relevance of the largest private fleets. For North America, PepsiCo and Sysco would rank among the top ten largest North American trucking firms, as measured by the number of truck tractors (Figure 3).

Alternatively, if measured by the number of trailers, Walmart would rank as the fourth largest trucking company behind FedEx, UPS, and the recently merged Knight-Swift (FedEx and UPS are sometimes categorized separately as "integrators," but in this report are included in the for-hire less-than-truck-load category due to their large trucking footprint).

Figure 3. U.S. Largest Asset-based For-hire Carriers and Private Fleets by Fleet Size: 2018
Tractor count



Source: Transport Topics (2018), "2018 Essential Financial and Operating Information for the 100 Largest For-Hire Carriers in North America" and "2018 Essential Management and Operating Information for the 100 Largest Private Carriers in North America".

Many of the large shippers with globally recognizable brands continue to outsource transportation to for-hire asset-based carriers or work with 3PLs in most if not all of their geographies.[14] These shippers do not see themselves as transportation providers, and would rather leave these functions to third parties better able to create value. The shipper perspective is discussed in more detail below.

Definition and Dimensions of Trucking Performance for For-hire Trucking Service Providers

For-hire trucking service providers have a commercial view of performance. They seek to maximize the profitability, or return on capital employed (ROCE), from the services they provide. This is as true for asset-based carriers as it is for non-asset based carriers. A statement like "our improved profitability and strong cash flow in 2017 reflect the successful implementation of our primary mission to continually create and

[13] American Trucking Associations.
[14] Based on selected interviews carried on for this report.

unlock shareholder value"[15] exemplifies this view. Most ancillary services providers that support or enable the provision of trucking services (e.g., equipment providers, insurers, and providers of fuel and maintenance services) likewise generally have a profit objective.

Generally, the key performance dimensions that contribute to the profitability or ROCE of trucking services providers are revenue, variable cost, and fixed cost, which are each related to service type and quality.

There is a trade-off between these dimensions. Generally, higher service levels – for example faster or specialized service - entail higher operating and/or fixed costs. There is a likewise a trade-off between fixed and variable costs. Capital investments in new equipment or technology can lead to reductions in variable costs. The "optimal" trade-off between variable cost, fixed cost, and revenue (via service quality) will be context specific, but trucking service providers will always be engaged in trading-off these factors with the aim of maximizing profitability.

For an asset-based carrier, for example, investments in more fuel-efficient truck fleets can reduce (variable) fuel costs. Conversely, delaying the renewal of an aging truck fleet may mean lower fixed costs (i.e., deferred capital investment, limited/no depreciation costs on assets previously amortized), but will lead to increased (largely variable) maintenance costs, fuel costs, and other variable costs associated with inefficiencies. For non-asset based services providers, technology that can improve efficiencies through transaction automation can help reduce unnecessary paper work.

Ancillary service providers, including but not limited to services to trucking operations (fueling/truck stops, mechanics), trucking firms (financing, insurance, third party fleet management, customer relationship management systems), providers of training and certification, truck equipment providers, and others, together influence the cost function of trucking services providers – both directly (e.g., higher or lower input costs) and indirectly (e.g., inadequate availability of trained and certified drivers, which can lead to higher recruitment and training costs, or impediments to business growth). These ancillary services providers tend to be private businesses that have their own profitability objectives – also similarly a function of revenue, services, variable costs and fixed costs.

From a truck service provider performance standpoint, the key question with respect to ancillary services is the extent to which the "ancillary market" is robust and/or has gaps that impede trucking sector performance. Examples of these gaps could include lack of roadside fueling stations or truck stops, or a shallow insurance market.

There could also be a gap within the trucking services market itself which negatively impacts the performance of trucking services providers and the broader trucking sector. For example, the trucking sector performance in a jurisdiction may be hindered by a limited market for non-asset based carriers or 3PLs that can help match demand with asset-based trucking services providers looking for backhauls.

Revenue

From a commercial standpoint, revenue is primarily a function of trucking service volume and pricing. Volume is typically a function of customer acquisition, retention, and market outreach efforts.

[15] TFI International 2017 Annual Report. http://tfiintl.com/wp-content/uploads/2018/03/2017-Annual-Report-TFI.pdf.

Service pricing is a function of factors including service type (e.g., dry-van, refrigerated, oversize/ overweight service, etc.), nature of the move (e.g., short haul/long-haul, domestic/international, etc.), nature of the service (e.g., dedicated, less than truckload (LTL)/truckload (TL)), among other service and market based factors. All else being equal, higher levels of service command a price premium, in part because of the higher cost associated with higher levels of service quality, but also because of the value shippers associate with higher service quality. Other factors that could influence pricing include level of competition and by extension trucking service provider market power, as well as higher input costs due to regulations or otherwise. In any case trucking services providers, whether asset-based, non-asset based, dedicated or not, will generally seek to set pricing to maximize overall revenue yields form their specific services.

Most of the trucking service providers in developing economies indicated in our stakeholder consultations that competitive pricing is the most important aspect while providing services to shippers. For example, in Sri Lanka's unregulated trucking industry, competition is fierce due to a vast amount of start-up companies and individuals operating in the market, often informally.

Value added services that complement core trucking service operations (e.g., warehousing and logistics services such as transloading and crossdocking) are equally a function of pricing and business value but can be a distinct vector of revenue. Many players in the trucking services industry, including asset-based and non-asset based carriers, often look to expand their services in search of new peripheral markets that could help increase their market position and revenue. This is also in many cases a strategy used by trucking services providers in hopes of further binding shippers to them and securing longer term market position and revenue.[16]

Service type

Service type/quality refers to the nature of the services provided, and the associated level of service offered. Service types that require more specialized and capital intensive equipment (e.g., refrigerated trucks), more administrative requirements (e.g., oversize/overweight or hazardous material transport, which require special permitting and safeguards), that involve services beyond transportation (e.g., warehousing and logistics), or that have other service requirements (e.g., customs), generally command a price premium in part because these services entail higher variable and/or fixed costs (Box 3). Higher quality services (e.g., companies known to provide reliable and quality services) also translate into higher brand value and goodwill which can command a price premium and can lead to higher profitability.

[16] CPCS, Analysis of Third-Party Logistics Providers (3PLs) Supply Chains (for Transport Canada), 2011.

Box 3. Examples of Specialized Service Types and Vehicle Types

Service Types	Vehicle Types
▪ **Time-Definite:** Services are guaranteed to deliver cargo within a pre-specified window of time, and would incur penalties payable to the shipper if the delivery window is missed. ▪ **Overnight/Expedited:** Some companies specialize in shipments requiring immediate or priority delivery – this often means using a variety of modes (e.g., air and truck). ▪ **Team Driving:** Services that deploy two drivers in the same truck, to allow for near-continuous driving for faster delivery in long-haul itineraries. This is a premium product. ▪ **Cold Chain:** Fresh/frozen products and pharmaceuticals are two notable examples of commodities that have exacting requirements in the maintenance of stable. ▪ **Oversize/Overweight:** Some trucking companies specialize in shipping project cargo or other equipment, parts or machinery that are too large to fit on a regular truck (or rail car). OSOW shipments are generally subject to a larger number of restrictions which require considerable advance coordination and which regulations may not be coordinated across geographies. ▪ **Waste and Scrap:** Although not always considered as freight, waste and scrap products rely on trucks both for initial pickup and ultimately for disposal.	▪ **Dry Van:** Most common type of trailer, used for a wide variety of commodities. ▪ **Refrigerated Van (Reefer):** similar to dry van but with temperature control. ▪ **Container:** Allows for ease of transfer between modes (e.g., to rail). ▪ **Flat Bed (and similar, e.g. Step Deck):** Used for shipping machinery and metal products. ▪ **Tanker:** Used for shipping fuels, chemicals, and other fluids. ▪ **Pup Trailer:** Shorter trailer that can be used for urban deliveries or combined with another trailer for long hauls. ▪ **Straight Truck:** Used predominantly in urban settings for last-mile deliveries. ▪ **Other:** Many kinds of specialized configurations exist for shipping agricultural products, aggregate, cement, livestock, forestry products, automobiles, and many other commodities with unique needs ▪ **Combination Vehicles:** Trailers can be combined in various configurations, depending on the regulations.

Source: Authors.

Variable costs

Variable costs associated with trucking service and related inputs can differ greatly by type of operations. The main variable costs for asset-based trucking services providers, for example, include a portion of labor costs[17], fuel, trip-specific fees (e.g., tolls and similar trip-specific formal and informal charges), material expenses such as tires, and basic maintenance. These costs are directly related to the level of trucking activity, such as miles traveled, hour on the road, etc. Non-asset based trucking service providers' variable costs beyond purchased transport are related to semi-fixed labor costs tied to, for example, the volume of business transactions.

Fixed costs

Fixed costs will scale with the extent of operations typically in a lumpy manner but are otherwise not directly correlated to level of activity (e.g., number of truck moves).

[17] While, nominally, drivers tend to be paid by the mile or the trip, thus implying a variable cost basis, in practice drivers expect to receive/make a minimum compensation level to meet their income needs. All else being equal, carriers that are unable to meet this minimum income level will struggle to retain drivers.

As with variable costs, fixed costs differ greatly by type of operation. Asset-based trucking service providers' fixed costs include expenses related to equipment, systems, facilities, and other capital (which are from an accounting standpoint asset on a firm's balance sheet). Asset depreciation and financing costs, insurance, as well as general overhead (e.g., office administration) are other examples of fixed costs (reflected on the income statement).

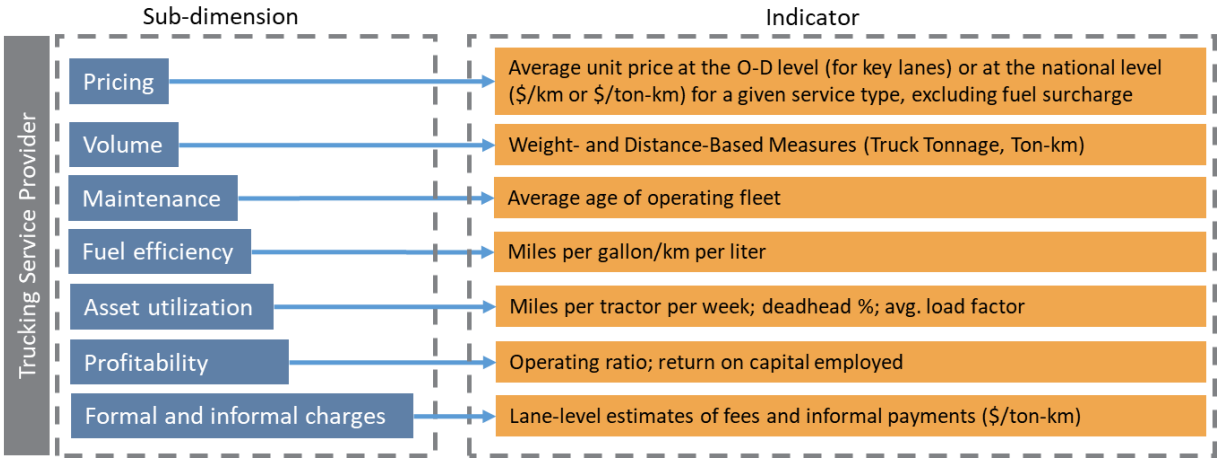
As less capital-intensive operations, non-asset based trucking services providers correspondingly tend to have lower fixed costs than asset-based carriers, but this distinction is much less pronounced beyond the net revenue line, after the (largely variable) purchased transportation costs have been accounted for. Major non-asset-based service provider fixed costs included facilities (e.g., offices) and IT/communications systems, minimum purchasing agreements with carriers, and general overhead (management, admin functions, etc.).

Performance Measurement

A key challenge in measuring performance of service providers is to unpack the dimensions that contribute to the profitability or ROCE, reflect the trade-off between the key performance dimensions (revenue, variable cost, and fixed cost, which are each related to service type and quality) and select observable yet meaningful indicators to trace such performance.

The proposed performance measurement settled on 7 indicators (Figure 4). This list necessarily leaves out numerous other performance indicators that could be considered and thus is not meant to be comprehensive, but it is meant to be practical and to make it more feasible for decision makers, particularly in public sector agencies, to measure the performance of their trucking sectors from the perspective of asset-based carriers (see Annex: Definitions of Performance for details).

Figure 4. Key Performance Indicators for Asset-based For-hire Trucking Service Providers



Source: Authors – For details see Annex: Definitions of Performance

Chapter 3. The Demand-side: Shippers

The demand side is represented by shippers and receivers—collectively referred to in the jargon as simply "shippers", sometimes also called beneficial cargo owners (BCOs). While any single shipment has a shipper (origin) and receiver (destination), in the wider sense most or all businesses act as both receivers on the inbound side, and shippers on the outbound side. For this reason, the demand side is best represented according to the stage of the supply chain at which companies operate. These can be simplified as extraction, manufacturing/distribution, and retail/e-tail (Table 4). Further, there is a general correlation between the stage of the supply chain and the value of commodities shipped, with commodity values increasing as they move further down the supply chain (towards the consumer). For this reason, a secondary sub-type can broadly be defined based on the value or type of commodities. Although a simplification, the key element of this approach is that it hints at the different needs and priorities of shippers at different stages of the supply chain.

The demand-side view is of supply chain and logistics as a whole, not just trucking. While trucking is an important component, shippers are only motivated to reduce trucking costs insofar as doing so is not offset by an increase in some other component of their total logistics costs. Therefore, shippers demand a trucking industry that integrates seamlessly with other modes and helps them reduce their total logistics costs. From the perspective of shippers, the importance of the trucking industry to their supply chain depends on the commodities being shipped and factors such as value density, shipment distance, shipment size, time criticalness, and the geographic concentration or dispersion of facilities, among other factors.

Table 4. Demand-side Actors

Primary Sub-Type	Description	Secondary Sub-Type	Description
Extraction	Businesses involved in the extraction of raw materials.	Bulk commodities	Bulk commodities such as grain, agricultural products or gravel are generally low-value and thus trucking competes with other low-cost modes such as rail and water. However, trucking can offer flexibility of access which is critical for certain products (e.g., wood products, gravel/quarry products).
Manufacturers and Distributors	Businesses involved in producing manufactured products.	Low/medium-value manufactured products	Low/medium-value manufactured products include chemicals, metals, low-cost parts, chemicals, and wood products, among others. These generally serve as inputs into further downstream manufacturing processes. Shippers are generally cost-sensitive, though reliability is also important for certain products. This may be due to perishability (e.g., in the case of cement) or because disruption of a reliable inbound flow of parts or inputs would force a plant to temporarily halt operations – a high-cost outcome.
		Medium/high-value manufactured products	These may include food products, machinery and parts, equipment, and general consumer goods. These may be inputs into manufacturing processes or end goods. Travel

Primary Sub-Type	Description	Secondary Sub-Type	Description
			time, reliability, and service quality are generally as or more important than cost.
		High-value manufactured products	The highest-value products include expensive equipment and machinery, luxury goods, and pharmaceuticals. For these time-sensitive products travel time is often of the utmost importance. Service quality is also often critical – for example, poor roads can be an impediment to transporting sensitive optical instruments.
Retailers and E-tailers	Businesses that sell consumer goods to end consumers	Traditional retail goods	Bricks-and-mortar retailers generally operate distribution centres, often in cross-dock format, from which they receive inbound finished products from manufacturers or distributors and ship pallets to stores or restaurants. These businesses are motivated to avoid stock-outs while minimizing the amount of inventory on-hand in-store, where the cost of land and shelf space can be high. These businesses thus prioritize a reliable transportation system.
		E-commerce	E-commerce refers to the growing market for deliveries directly to homes and businesses, either from retail fulfillment centres or directly from manufacturers or distributors. Speed and reliability are of high importance.
Commercial Advocacy Organizations	Promote or advocate for demand-side businesses.	Shipper or logistics councils	Shipper councils are industry trade groups representing particular or collective shipping industries that depend on the movement of goods.
		Chambers of commerce	Chambers of commerce are motivated by an interest in economic growth and development and would generally represent the interests of the demand side rather than the supply side of trucking.

Source: Authors.

Commodities with a higher value density tend to be more suited to trucking for long haul moves. Value density can be defined as the market value of a commodity per ton. Among other things, value density typically plays an important role in the mode of transportation selected - as demonstrated through analysis of national commodity flow surveys, such as the U.S. Commodity Flow Survey (CFS) (Table 5).[18] Trucking is often not the preferred mode of transport for low-value commodities, which tend to move by rail or water. In contrast, around 70% to 90% of higher-value commodities tend to move by truck – with competition from air transportation, and in some cases parcel or rail/intermodal. Instances of low value density commodities with high trucking incidence, such as gravel, logs, and building stones, refer to bulk commodities for which production is highly fragmented geographically, which makes provision of rail or inland waterway connectivity impractical and reduces shipment sizes, making bulk trucking often the only option for many shippers.

[18] Excludes foreign component of imports/exports, and includes only shipments conducted exclusively by truck.

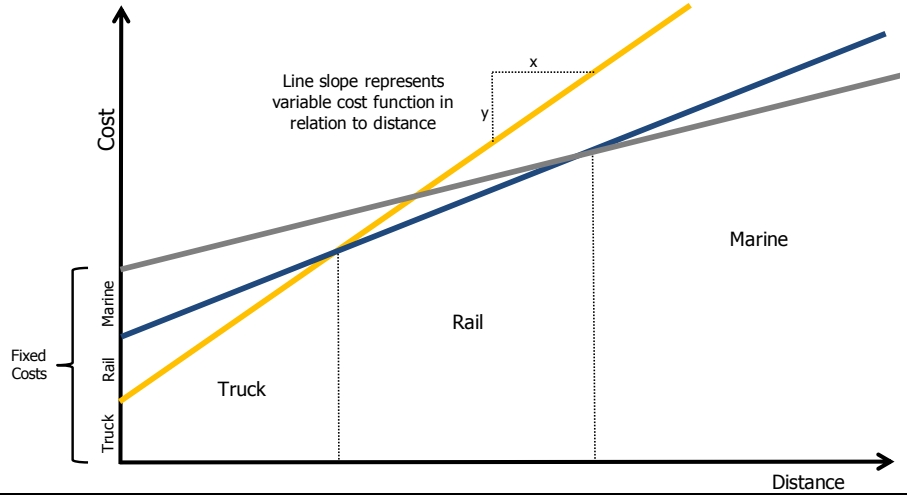
Table 5. U.S. Trucking Ton-mile Share by Commodity Type: 2012

Commodity	Value Density (US$/ton)	Truck % (by Ton-miles)
Gravel and crushed stone	$11	48%
Coal	$39	1%
Logs and other word in the rough	$94	85%
Cereal grains	$272	9%
Metallic ores and concentrates	$307	8%
Monumental or building stone	$371	92%
Wood products	$485	64%
Fuel oils	$838	35%
Agricultural products	$903	36%
Basic chemicals	$924	32%
All Commodities	$1,226	42%
Plastics and rubber	$3,002	54%
Meat, poultry, fish, seafood	$3,354	97%
Articles of base metal	$3,495	80%
Motorized and other vehicles (incl. parts)	$7,983	76%
Machinery	$10,088	88%
Textiles, leather, and articles thereof	$11,689	84%
Electronic and other electrical equipment	$22,331	84%
Precision instruments and apparatus	$48,165	70%
Pharmaceutical products	$50,300	85%

Source: Authors' analysis of U.S. Census Bureau, Commodity Flow Survey (2012). Note: Selected commodities shown. Value density is in 2012 US$ and for all modes. Pct. Truck includes only shipments conducted exclusively by truck (does not include parcel, rail and truck, or air and truck).

Another important factor is shipment distance. In general, rail and other low-cost modes of transportation become more competitive as shipment distance increases (Figure 5). Over longer distances, the relative per unit cost of transport favors modes offering greater capacity and economies of scale, such as rail. In the case of containerized commodities, which will typically need a truck drayage leg at either end of the rail linehaul journey, longer distances reduce the cost and time impact of these intermodal transfer operations. Trucking services tend to be used for shorter-distance moves, all other things being equal, for which flexibility matters a great deal and intermodal transfers are impractical and costly.

Figure 5. Relationship between Transportation Costs and Distance



Source: CPCS, RTG.

Beyond value density and distance, there are other supply-chain-specific factors that influence the role of trucking in any given supply chain. This includes factors such as shipment size, the concentration or dispersion of freight activity, and requirements related to perishability and time-sensitivity. Broadly speaking, trucking is less competitive, and indeed may simply be incompatible with, large-size shipments that require larger conveyances, such as barges or trains able to move hundreds of tons in a single shipment. On the contrary, time- and reliability-critical shipments of commodities exposed to perishability, obsolescence, and time-sensitivity would tend to justify trucking services, even premium trucking services (say, team driving for long-haul shipments, where two drivers on board take turns to provide round-the-clock transportation). All else being equal, highly concentrated (typically high-volume) freight activity may make it easier to justify dedicated rail or waterway connectivity, whereas dispersed (typically low-volume) freight activity would tend to be served by trucks.

Definition and Dimensions of Trucking Performance for Shippers

For shippers, trucking sector performance is a defining element of the efficiency of their supply chains. In most cases, trucking and logistics are typically not the core business of shippers, and are but one input into shipper operations, which might also include sourcing raw materials, research and development, manufacturing, distribution, and retailing, among many other functions. Nevertheless, trucking and logistics can be a significant contributor to shipper performance – directly or indirectly.

Retailers, for example rely on trucking and logistics to ensure products are on store shelves at the right place at the right time. Automotive manufacturers rely on trucking and logistics as a critical enabler of their manufacturing processes, both for ensuring that components are delivered on time, and finished goods, i.e. automobiles are delivered to dealerships

Private fleet trucking fits best under the shipper's supply chain view relative to the trucking services provider (commercial) perspective. The objective of a private fleet is not so much to maximize profitability

of the trucking operation but rather supporting the shipper's overall supply chain strategy, which is often considered a basis for corporate competitive advantage.

In consultations carried out for this report, shippers suggested that they would only own private fleets as a cost management response, if there was little to no reliably available trucking capacity through the contract and spot markets. The other main reasons for owning private fleets are to preserve some flexibility in responding to customers' needs and maintain a good customer relationship, and to mitigate an almost universal driver shortage issue through offering better working conditions to attract and to retain drivers.

Experience and literature point to four main dimensions of trucking service performance from the perspective of shippers: cost, transit time, service level, and reliability. While performing well on all these dimensions of performance is desirable, shippers generally cannot optimize them individually and simultaneously. They will make trade-offs between these dimensions in favor of those dimensions that will best enable their broader supply chain performance goals.

The "optimal" trade-off and related performance will be product and supply chain specific. For instance, shippers of low value-density goods (e.g., gravel) will tend to favor low cost at the expense of transit time. Shippers of high value-density goods (e.g., high-end electronics) will tend to favor transit time, and pay a premium (higher cost) for speed. Manufacturers using a Just-in-Time (JIT) inventory system will similarly pay a premium for reliability, just as shippers of temperature-sensitive products (e.g., pharmaceuticals or edible perishables) will pay a premium for service and the use of certain types of specialized equipment (reefers or cold storage facilities).

Cost

Door-to-door transportation and logistics service costs can be a significant component of the total cost for a wide array of products. This is particularly the case for low value, high volume commodities, like bulk grain or construction material shipments, where transportation costs represent a relatively higher share of total product cost. Trucking service costs may represent the sole transportation cost, or they may be a component of total transportation cost if a particular move involves multiple modes.

Beyond direct trucking transportation costs, shippers also incur in-transit and safety stock inventory carrying costs, as well as the cost of lost sales due to stockouts. Shippers will weigh these factors in designing their supply chains, which in turn influence their willingness to pay a premium for trucking services as a component of their overall logistics costs.

Transit time

Transit time, and in particular door-to-door transit time (as opposed to speed, per se), is an important consideration for shippers for a number of reasons. First, the longer a shipment is in transit, the longer it takes to bring it to market and generate revenue from its sale or use as an input into another product or process. Second, the longer the transit time, the more in-transit inventory costs are incurred by shippers, and the more likely it is that shippers may face stockouts during the delivery cycle, an eventuality they must protect against by keeping safety stock inventory on hand. All else being equal, for high value density commodities that incur significant inventory carrying costs, shorter transit times are typically of the utmost importance as a driver of overall logistics costs.

Service level and type

Shippers, depending on the nature of their product and markets, may seek higher or specialized levels of trucking service. Examples include light and voluminous products (e.g., packaging), temperature-controlled trucking, specialized handling (e.g., for fragile products), higher levels of security and tracking, or customized delivery schedules (e.g., for JIT operations). Dedicated trucking and logistics services also represents a form of service level. Our stakeholder consultations show that shippers who play in a niche transport market tend to use dedicated fleets, because capacity from niche service providers is limited and shippers are willing to pay a premium for reliable access to that capacity. Shippers need to secure the services to their clients by having better commitments from the carriers through contracts.

Some trucking services providers and 3PLs also provide integrated solutions with shipper operations whereby they are involved not only in trucking and related logistics services but also become imbedded in the design and management of the shipper's operations (e.g., manufacturing process). These higher or specialized levels of service generally command a premium.

Reliability

Reliability factors include accuracy of scheduling, consistency of transit times (as per schedule) and on-time delivery, the safety/security of cargo (minimum damage, preserving product integrity, theft), and other factors. In effect, reliability is about mitigating risks to supply chains. Reliability, or predictability, of delivery lead times in the supply chain is, in addition to the predictability of end-product demand, the main determinant of safety stock inventory carrying costs for shippers.

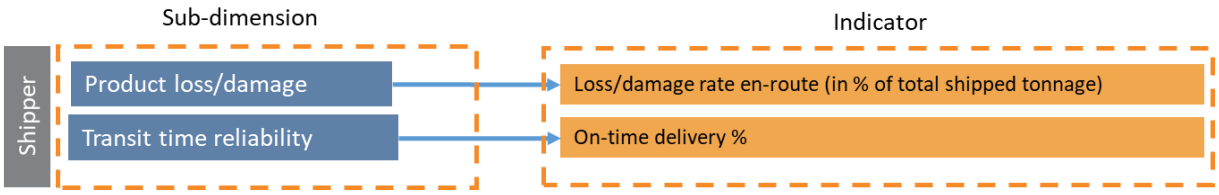
Notwithstanding the fact that shippers will favor different dimensions of trucking service performance – cost, transit time, service level, and reliability – based on their unique supply chains, the 'rational shipper' will generally seek to minimize total logistics costs, broadly defined to include all costs – direct and indirect – associated with their supply chains. In other words, paying a premium for trucking service may in fact lower total transportation costs if inventory carrying costs and indirect cost savings outweigh the increased direct trucking service transport cost.

Performance Measurement

A key challenge in measuring trucking performance from the shippers' perspective is to capture as much as possible the key performance dimensions of cost, transit time, service level, and reliability. The proposed performance measurement settled on 2 indicators, the incidence of product loss/damage en-route as a percentage of total shipped tonnage (sometimes also referred to as the level of "inventory shrinkage") and transit time reliability, as measured by on-time delivery percentage[19] (Figure 6). This list necessarily leaves out numerous other performance indicators and presents a prioritized list. Clearly shippers will track more indicators in their supply chain management function. Ultimately, logistics costs per ton or per TEU may be the most meaningful indicator of supply chain management performance for shippers. But from the perspective of policy makers looking to assess overall sectoral performance, the proposed indicators are a reasonable place to start (see Annex: Definitions of Performance for details).

[19] The variability/predictability of delivery lead times, as measured by the standard deviation or the coefficient of variation of delivery lead times, may also be considered, either in addition to or instead of the on-time delivery percentage.

Figure 6. Key Performance Indicators from the Shippers' Perspective



Source: Authors – For details see Annex: Definitions of Performance

Chapter 4. Public Interest: Government and Society

The role of public interest actors in the trucking value chain is to ensure that the market functions as intended while minimizing adverse impacts or externalities. The functions of these actors are implemented through developing enabling requirements, such as the licenses to operate trucking services (carrier authority, broker authority, etc.), insurance coverages, regulations around handling of hazardous or otherwise sensitive materials, regulations on emissions, and provision of public goods such as infrastructure. This category can be simplified as comprising five main groups (Table 6):

- **Law-Making Bodies**. These bodies set laws and regulations that govern how the trucking industry operates.
- **Administrative Agencies.** These are agencies within government that are responsible for implementing and enforcing policy and conducting planning and investment.
- **International Bodies.** These are intergovernmental or international bodies that promote and aid social and economic development around the world, and in some cases set the ground rules under which cross-border economic and social policies are enacted.
- **Civil Society Organizations.** These bodies are formal organizations that impact or are impacted by the trucking industry, but fall outside of the supply-side and demand-side actors. They generally promote particular causes or advocate for a particular group of people.
- **Civil Society at Large.** This refers to informal groups and individuals within the general public.

Table 6. Public Interest Actors

Primary Sub-Type	Description	Secondary Sub-Type	Description
Law-Making Bodies	Law-making bodies set laws and regulations that govern how the trucking industry operates.	Federal	Federal legislatures typically set the ground rules that govern the competitive landscape, such as entry terms, cabotage, quotas and similar regulations; as well as regulate externalities such as through laws impacting public safety.
		Regional / Provincial	Regional, state, or provincial legislatures may regulate things like oversize/overweight restrictions.
		Local	Local agencies may regulate things like which roads trucks can or cannot use and at which times, and where and for how long trucks are allowed to stop.
Administrative Agencies	Administrative agencies are responsible for implementing and enforcing policy.	Transport	Transport ministries typically oversee considerations related to transportation investment, user fees, safety and emissions. Some countries utilize a siloed approach with different ministries for different modes of transportation.
		Roads / Infrastructure	Some jurisdictions have separate ministries or departments that are responsible for infrastructure, distinct from a ministry of transportation. In this case these ministries have more of a strategic rather than operational focus.
		Planning	Planning agencies are responsible for land use decisions, which can have impacts on the trucking industry (for example, the location of trucking facilities or the routes used by trucks).
		Environment	Environmental agencies are responsible for regulating trucking-sector emissions, for example via vehicle fuel efficiency standards.
		Trade / Customs	Customs agencies are responsible for trade and border policies, such as regulating the documentation required by trucking companies and truck drivers when crossing the border; as well as quotas or fees payable.
		Tax	Tax authorities are responsible for administering taxation programs, such as excise taxes on fuel and tires; as well as for setting rules regarding deductions.
		Health / Safety	Health and safety authorities implement policies related to driver hours of service and vehicle safety standards.
		Social / Urban Impacts	Other agencies involved in social or urban affairs may impacted the trucking industry, for example via labor market policy.

Primary Sub-Type	Description	Secondary Sub-Type	Description
International Bodies	International bodies are responsible for setting cross-border ground rules as well as promoting and aiding social and economic development.	WTO	The World Trade Organization is responsible for setting the global rules of trade between nations, and adjudicates trade disputes between nations.
		UN	The UN is an intergovernmental organization which promotes international co-operation, with a particular focus on improving living standards in the developing world.
		IFIs (World Bank, regional development banks, etc.)	International financial institutions such as the World Bank, regional development banks, and similar institutions serve to advise on, fund, and assist in implementing social and economic development programs in developing countries.
		UNFCCC	The United Nations Framework Convention on Climate Change is an international environmental treaty that is responsible for combatting greenhouse gases and climate change.
Civil Society Organizations	Civil society organizations are formal organizations that impact or are impacted by the trucking industry, but fall outside of the supply-side and demand-side actors.	NGOs	Non-governmental organizations are typically involved in particular areas of interest – such as reducing the human impact on the environment.
		Think Tanks	Think tanks are policy and research institutes, typically with targeted focus areas such as policy or economics.
		Advocacy Groups	Advocacy groups advocate for the interests of particular groups of stakeholders or promote specific causes, for example trucking safety.
		Unions	Labour unions are interested in improving the bargaining power and conditions of workers, for example truck drivers.
		Interest Groups	Special interest groups in general have shared interests in advocating for particular causes, for example new technological solutions.
Civil Society at Large	Civil society as a whole refers to non-organized groups or individuals in the general public.	Informal Groups and Individuals	The general public is motivated by a desire for a strong economy; high quality goods and services at affordable prices; and protection of social or environmental interests (such as public safety and reduction of greenhouse gases and other emissions).

Source: Authors.

Definition and Dimensions of Performance from the Public Interest Perspective

Governments and other public interest entities view trucking sector performance largely through a economic welfare, societal viewpoint. In other words, Governments and public interest entities seek to enable a trucking sector that delivers the most value to society at large, while shaping or constraining the implications of the trucking sector. Four aspects are taken into consideration by governments: (i) Industry structure, to avoid any form of capture, minimize informality, and ensure acceptable levels of social protection; (ii) market environment, to ensure contestability in the greatest extent; (iii) negative externalities generated by the industry, essentially CO_2 emissions, congestion, noise, and crashes related fatalities and injuries; and (iv) fiscal considerations.

Table 7. Contextual Factors that Influence Trucking Sector Outcomes

<table>
<tr><th>Legal / Regulatory Framework</th><th>Institutional Structures</th></tr>
<tr><td>Do the laws and regulations promote good performance in the trucking sector?
Rationale: A supportive legal and regulatory framework is the bedrock of any well-functioning industry.

Considerations:
▪ Do elements of this framework support or hinder competition?
▪ Does the framework properly address externalities related to trucking?
▪ Are laws and regulations coordinated / harmonized across jurisdictions?</td><td>Do the public and private institutions support a well performing trucking sector?
Rationale: Laws and regulations are not enough if the institutions do not serve the industry well.

Considerations:
▪ Do the agencies successfully enforce compliance with laws and regulations?
▪ Do the agencies implement policy in a way that supports national goals related to trucking?
▪ Is the private sector mature in the depth and quality of associations and value-added intermediaries?</td></tr>
<tr><th>Competitive Environment</th><th>Assets and Infrastructure</th></tr>
<tr><td>How open to competition is the trucking sector?
Rationale: Competition promotes improved performance, in terms of both adoption of best practices and pursuit of innovation.

Considerations:
▪ Does the level of industry concentration support competition – when measured at the national or corridor level?
▪ Is there evidence of distinct anti-competitive practices such as cartelization or rate-fixing?
▪ Is there evidence of “short-termism” (such as pricing below marginal cost) which would lead to an unstable market?</td><td>Are the public and private assets and infrastructure functioning well, are they fit for purpose, and are they resilient?
Rationale: Good infrastructure is a prerequisite for transportation and trade.

Considerations:
▪ What is the adequacy, condition and performance of road and related infrastructure?
▪ What is the degree of modernity and calibre of vehicles and related assets?
▪ To what extent is there adoption of new and emerging technology?</td></tr>
<tr><th colspan="2">Data and Performance Monitoring</th></tr>
<tr><td colspan="2">How well is data captured, curated, and used across all aspects of the trucking industry?
Rationale: The availability of good data can help support reforms by pinpointing where the major issues lie.

Considerations:
▪ How strong is data collection and performance monitoring across the key actor groups?
▪ How extensive are the data collected (e.g., commodity flows, vehicle movements, economic performance)?
▪ What are the accuracy, comparability, comprehensiveness, availability, timeliness, and integrity of the data?
▪ What evidence is there that data collection impacts sound evidence-based decision-making?</td></tr>
<tr><td colspan="2">Source: Authors.</td></tr>
</table>

For practicality purposes, and to keep the focus of performance monitoring on issues directly linked to the trucking industry, aspects pertaining to industry structure and market environment will be dealt with as contextual aspects. Although influenced by government interventions, these contextual factors do not represent performance as such, but they can influence performance and merit to be explicitly recognized as such (Table 7). Contexts also reflect the sheer heterogeneity and uniqueness of settings and challenges inherent to the characterization of trucking industries in developed and developing countries alike (Box 4).

Box 4. A Sample of Trucking Sector Contexts Globally

The World Bank's own literature on the trucking sector, produced to support policymakers and practitioners in improving sectoral performance, and which has informed, in part, World Bank lending in projects related to logistics and trade facilitation, provides a good illustration of the heterogeneity of trucking sector contextual factors globally. Below is a partial summary of this body work, using income levels as a summary contextual dimension (other dimensions could be used, such based on geographic factors or market structure factors):

High-income Countries

Greek Logistics: Unlocking Growth Potential through Regulatory Reform and Complementary Measures (2013) (https://openknowledge.worldbank.org/handle/10986/16764?locale-attribute=en)

Upper Middle-income Countries

China: Guangzhou Green Trucks Pilot Project : Technology Pilot Report (2010) (https://openknowledge.worldbank.org/handle/10986/12940)
Mexico: Regulatory Reform, Competition, and Innovation: A Case Study of the Mexican Road Freight Industry (2000) (https://openknowledge.worldbank.org/handle/10986/22187)
Western Balkans: Corridor Performance Measurement and Monitoring (CPMM) System (2018) (http://documents1.worldbank.org/curated/en/634241546835881023/pdf/Developing-a-Digital-Platform-for-Pilot-Corridor-Vc-in-Bosnia-and-Herzegovina-and-a-Roadmap-for-Regional-Scale-Up.pdf)

Low- and Lower-Middle Income countries

Africa: Transport Prices and Costs in Africa : A Review of the International Corridors (2009) (https://openknowledge.worldbank.org/handle/10986/6610)
Central America: What Drives the High Price of Road Freight Transport in Central America? (2013) (https://openknowledge.worldbank.org/handle/10986/17845)
India: Road Transport Service Efficiency Study (2005) (https://openknowledge.worldbank.org/handle/10986/8356?show=full&locale-attribute=es)
Lao PDR: Transport Costs and Prices in Lao PDR : Unlocking the Potential of an Idle Fleet (2018) (http://documents1.worldbank.org/curated/en/469191543240299696/pdf/Transport-Costs-and-Prices-in-Lao-PDR-Unlocking-the-Potential-of-an-Idle-Fleet.pdf)
Vietnam: Strengthening Vietnam's Trucking Sector: Towards Lower Logistics Costs and Greenhouse Gas Emissions (2019) (http://documents1.worldbank.org/curated/en/165301554201962827/pdf/Strengthening-Vietnam-s-Trucking-Sector-Towards-Lower-Logistics-Costs-and-Greenhouse-Gas-Emissions.pdf)
West and Central Africa: West and Central Africa Trucking Competitiveness (2018) (https://www.ssatp.org/publication/west-and-central-africa-trucking-competitiveness)

Source: Authors.

Each of these contextual factors comprises several possible sub-elements (Table 8). These are not intended to be exhaustive but rather illustrative of the complexities involved. For instance—while not explicitly developed here—it might be of interest to define contextual elements to highlight areas where incentives or social schemes may be introduced, for example to reduce externalities or respond to social, political or community demands. Notably, this applies to social vulnerability aspects, formalization and professionalization of the sector, extension of social benefits to truck drivers, unions, and associations, and—in the most recent context—COVID-19 related health aspects, such as hygiene and social distancing protocols.

Table 8. Examples of Contextual Factor Sub-components

Legal / Regulatory Framework

- Artificial barriers to entry
- Operational freedom
- Quotas, cabotage, investment restrictions,
- Driver licensing and accreditation
- Insurance requirements
- Hours-of-service
- Dangerous goods regulations
- Technical standards for vehicles
- Oversize-overweight
- Regulatory harmonization across subnational structures (e.g. states), laterally across agencies, with neighbouring countries / regionally

Institutional Structures

- Clear and consistent enforcement mechanisms
- Well-trained enforcing officers
- Accountability, lack of corruption
- Sophisticated network of value-added intermediaries
- Influential trucking industry associations
- Influential shipper industry associations
- Lack of informal sector
- Forums for sharing of best practices
- Voluntary programs (e.g. SmartWay)
- Access to credit for carriers
- Financial and economic education
- Quality and availability of driver training programs

Competitive Environment

- National-level competitiveness measured by industry concentration (e.g. share of freight by Top 4 Carriers)
- Measures by segment of the industry (truckload, less-than-truckload, etc.)
- Measured by rural, national intercity, cross-border intercity, etc.
- Measures at a corridor level for key trade corridors
- Evidence of cartelization?
- Evidence of price fixing / monopoly pricing?
- Evidence of loads assigned to carriers on other-than-free-market principles?
- → Evidence of rampant pricing below cost?

Assets and Infrastructure

- Physical condition of key trade corridors
- Speed and reliability of key trade corridors (e.g. congestion)
- Redundancy of key trade corridors
- Sufficiency of and amenities for formal truck parking facilities
- Age and condition of vehicles
- Environmental efficiency
- Cold chain infrastructure
- Vehicle telematics and fleet tracking
- Information-sharing
- Truck platooning, autonomous trucking, electric trucks
- Load boards, load matching
- Back-end infrastructure – payments, orders, IT (e.g. blockchain)

Data and Performance Monitoring

Key players that should be assessed:

- Government agencies
- Industry associations
- Shippers, Carriers
- Educational institutions
- NGOs, Advocacy organizations

What should be tracked:

- Commodity flows
- Vehicle movements
- Infrastructure characteristics
- Economic performance

Angles to consider with data sources:

- Accuracy
- Comprehensiveness
- Availability and Coordination
- Currency and Timeliness
- Integrity

Impact on decision-making:

- Public-sector decisions data-driven?
- Industry benchmarking tools available?
- Formal partnerships betw. the players?

Source: Authors.

A focus on issues that are specific to the trucking industry allows for a more targeted assessment of key performance drivers. Specifically, it uncovers the need to elaborate, in particular, on 4 salient dimensions of trucking sector performance that are of importance to governments, and by extension, the public interest more broadly: (i) minimizing negative externalities; (ii) internalizing external costs to the trucking sector (i.e., such that they are not borne by society at large); (iii) promoting the robustness and resilience of the trucking services market to appropriately respond to evolving market needs and unforeseen shocks; and (iv) increasing value for money from public expenditure that directly or indirectly enable the trucking sector.

Negative externalities

Several trucking service costs are borne not by shippers, or trucking and ancillary services providers, but by society at large. These external costs or "externalities" include emissions of GHGs and local pollutants, road congestion, public costs associated with road accidents (e.g., injuries, fatalities, property damage), wear and tear on public infrastructure (roads, bridges), noise, etc., and lost welfare or economic productivity at large.

In consultations carried out for this report, trucking service providers and shippers both suggested that they are aware of environmental and pollution concerns, however unless there are specific regulations such as fleet emissions standards, or operating requirements, shippers do not usually have a choice to select less emissions-intensive fleets over others without paying a cost premium. On the carrier side, truckers tend to invest in newer fleets to avoid the high-maintenance costs of old fleets.

As the stewards of the public interest, governments generally seek to minimize or otherwise control negative externalities relating to the provision of trucking services.

Internalization of externalities

Who pays for the external costs of trucking services imposed on society? From the perspective of government, these costs should, to the extent possible, be borne by the providers and end-users of trucking services, rather than society at large, or government.

The extent to which the cost of externalities are internalized by the trucking services industry is thus one measure of public interest trucking sector performance.

Robust and resilient market

As an enabler of economic activity, transportation services, including trucking services, should effectively respond to the needs of shippers. A robust trucking services market is one in which the supply of trucking services adequately satisfies the demand for trucking services in a particular jurisdiction. A market in which the supply of trucking services does not adequately respond to the needs of shippers can have negative implications for economic competitiveness and growth. Governments generally have an interest in ensuring that the trucking services market is both adequate and responsive to evolving market needs for trucking services, including resilience to shocks through business continuity provisions.

Value-for-money

Governments of all levels typically make expenditures to support the performance of the trucking sector (and transportation sector more broadly). These include, among others, investments in roads, bridges, culverts, and other transportation infrastructure, road infrastructure maintenance and rehabilitation,

various other road transportation operating costs (e.g., traffic management, policing roads, road cleaning/snow removal, etc.), the cost of licensing, etc.

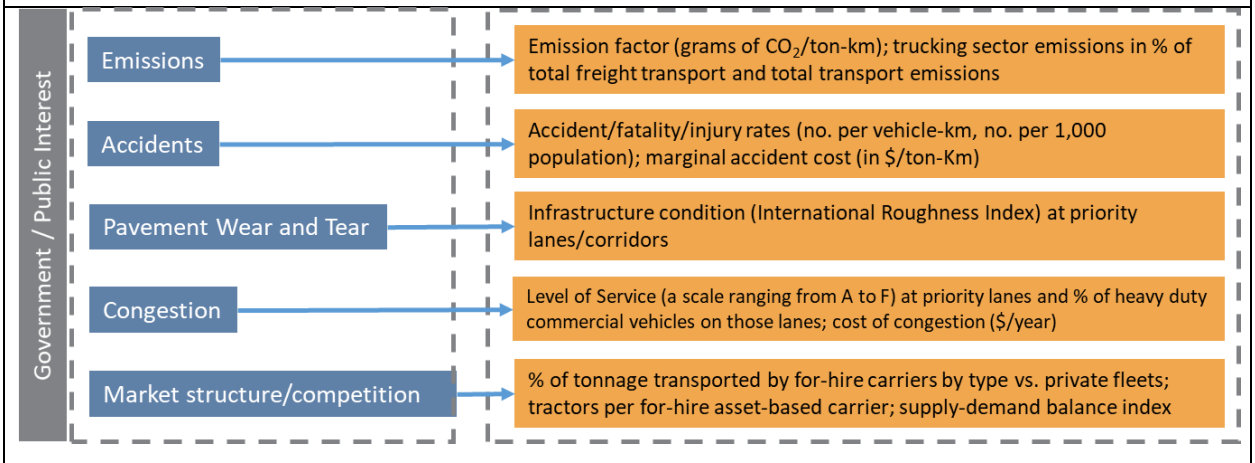
Governments seek value for money from these expenditures – whether measured in the form of economic benefits, road network accessibility, infrastructure sustainability and quality, reduced negative externalities (e.g., traffic accidents), etc. To be clear, this is not to suggest that governments seek to minimize these costs, or that public expenditures on roads are preferable to other public sector expenditures. Rather, the function is one of seeking to get the best "value" from these road sector expenditures.

Of note, road sector expenditures that support the performance of the trucking sector need not necessarily be made by the public sector. Indeed, there are various examples of private or public-private roads. These are nonetheless subject to realization of value-for-money for the public sector. Governments and public interest entities seek to enable a trucking sector that delivers the most value to society at large, while shaping or constraining the implications of the trucking sector.

Performance Measurement

A key challenge in measuring trucking performance from the government's perspective is to capture those aspects that manifest in the way and extent to which the trucking sector delivers value to society at large. The proposed performance measurement settled on 5 indicators (Figure 7). This list necessarily leaves out numerous other performance indicators that could be considered and thus is not meant to be comprehensive, but it is meant to be practical and to make it more feasible for decision makers (see Annex: Definitions of Performance for details).

Figure 7. Key Performance Indicators from the Government and Society's Perspective



Source: Authors – For details see Annex: Definitions of Performance

Chapter 5. Concluding Remarks and Final Reflections

Relative size of trucking compared to other modes. In most countries around the world, including in virtually all high- and middle-income countries, trucking accounts for both a majority of tons moved, and a significantly higher tonnage share compared to other modes of freight transport. The nature of most of these trucking sector demand and supply drivers implies that trucking is likely to continue to account for the majority of freight volumes—and therefore for the lion's share of transport costs and a significant share of direct and indirect logistics costs in supply chains—across most markets globally for the foreseeable future.

The policy implication is that trucking should be an essential, top-priority concern of countries' strategies to: (a) enhance trade competitiveness, by reducing logistics costs; and (b) mitigate the risks of climate change and environmental degradation, by reducing the emission of greenhouse gases and local pollutants. Fortunately, when it comes to trucking service delivery, emission reductions and profitability improvements at the firm level go hand-in-glove; which for most makes these two strategies naturally aligned. However, devising and successfully implementing such strategies requires an understanding, on the part of policy makers, of the nature of trucking operations, the structure of trucking markets, the levers that incentivize and influence the behavior of truck carriers, shippers, and logistics service providers, and the extent and manner in which public policy can complement private sector practices to attain sectoral productivity and efficiency improvements.

Knowledge deficit related to the trucking services. Despite the critical role that trucking plays as a driver of both logistics costs and transportation emissions, trucking markets globally, and especially in developing countries, remain insufficiently understood and under-studied. In particular, the structure and operational characteristics of most trucking markets around the world –complex, atomized and informal-- remain opaque to policy makers, regulators, and private sector actors alike. Further, there are no widely accepted standards and criteria to *benchmark* performance and with that assess trucking sector policy interventions and associated outcomes: the structure and performance of national trucking markets tend to be highly context-specific, dependent upon myriad political economy, industrial organization, and economic geography considerations, and therefore difficult to be meaningfully compared across countries in practice.

Trucking plays a critical role in the movements of goods throughout the supply chain. Compared to these other modes, trucking is the most flexible and adaptable mode of freight transportation. A well-functioning trucking industry also contributes to other modes of transportation. For this reason, virtually all supply chains rely on trucks at some stage—and typically at many or most stages. Taking into account the importance of trucking services within supply chain management, the World Bank has been publishing its flagship Logistics Performance Index[20] (LPI) since 2007. Incidentally, LPI data can be eventually used as a proxy for measuring aspects of trucking industry performance at national level.

However, giving the impression that trucking services is only about trucks, truck driving, and truck drivers, or about fragmentation and informality, is not only incomplete but erroneous. To assess whether trucking services in a country render an efficient performance, it is critical to recognize the parts and perspectives that make them possible. To start, the functionality of trucking services is contingent upon the efficiency of non-asset operations that matches users, providers, routes, type of goods and markets. The overall

[20] https://lpi.worldbank.org/.

load capacity of the industry combines for-hire assets but also private fleets, with total and partial use and lease agreements, and the same agent can at times be the user and at other times be the provider. In other words, we are in front of a very complex universe of public and private, formal and informal, and stakeholders with various interest, behaviors and viewpoints.

Also, any assessment of trucking sector performance must recognize the interest and objectives of each actor type and their respective perspectives of performance. As such, a trucking sector that performs well is one in which the three different perspectives—the commercial view of trucking services providers, the supply chain view of shippers and the socio-economic view of governments—mutually enable their respective objectives.

The high-level dimensions of performance from the perspective of each actor type, can be structured and summarized in building blocks that drilled down to the key dimensions identified as critical from the performance assessment through the lens of each actor (Figure 8). This simply yet comprehensive framework can be later used to assess and benchmark trucking sector performance across jurisdictions and dimensions of performance.

With this framework, the study responds to the need for analytical tools to facilitate holistic trucking sector performance assessments within and across countries—tools that may allow policy makers and practitioners to benchmark sectoral performance internationally, based on a limited set of high-impact, high-priority, and well-contextualized indicators. Such tools, which can help make a case for reform, galvanize public interest in implementing reform, and guide the reform process in practice, remain unavailable to most countries at present, irrespective of income level. Against this backdrop, the study is expected to provide the basis for a global performance benchmarking exercise of trucking services in which the complexities of the sector are properly represented and characterized.

To bring the framework close to home, it was also necessary to select a short list of headliner indicators among myriad options. Therefore, the process of producing a short-list of headliner indicators involved a thorough prioritization process. Measuring sectoral performance at the national level—typically a function of the public sector as a public good—requires the prioritization, choice, and definition of performance indicators across the performance drivers described in the previous chapter. We propose three key criteria, or “tests” to prioritize indicators:

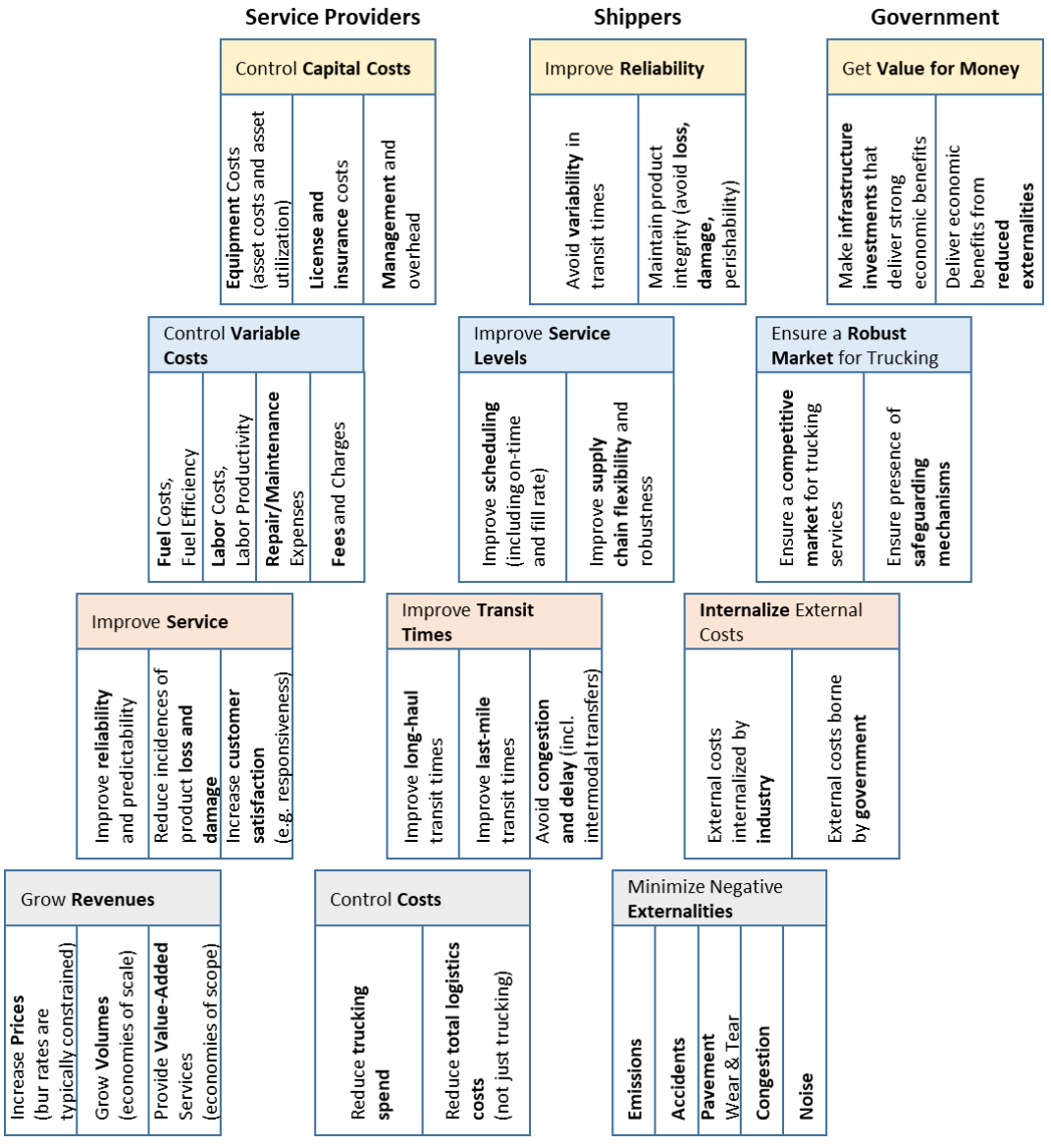
1. **Policy Relevance**. Indicators should be rise to the level of public policy observability and interest, and be meaningful within the jurisdictional and operational mandate of public sector agencies. Our consultations suggest that policymakers want to track a small handful of indicators that serve as the vital signs of the trucking sector.

2. **Feasibility.** The development and implementation of trucking sector performance indicators in a benchmarking context should be feasible to implement, and replicable by high-, middle- and low-income country governments. The most significant feasibility criterion is the availability and credibility of data or suitable proxies to inform these indicators. Certainly, “second best” approaches such as roadside surveys could be envisaged in countries where adequate data is lacking to strengthen the feasibility of implementation, but proxies and second-best approaches should nevertheless be practical enough to develop and provide reasonable estimates. However, we also recognize that a laundry list of prescriptions to collect more data will not be tractable unless they are tied to the relevance criterion as above. Private sector interviewees uniformly revealed that most low- and

middle-income countries lack even the most fundamental statistics on the trucking sector, making basic survey-type data collection paramount, prior to other complex indicators.

3. **Comparability.** The indicators in question must be reasonably comparable across jurisdictions. This is a function of many considerations including the comparability of the underlying data used in developing the indicators, reasonably comparable methodologies and assumptions used in collecting this data and developing the indicators, and an appropriate basis to normalize the effect of different contexts (e.g., impact of geography) on trucking sector performance.

Figure 8. Building Blocks of Trucking Sector Performance by Actor Type



Source: Authors.

The report concludes by summarizing, based on the above principles, the proposed prioritized set of performance indicators (Figure 9).

How to Interpret the Results from this Framework and Indicators?

There are several considerations as to how to use the proposed framework in practice. First, the performance assessment framework and associated indicators is meant to compare countries with themselves over time, as well as with other countries. Due to the impact of contextual factors on performance, cross-country comparisons should ideally be made across countries that share similar contexts along key dimensions. These should include, most fundamentally, income level (as a proxy for a range of contextual factors, from quality of infrastructure to governance practices, that are highly correlated with income), and market structure—specifically, competitive/deregulated/liberalized markets vs. partially- or non-competitive/regulated/closed markets. Other contextual dimensions that may be considered when selecting comparator benchmarks can include geographic characteristics, for example to make a distinction between landlocked and coastal countries, or between long length-of-haul/continental countries vs. short length of haul countries, etc. The framework is deliberately flexible as to the definition and grouping of comparator sets, as this will change from country to country and the specific goals of the performance measurement analysis should guide the benchmarking approach.

Second, the framework and indicators are not intended to summarize "performance" in a single summary metric that is 'rankable', such as an index. Producing such a metric would necessarily entail simplification of highly complex markets, and the results obtained would therefore be unlikely to be sufficiently actionable to inform policy. The proposed framework is admittedly not as straightforward as a single summary metric, but it is based on observable variables that can be measured and compared over time and that are influenced by policy. Rather than necessarily ranking countries even at the level of single indicators, the framework is likely best placed to be used as a "traffic light" type of tool, which could signal whether a country's performance is largely adequate (green traffic light), showing signs or risks of deterioration (amber light), or generally low (red light).

Third, the framework is flexible as to the amount and extent of indicators used. Users may decide to use a subset of the proposed indicators, or indeed add to this initial list, depending on need or objectives. What matters most is for the analysis to be informed by the principles outlined in the framework, such as the motivations of the sectoral actors, the range of service typologies in the industry, and the ways in which "performance" can be defined.

Finally, indicators are particularly insightful when assessed in combination. For example, pricing movements may say relatively little in isolation, but when compared with demand movements, disconnects between pricing and demand changes may signal insufficient market contestability or barriers to industry entry and exit. Similarly, stable profitability estimates combined with an increasing aging national fleet may signal the presence of a dominant informal sector. And while the shortlisted indicators are meant to be applied to the for-hire asset-based market, some of the indicators may be used, either directly or with adjustments as needed, to assess private fleet and non-asset based markets. For example, the deadhead percentage of private fleets could be estimated separately, and policy makers may assess whether empty miles driven by private fleets are on the rise or diminishing, and engage with private fleet operators to more deeply assessed the likely causes. The Annex below, on the definitions of the proposed

performance indicators by actor type, provides further considerations as to how the indicators may be used and interpreted.

Data Sources

The use of the framework and indicators (Figure 9) requires data gathering. Data may be obtained from a variety of sources. Two approaches to data gathering deserve special attention. The first is the regulatory aspects of data gathering based on administrative records and surveys. Some jurisdictions (mostly in high-income contexts, such as the EU and the U.S.) require, as a matter of sectoral regulation and governance, for individual firms to periodically report, on a confidential basis, a range of financial and operating data that regulatory and planning agencies can use to support the sector and improve its performance. This approach may be replicated in middle- and low-income contexts. Other institutional approaches to data gathering (also indicated in Figure 9), include institutional surveys. These are periodic, rather than (or in addition to) one-off or single-purpose surveys, that are conducted by permanent, credible public institutions with sector-wide and nationally representative output that is publicly verifiable. Examples of this include the U.S. Commodity Flow Survey (CFS) and the U.S. Vehicle Inventory and Use Survey (VIUS). Data from these surveys may be further complemented by national freight flow models, which are increasingly adopted across high-income and middle-income countries as an input to policy making and investment planning.

The second approach to data gathering is the decentralized capture of data at the level of the firm, the vehicle, or even the transaction/shipment through low-cost, high-frequency digital tools that can facilitate 'big data' analytics. This includes the use of Electronic Logging Devices (ELDs), enhanced Global Positioning System (GPS) units, sensors, and other "internet of things" (IoT) devices mounted on trucks and trailers. This also includes the use of smartphones carried by truck drivers and equipped with data gathering and processing apps. Some of these data gathering approaches have limitations, in that they may not reveal key parameters that are critical to performance measurement, such as the commodities transported, whether a truck is moving full or empty or its load factor, or the reasons behind a truck that idled or stopped for extended periods of time. But the real-time, low-cost, and high-frequency, high-coverage nature of these tools make the data particularly valuable and not necessarily replicable through surveys. These technologies also have the advantage that they are relatively less dependent upon institutional building and strengthening, which is a desirable contextual influencer of performance but one that can only be realized over long periods of time. As such, big data and digital approaches offer the opportunity for countries, particularly in low- and middle-income settings, to more quickly improve their data gathering and assessment practice through "leapfrogging" techniques.

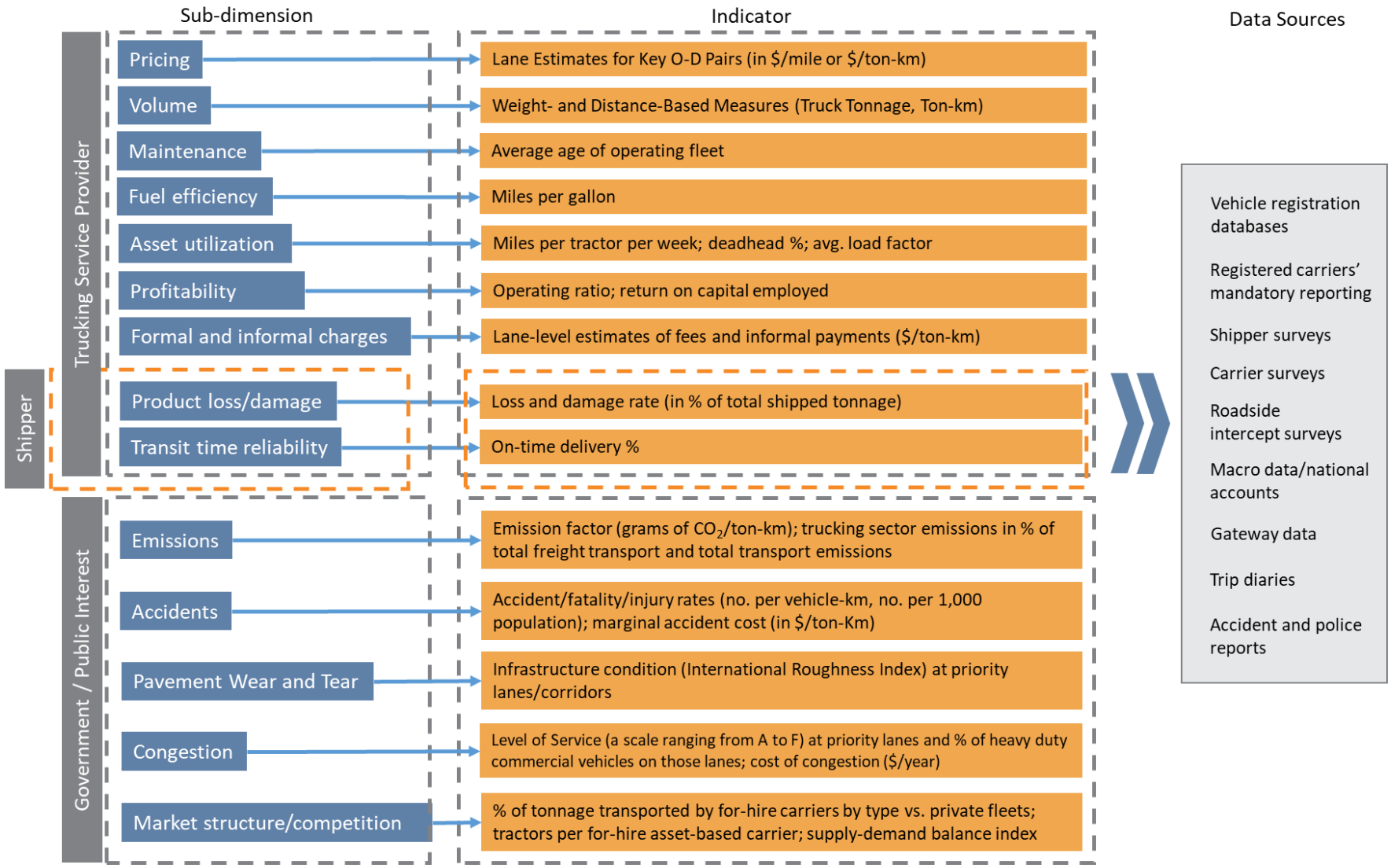
What is Next?

The natural next step stemming from this report as an opportunity for future research is the application of the proposed benchmarking framework in various country and sectoral contexts. This would establish a baseline of indicators to better assess and compare trucking sector performance. The framework may be applied to contexts with relative data limitations/abundance, regulated/liberalized environments, low-income/high-income contexts, etc. Its relative simplicity should allow for low-cost data collection, and its structure should yield performance insights that are both useful for policy making purposes in the public interest and recognizable as accurate by industry practitioners. Collaboration in data sharing and

experiences across countries could also be explored, including through regional and international entities that may facilitate this process. This process may be facilitated by an initial focused effort to test out this framework, as a proof of concept, in a limited number of countries where initial conditions, such as data availability, may facilitate implementation. Lessons can then be reflected to help extend application of this tool – or variations thereof – to more challenging contexts.

Based on the results of the proof-of-concept, it might be worthwhile to retrofit the specific selection of indicators, replacing or adding one or two as needed but keeping the framework tight and simple to preserve what are considered its key features. Another area for future research, ideally in the context of testing the framework as a proof-of-concept, is the difficulty of incorporating indicators linked to the performance of non-asset based service provision and the "desirable" market share of private fleets in order to have contestability and healthy market competition. A fuller treatment of this issue is beyond the scope of this work, but it should make for a useful line of further research.

Figure 9. Mapping of Prioritized Trucking Sector Performance Indicators at the National Level



Source: Authors.

Annex: Definitions of Performance Indicators by Actor Type

Supply-Side: Trucking Service Providers

Pricing

Definition: Pricing refers to the rates charged by a trucking service provider for freight transport services. In a freight transport market setting, prices are the result of agreed rates through tender procurements (auctions) or negotiated rates between the shipper and the service provider, normally covering transport costs, the carrier's overheads and a profit margin. Unit pricing (i.e., per km or per ton-km) is a function of many factors, including, inter alia, commodity types, destination types, market segments (e.g., truckload `versus less-than-truckload), length of haul characteristics, and above all (in competitive markets) the relative availability of supply compared to demand. For a like-for-like comparison, unit prices should be compared over time within the same typology of service (say, dry van truckload separately from less-than-truckload). Importantly, unit prices are also a function of fuel prices, which typically account for about 30-40% of operating costs of asset-based trucking companies in low- and middle-income countries, and 20-40% in high-income countries. Yet fuel prices, currently and for the foreseeable future, depend on the price of diesel fuel, which in turn depends on the price of oil, which is globally traded. Fluctuations in fuel prices, therefore, are generally de-linked from supply-demand balance or other operating considerations in any given geographical market, the key implication being that the most meaningful way of assessing changes in pricing in a given market (at the lane or national level) is to do so, ideally, by excluding the portion of pricing that is due to carriers' fuel surcharges. If a breakdown of fuel surcharges is not available, then gross pricing, inclusive of all fuel surcharges, can be used, but comparisons over time should take account of major fuel price fluctuations.

Relevance: Unit pricing is a measure of competitiveness that allows shippers to compare service offerings at the origin-destination (lane) level across carriers. Pricing is a direct component of shippers' explicit or implicit calculations of total logistics costs when making modal, routing, service type, and carrier choices. For the carrier, pricing is a major, perhaps the most important, determinant of profitability at the shipment level. The public sector is also interested in monitoring market prices to analyze the determinants and driving forces behind firm cost structures and the effects of changes in market structure and competition on prices. In competitive markets, fluctuating unit prices are a sign of healthy market competition, particularly when the directionality of these fluctuations is consistent with changes in the market's supply-demand balance. Indeed, rising (falling) prices are a proxy for tightening or loosening market capacity in well-functioning competitive markets. As a matter of performance assessment, public sector entities may consider static (consistently low or consistently high) prices, with little pass-through response to changes in supply-demand fundamentals, as a sign of concern for the level of competition in trucking services. Limited competition can lead to abnormally high prices without regard to demand, whereas cut-throat competition may yield uneconomic prices that can distort service provision, promote informality and corruption, and lead to undesirable externalities. Both are signs of shortcomings in industry entry and exit dynamics, which can be influenced through regulation.

Volume

Definition: Trucking demand volume represents the road freight activity measured as the amount of cargo (weight) transported, expressed in tons or ton-km at the national level.

Relevance: From the trucking service providers' perspective, the amount of freight movement is the most important indicator of the firms' output. From the public sector's perspective, as pointed out by McKinnon (2015), the amount of freight movement can be a good barometer of the level of economic activity, as it is considered to be closely correlated with GDP, though the level of correlation can decline as an economy develops and services increase their share of total output. Knowing the freight volumes can indicate the related transport demands for infrastructural capacity, fuel, labor, and vehicles.

Maintenance

Definition: Maintenance expenditures typically account for approximately 10% of trucking service providers' cost structure and are therefore an important driver of overall profitability (if not as dominant as fuel or driver pay). Maintenance includes upkeep of power units and trailer equipment over time, and it is directly related to the age of this equipment. As such, the average age of the fleet, whether at the national or firm level, is a primary determinant of maintenance expenditures—other things being equal, the older the fleet, the more costly it will be to maintain it in adequate working condition. Fleet age is therefore a useful proxy for maintenance expenditures. Critically, fleet age is also an indicator of reliability in truck-based supply chains, as older equipment is, all else being equal, more likely to breakdown en-route or not be operationally available to be deployed, both signs of sub-optimal performance. Furthermore, older equipment is less environmentally efficient per ton-km transported than newer equipment, and thus an aging fleet indicates losses in environmental performance.

Relevance: The average age of the national operational fleet is an important indicator of profitability through it impact of maintenance costs. But it is especially useful as an indicator of operational and environmental efficiency. In general, as a rule of thumb, trucks 10 years or older would tend to incur unreasonably high maintenance costs, have an impact on operational efficiency, and disproportionately contribute to losses in environmental efficiency. Fleets with average age above 10 years would signal opportunities for fleet renewal. It is important for the fleet age indicator to be based on the operational fleet, meaning, the age of the equipment actively used in truck operations. Non-operational equipment, or equipment no longer used for trucking service delivery, should be excluded from truck fleet age calculations.

Fuel efficiency

Definition: Fuel efficiency, also known as fuel economy, indicates the efficiency with which energy is converted into the movement of trucks. Fuel efficiency is a measure of how far a vehicle can travel with a certain unit of fuel (e.g., miles per gallon, kilometers per liter), or how many unit of fuel is needed to travel a certain distance (e.g., liters per kilometers or per 100 kilometers).

Relevance: According to American Transportation Research Institute annual reports on the operational costs of trucking across the U.S., fuel cost accounts for 30% to 40% percent of a trucking service provider's cost per mile. Therefore, trucking service providers are interested in tracking and reducing the amount of fuel consumed per distance traveled and cargo carried.

Furthermore, the amount of carbon dioxide emitted from diesel engine of trucks is directly related to the amount of fuel consumed. Monitoring the annual fuel consumption of different transportation sectors enables the governments to make informed decisions in developing policies and regulations that promote alternative fuel consumption and improve air quality and environmental security.

The most common fuel efficiency measure is the average amount of fuel consumed (in liter) to travel a certain distance (in kilometers). This measure varies greatly across different truck classes, such as light-

duty commercial vehicles, medium and heavy-duty trucks and is one of the recommended indicators for benchmarking fuel consumption. Fuel efficiency can also be evaluated with respect to the weight or volume of goods transported (e.g., per ton-kilometer), often referred to as "energy intensity" (McKinnon, 2015).

Asset utilization

Definition: Asset utilization is a measurement that shows the extent to which vehicles are used. There are different measures for utilization, such as miles/km per tractor per week, "deadhead percentage" or the share of miles trucks are driven empty relative to total driven miles, and the average load factor of the available trucking capacity as a measure of supply-demand balance as well as efficiency of asset utilization.

Relevance: Trucking companies endeavor to increase operational efficiency to decrease unit fixed costs. Capacity utilization of trucks is an important indicator of how well economic resources are used both from the perspective of carrier and shippers, which rely on their service. Improving truck capacity utilization can reduce the amount of vehicle kilometers required to meet the demand for shipments and the related detrimental effects. For governments, asset utilization indicators have multiple implications. Gains in utilization mean improvements in productivity, which are a component of economic growth. Empty miles driven are a direct indicator of waste in truck operations, and reductions in deadhead percentage indicate both gains in operational efficiency and reductions in avoidable emissions. Improvements in load factors point to better installed capacity utilization, although high load factors, say above 75-80% may signal supply-demand mismatches and possible capacity bottlenecks (and vice versa: low load factors may signal over-capacity and the need to consolidate).

Profitability

Definition: Trucking companies typically measure profitability in terms of their so-called "operating ratios", defined as the inverse of their operating margin—and thus lower operating ratios indicate higher levels of profitability. Typically, operating ratios in the 90-95% range are considered healthy, although highly profitable/efficient trucking companies can attain operating ratios well into the low 80s. Beyond operating margins/operating ratios, returns on capital employed (ROCE) are a more meaningful measure of profitability, as they measure profitability relative to the amount of capital invested in the business. ROCE is typically defined as operating income (earnings before interest and taxes, or EBIT) divided by capital employed, where the latter is typically defined as the summation of net operating working capital and net property plant and equipment. In accounting terms, EBIT is a flow item from the income statement, whereas capital employed is a stock item from the balance sheet. The combination of the two yields a measure of earnings relative to the investments necessary to produce them.

Relevance: Operating ratio and ROCE indicators are typically tracked by individual firms. From a public sector perspective, an industry-level operating ratio or ROCE estimate would be a useful indicator of changes in profitability for the sector. Such estimates are likely only able to be computed from representative industry surveys where data is anonymized and confidentiality preserved, given the sensitive nature of this information as a matter of competition. In their role as sector regulators and planners, governments can implement confidential data gathering mandates at the firm level, as a regulatory measure, for this and other kinds of indicators, such as those proposed here, for the purposes of performance assessment and monitoring. This practice is common in high-income markets (the U.S. being a case in point), and can be emulated in other settings.

Formal and informal charges

Definition: The fees and charges paid by the trucking service providers include the governmental fees such as the costs of trucks using tolled roads, and the informal payments that are forced on drivers such as the informal charges requested by custom officials at border checkpoints or by police officials in some countries.

Relevance: From government's perspective, truck tolling is an increasingly popular solution among governments seeking to recoup the cost of road construction and wear and tear caused by road freight movements, encouraging more efficient operations, managing demand for road space and reducing CO_2 emissions. However, informal payments plague the trucking operations, especially in developing countries, causing increase in operating costs and consequently the prices and imbalance between the trucking demand and supply. Concerns of high zero value added intermediary cost were raised many times by trucking associations and service providers in less developed countries. In some countries, zero value added intermediaries cost could take more than 30% of the transport fee.

Both governmental and informal charges can impose significant costs on the carriers. These charges are highly dependent on the regions of operation and typically, carriers attempt to avoid paying them whenever possible (e.g., by taking detours), since shippers are highly unlikely to reimburse a carrier for toll expenses. This depends on the trade-off between timeliness and distance traveled.

At the national level, lane estimates of the average fees and charges, expressed in $ per TEU-kilometer or ton-kilometer can be an effective indicator for benchmarking purpose. It can be calculated by dividing the combination of total toll revenues and informal charges by the total trucking volume (measured as ton-kilometer) on key freight corridors. The same indicator can as well be operationalized by truck type (weight class, emission class, etc.). Informal charges

Demand-Side: Shippers

Transit time reliability

Definition: Transit time reliability is a measure that shows how actual truck travel times vary relative to schedule/expected delivery times. A reliable trucking service means that goods are consistently delivered to customer on-time as per expected delivery timelines as agreed between shippers and trucking service providers. Service reliability is a performance indicator that is tracked by both carriers and shippers, as confirmed by almost all the stakeholders we consulted.

Relevance: Transit time reliability is known to be one of the most important variables influencing trucking services today, according to the literature and our stakeholder consultations. In order to quickly identify problems and discrepancies, to better serve their customers' interests, and to improve their services and customer's satisfaction, trucking companies often assess the quality of their delivered services. Shippers also have a strong interest in reliable trucking services with high frequencies and short transit times, combined with a high degree of schedule reliability. Note that transit time reliability is not affected by congestion but by event-driven (non-recurring) congestion conditions which create travel time variability.

Although reliability is a significant factor in the trucking industry, there is no accepted standard for measuring it. While carriers are more interested in the measures that can reflect the reliability of on-road travel time (transit time), shippers might be more interested in the punctuality of delivery service.

Southworth and Gillett (2011) refer to reliability as the level of consistency or dependability in a trucking service's travel times, as measured from day to day and/or within different times of the day.

Improving both the mean and variability of transit time lowers total logistics cost for shippers. Also, the quality of service provided by the carriers heavily depends on the consistency in en-route travel times. Thus the deviation of truck travel times on the transport network from the average is an important indicator of the reliability of the traffic condition. Moreover, measures of transit time variability are widely adopted because it does not demand additional data other than that already collected travel time or average travel speed information. It could also be argued that standard deviation is both the simplest and most universal measure of reliability.

At the national level, the Planning Time Index is recommended for monitoring the reliability performance of trucking services. Planning Time Index includes expected and unexpected delays and is calculated as the ratio of the 95th percentile travel time (between two specified locations) to the free-flow (or posted speed limit) travel time. It informs the total travel time that shippers/carriers can plan for when an adequate buffer time is included.

Product loss or damage

Definition: Product loss or damage refers to the lost commercial value of the freight due to damage, theft or accidents, sometimes collectively referred to as "inventory shrinkage" in supply chains. Freight transportation involves many handling operations, and it is thus probable that loss, theft or damage may occur in transit. Low or declining levels of shrinkage en-route would indicate improving trucking sector performance from the perspective of shippers.

Relevance: Product loss or damage plays a key role in shippers' modal and carrier choice decisions, and the value and extent of loss or damage depends on the type of goods, their value, and sensitivity/fragility. The definition of product loss-and-damage from shipper's perspective is equivalent to the one from carrier's perspective. Essentially, they are or should be tracking the same thing. From the carriers' perspective, delivery securement is an important criterion to track service quality. Shippers are also very concerned about the loss of or damage to the products/freight being delivered to their customers or consumers.

Data of delivery securement and the value of loss/damage at the national level requires access to the financial records of trucking service providers and shippers. However, information on the percentage of total shipments lost or damaged over a certain period can be collected through survey of the trucking firms. Trucking companies and shippers apply various indicators to track the loss-and-damage performance: for example, the value of loss-and-damage (Witlox and Vandaele, 2005), the frequency of loss-and-damage (Domingues et al., 2015), the percentage of shipments correctly delivered and rate of incidents (Garcia et al., 2012), etc.

The loss and damage rate over a certain period is recommended as an indicator of the trucking service quality performance. The loss and damage rate represents the combined number of cargo damaged or lost during transportation, in relation to the total number of products transported over a certain study period. This indicator is widely applied for benchmarking the logistics operations efficiency (Garcia et al., 2012; Domingues et al., 2015).

Public Interest: Government and Society

Emissions

Definition: Fossil fuel combustion in truck engines leads to emission of Green House Gas (GHG), which is primarily consisted of nitrogen, water vapor, and CO_2. In addition, approximately 1% of truck engine exhaust consists of harmful pollutants, the most significant of which are nitrogen oxides and dioxides (NOx) and particulate matter (PM) (Resitoglu et al., 2015). The environmental and health-related impacts of fossil fuel consumption are broadly divided into two categories: localized impacts and dispersed impacts.

Relevance: The localized impacts are associated with the emission of pollutants that directly affect an individual's health and quality of life in the vicinity of the pollution source (communities, neighborhoods, cities, etc.). In the case of diesel engine emissions, NOx, PM, and noise pollution are the primary cause of localized health and well-being impacts. The localized impacts of emissions decrease as the distance from emission source increases.

Environmental protection agencies adopt standards and mandate pollution reduction regulations to reduce the localized impacts of fossil fuel consumption. To control the compliance with these standards, fossil fuel dependent industries must follow specific test procedures in cycles defined by regulations. Such regulations tend to be broad, and specific implementing agencies are empowered to develop standards, regulations and other mechanisms for complying with the broader policy and legislative objectives.

The dispersed impacts of trucking are associated with the CO_2 emitted from diesel combustion which although harmless if inhaled, is a major GHG and the primary cause of global warming (Hunter, 2007). Unlike the localized impacts of emissions, the dispersed impacts of trucking affect the society at large, regardless of the distance from the emission source.

The disperse impacts have a direct relationship with the amount of fossil fuel consumed and therefore, the regulations and standards that focus on limiting the dispersed emissions impacts (i.e., carbon (CO_2) emissions) are mainly focused on reducing fossil fuel consumption through technological advancements in diesel engine design, investments in sustainable fuel resources, and improving the driving behavior (reducing vehicle kilometers traveled and idling). In this respect, performance from a public sector's perspective (reduced emissions) is aligned with and moves in the same direction as an asset-based carrier's perspective (reduced fuel consumption, and related operating cost).

The impact pathway method (Danish Ministry of Transport, 2004) is typically used for estimating both localized and dispersed impacts of trucking emissions. The total social cost of emissions imposed on a particular geographic area over a desired period is a function of the trucking activities, magnitude of localized and dispersed impacts, the population exposed to the adverse impacts of emissions, the damages caused by trucking emissions on the exposed population, and the social cost attached to the damages.

The data of trucking activity (i.e. annual vehicle kilometers traveled, and tons of cargo carried) at the national level can be aggregated for each vehicle class. In cases where the truck classification data (type, number, vintage) is not available, the trucking activity at the national level can be represented as the total annual distance traveled and the tonnage carried by all types of trucks.

The data of magnitude of localized and dispersed emissions can be obtained from vehicle inspection records and can vary across vehicle age groups. Also, estimation of the society's willingness-to-pay for emission-related mortality risk reduction or the Value of Statistical Life (VSL) can be based on individual surveys or empirical observation of health risks associated with pollution (Case, 2013).

In general, the public sector is interested in internalizing the external costs of trucking so that the system users pay their way with minimum impacts on the society at large. To calculate and monetize the social costs of emission however, a technical estimation of the emission indicators is required. Two types of emissions indicators should, therefore, be used for benchmarking externalities of the trucking sector (from a public sector performance view):

- Technical indicators: which are relevant to the amount of pollution emitted from a stationary or mobile source and are estimated according to the base values (in grams per liter of fuel consumed) resulting from source emission tests and engine performance modeling approaches.

  The product of emission base values (for various truck classes) and the fuel consumption rate would result in the **emission factor**, which is one of the main components of emission cost estimation models. The fuel consumption rate of a specific truck class can be estimated as the average amount of fuel burned (in liters) per unit of distance traveled obtained from a national level survey of fuel usage by truck fleets (Schoettle, 2016).

- Monetized indicators: a wide variety of methodologies facilitate the monetary valuation of emissions, utilizing different factors and perspectives to measure and mitigate the environmental impacts of fossil fuel consumption, including human capital damages. For the purpose of this exercise, the **marginal cost of trucking emission** is preferred as it enables the public sector to the measure the potential changes in the environmental and health effects of emissions resulted from a change in the distance traveled and weight carried by road freight. Marginal emission cost is calculated by dividing the total social cost of emission by the total distance traveled and cargo weight carried over a certain analysis period.

Accidents

Definition: Accidents (or crashes) are one of the externalities associated not only with trucking but with all the transportation modes. Road crashes impose various costs to the society many of which are complex and hardly quantifiable. Governments and public agencies typically analyze accident costs from three general perspectives (Miller, 1991):

1. The Human Capital perspective, which measures the economic costs associated with crashes including property damage, emergency response, and medical treatment, lost productivity, legal and insurance administrative costs, and congestion impacts. In this method, typically a value is set for saving one human life while lesser values are set for preventing disabilities and injuries.

2. The Quality Adjustment perspective, which measures the lost quality of life due to death or injuries based on the willingness-to-pay for accident prevention.

3. The Comprehensive perspective which includes both the human capital and quality adjustment methods and is the method commonly considered for estimating the truck-related accident externality imposed on the society.

Relevance: Road crashes impose various costs to the society many of which are complex and hardly quantifiable. Public sector has interest in quantifying the social costs of accidents due to loss of life, reduced quality of life due to injuries, reduced productivity, medical and other expenses to estimate the need and potential benefits of investment in infrastructure and policy programs.

Trucking associations, traffic safety administrations, and other transport agencies typically publish periodic records of crashes, which include statistics of fatality and injury rates as well as the types of vehicle involved. In order to associate different costs with different levels of injuries caused by trucking crashes, studies typically use injury scales which are often used in the police (or EMS) reports, reflecting the level of damages to property or the degree by which a victim of a traffic accident is incapacitated.

In the trucking sector, the **crash, casualty, and injury rates** of the truck-involved accidents are the most relevant measures of the safety level and accident costs of the trucking industry. The crash rate in trucking sector indicates the number of crashes (of different types and severities) associated with trucking activities and expressed per population of an area or vehicle miles or kilometers traveled.

The total accident cost can be estimated as the product of the number of crashes of each type and the costs associated with each level of injury or property damage. Dividing the total accident cost by the hours of operation, miles traveled, or ton-miles of commodity transported results in **the marginal accident cost** (FHWA, 2016; Victoria Transport Policy Institute, 2018). The marginal accident cost is the most common indicator used for the purpose of trucking performance measurement (TRB, 1996), as it reflects the change in total accident costs resulted from one additional freight shipment on a road.

Pavement wear and tear

Definition: Roadways are engineered and constructed based on the number of Equivalent Single Axle Loads (ESAL) they can carry over a specified period. One ESAL is equal to 18,000 pounds per single axle for rigid pavement and 20,000 pounds per single axle for flexible pavement. Regardless of the pavement type, the amount of pavement life decreases drastically as the gross vehicle weight per axle increases exponentially.

Relevance: The most commonly applied method to approximate the relative impacts of different vehicle types on road surfaces is the Generalized Fourth Power Law which assumes a fourth-power relationship for the load-equivalence factors relative to different vehicle weights. Thus, a 20,000 lb. single axle truck has 10,000 more impacts on the pavement compared to a 2,000 single axle car.

Therefore, public governments use truck weight regulations to protect roadway infrastructure from excessive wear and tear. Moreover, weight regulations reduce the safety issues that overweight trucks impose on other road users. Overweight trucks have higher kinetic energy which increases the likelihood of the truck being involved in a crash and the severity of the crash. Also, overloaded trucks are usually unstable, leading to loss of maneuverability and suspension performance reduction which in turn, results into braking defaults.

These regulations may vary depending on the road type and jurisdictional boundaries. Studies show that a 1% increase in the number of overweight trucks traveling on roadways leads to 1.8% reduction in pavement lifespan. This relationship is linear regardless of the pavement structure and traffic configuration (Wang et al., 2015).

The Fourth Power Law provides a quick way to approximate the potential impacts of a truck traveling on a road segment. However, the impacts of vehicle load on pavement deterioration can vary depending on the pavement distress category (USDOT, 2000). Therefore, the transportation agencies use ESAL factors to estimate the impacts of different road users on pavement wear and tear. ESAL factors are typically calculated based on a combination of road tests and analysis of cumulative traffic load statistics as well as traffic volume and classification data.

The average costs of pavement maintenance or resurfacing projects can be derived from highway project accounting data. A statistical analysis of the past pavement project costs is required to distinguish the pavement surfacing cost from other components of the highway projects. As when designing the highway and bridge structures based on the equivalent load factors, the damage cost of vehicles of various configurations is estimated as a multiple of the damage cost of a standard passenger vehicle.

In order to develop a time schedule for maintenance of each type and prioritize the available resources, public agencies monitor and report the **road surface condition** using the International Roughness Index (IRI). The IRI is the recommended indicator for evaluating the road surface condition as it uses a standardized methodology and is applied uniformly around the world.

To indicate the maintenance costs imposed to the public due to trucking activities, the common practice is to estimate the impacts of trucks on highway wear and tear and calculate the **marginal pavement cost.** Marginal pavement cost is a recommended indicator as it shows the impacts of an additional (kilometer of) truck trip on the highway surface deterioration.

Congestion

Definition: Traffic congestion is a condition of any transport system performance, characterized by increased travel time and reduced speed. Congestion is the most visible externality of truck transportation, recognized by both road users and the society at large.

Relevance: Road users are impacted by congestion through the lowered quality of road service (i.e., reduced effective capacity). Congestion can also increase the impacts of pollution emission, due to fuel use in excess of what would otherwise be needed to travel the road section, or idling. Analyses of the impacts of congestion on pollution emission have shown that the additional fuel consumption due to traffic congestion leads to increases in carbon emissions. A 2017 study of traffic congestion in the Mumbai region, India indicated that a 51% increase in travel time due to congestion could increase CO_2 emissions by nearly 53% (Bharadwaja, 2017).

The public sector interest in estimating the cost of congestion to the road users and the society is to ensure that the users of the system pay these costs through congestion pricing. Congestion pricing practices aim to improve traffic condition by regulating the demand; i.e., making the road users pay a fee when using a highway in the peak of demand (road tolls).

The quality of service for motor vehicles on a section of the roadway system can be determined using the travel speed and traffic volume on that section, relative to design performance of the section. In the U.S., the Highway Capacity Manual (HCM) and the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets use letters A through F to describe the Level of Service (LOS). The A scale indicates free flow condition at which the vehicles can travel at the posted speed limit or higher. The F scale represents a condition at which vehicles have to frequently stop or slow down due to the high density of vehicle on the road. Highway designers generally use LOS of C or D to balance cost efficiency with acceptable travel time for the road users during the peak hours (TRB, 2008).

Calculating the cost of congestion generally includes the cost of time spent in traffic by users (opportunity cost of delay in traffic usually estimated based on the user's WTP for every unit of time to avoid delay in traffic and expressed in $/minute, $/hour).

To calculate the delay, the desired LOS is compared with the peak hour LOS (or the LOS at the bottleneck). Increased stress levels and reliability can be reflected in the total cost of congestion as increasing factors. Also, impacts of trucks on congestion are expressed using Passenger Car Equivalent (PCE) factors, as indicated by Highway Capacity Manual (TRB, 2008).

Public agencies commonly use the **marginal cost of congestion** to indicate the performance of trucking with respect to the public. The Marginal External Cost of Congestion (MECC), is the cost associated with one additional unit of distance traveled by truck, on a congested roadway.

Market structure/competition

Definition: Market structure and competition within the trucking sector shows the types of trucking firms operating in the market and the degree by which a small number of carriers are holding major shares of the industry. On this basis, the trucking sector of a country is competitive if the market concentration is low.

Relevance: Studies have shown that competition in the trucking industry, can increase market flexibility and responsiveness to changes in demand, lower the market prices, and increase service quality (Pachón and Araya, 2014). The benefits of competition in the trucking sector are however dependent on many factors including the market concentration, regulatory frameworks, and accessibility to resources such as infrastructure and labor.

Although competition can be generated and improved through market liberalization and deregulation (Moore, 2018), the experiences of many developing countries have proven that competition needs to be protected and maintained to avoid price-fixing and abuse of the transactional agreements (Dutz and Khemani, 2007).

In order to balance the benefits of deregulation with the advantages of pro-competition policies, governments may intervene in the trucking industry to improve economic efficiency (TRB, 2003) and ensure robustness of trucking services (Dutz and Khemani, 2007). For that reason, government intervention is usually as a response to changes in market concentration and service quality, or for the purpose of internalizing the costs of externalities such as pollution emission, truck-related accidents, and congestion.

Data of the trucking industry structure includes the size of firms, type of services provided, and the number and condition of assets owned. Such information can be obtained through periodic survey of trucking industry. For instance, the American Trucking Associations conducts annual surveys of the industry, reporting the total revenue, tonnage carried, taxes, employees, number of trucks operating, and the number of companies belonging to "private, for-hire, and other" segments as aggregated national-level information.

In order to measure the structure of the trucking sector, categorizing the types of firms operating in the market and estimating the **number of firms in each segment** is recommended. Example of the types of trucking firms include: for-hire asset-based carriers, non-asset-based logistics companies, private fleets, ancillary service providers, and commercial advocacy organizations.

Another commonly accepted measure of market concentration is the **Herfindahl–Hirschman Index** (HHI) which takes into account the distribution of firms of different sizes and the market share of each firm. The HHI is used by the U.S. Department of Justice for market screening and providing merger guidelines. In general, a market with HHI of 2,500 or more is highly concentrated, and an HHI of 10,000 indicates monopoly. The square rooting of the firms' market shares in the HHI formula results into heavier weights for larger firms, reflecting the fact that competition is weak when there are a few firms that hold a large portion of the market. On the other hand, when HHI is very low (near zero), the market competition is considered vigorous (Rhoades, 1993).

An alternative approach may be to examine barriers to a competitive trucking market such as entry barriers, regional operating restrictions, and similar factors – possibly using a scorecard similar to the World Bank's "Ease of Doing Business" index.

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