# EFFICIENT URBAN FREIGHT

## EVALUATION METRICS

Smart City
MISSION TRANSFORM-NATION

सत्यमेव जयते
Ministry of Housing and Urban Affairs
Government of India

ROCKY MOUNTAIN INSTITUTE

Ministry of Housing and Urban Affairs
Government of India

**ABOUT MINISTRY OF HOUSING AND URBAN AFFAIRS (MoHUA)**

The Ministry of Housing and Urban Affairs is the apex authority of Government of India to formulate policies, coordinate the activities of various central ministries, state governments and other nodal authorities and monitor programs related to issues of housing and urban affairs in the country. The Smart Cities Mission was launched by the Ministry in 2015 to promote sustainable and inclusive cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.

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**ABOUT ROCKY MOUNTAIN INSTITUTE (RMI)**

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing. RMI has been supporting India's mobility and energy transformation since 2016.

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# Document outline

This document describes key performance metrics (KPIs) for monitoring a city's progress towards making its urban freight system more efficient.

# 1.0 Introduction to freight performance measurement

## 1.1 Purpose and logic of performance measurement

Many different causes, which are often mutually interdependent, contribute to the overall efficiency of urban logistics. For that reason, rather than trying to isolate and measure every potential cause of inefficiency, we suggest a set of metrics that are easy to understand and collectively describe key elements of urban freight efficiency that are amenable to action by policymakers.

This KPI system is designed to help policymakers understand, at a high level:

- What goods must travel on city roads
- How much vehicle travel to move those goods can be reduced
- For vehicle travel that must occur how much cost, both internal and external, can be removed from the system.

This metric system identifies and quantifies a limited set of drivers for excess freight movement on urban roads, excess vehicle travel per unit of freight demand and excess cost, both external and direct, per unit of vehicle travel. Further explanation of metric definition and potential pathways to improvement are discussed below.

## 1.2 Caveats on interpretation

Care must be exercised when interpreting this KPI system: analysis of any single metric in isolation is not meaningful. Many of these metrics are inextricably tied together and any change to affect one metric can have knock-on effects on many others. For example, a change in an average truck size would have knock-on effects on many other metrics such as load factor, number of trips, cost per kilometer, delivery productivity, etc. Furthermore attempting to use this KPI system to use one city as a benchmark against another is not possible. It is best interpreted as a time series for a single city.

While some lessons may be learned from looking at other cities, especially at how they have improved metric performance, strict comparison is misleading. Many exogenous factors such as size, geography, composition of the economy and even climate and weather patterns will affect the metric performance. Furthermore, when evaluating performance, robust engagement with logistics players, as outlined in the Policy Workbook Document, can help policymakers interpret why metrics have changed and whether the overall evolution of the system was positive or negative.

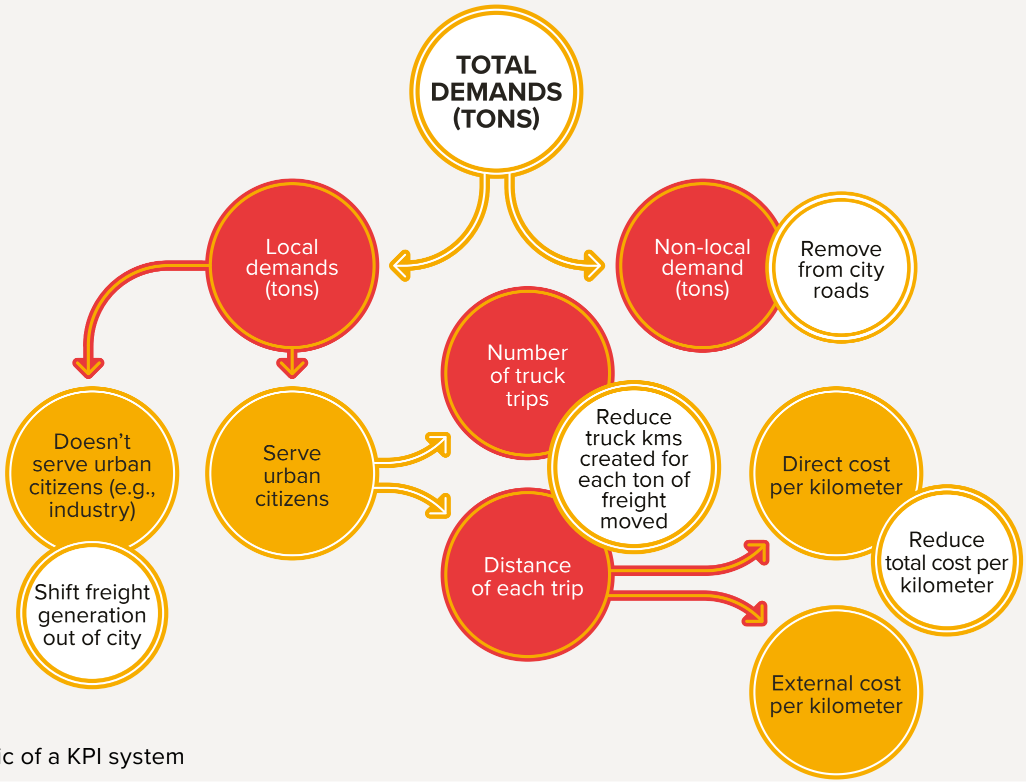



**Figure 1:** Logic of a KPI system

| INEFFICIENCY CATEGORY | SUB-CATEGORY | KEY PERFORMANCE INDEX (KPI) | CALCULATION METRIC |
|---|---|---|---|
| Demand | Local | Freight intensity of GDP | Ton/Rs. GDP |
| | Through | Share of total freight demand | Ton-through/total tons |
| Vehicle travel | Trips | Vehicle loading capacity | Tons |
| | | Net load factor | Ton-km/GVWR*km |
| | | Delivery productivity | Deliveries/hour |
| | Trip distance | Logistics sprawl | Km to barycenter |
| | | Routing efficiency | Deliveries/km driven |
| External cost | Congestion | Travel time index on freight lanes | Time during peak congestion/free flow |
| | Safety | Truck-related casualties | Injuries and fatalities/km driven |
| | Pollution | Freight-related emissions | Gm/km ($CO_2$, $SO_x$, $NO_x$, PM, VOC, $0_3$, etc.) |
| Direct cost | Fixed + variable | Unit costs per kilometer | Rs/km |

**Table 1 :** Metric system

**Note:** GVWR—gross vehicle weight rating

# 2.0 Metric discussion

## 2.1 Freight intensity of GDP

**TRUCK FREIGHT GENERATED BY ACTIVITIES ( IN TON-KM)**

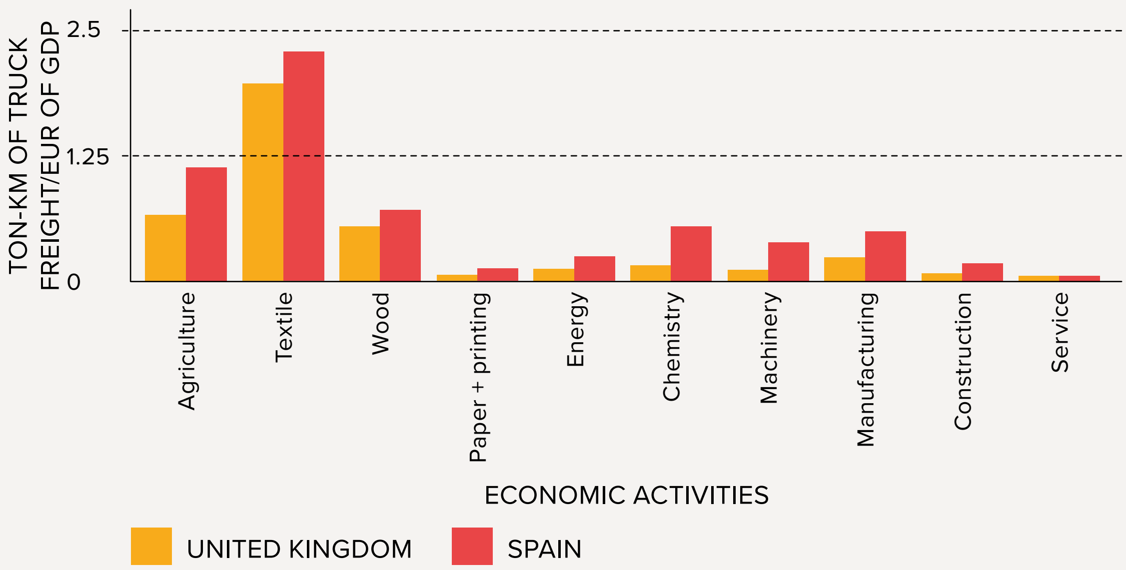



**Figure 2:** Ton-km of truck freight/EUR of GDP generated by different types of economic activities in the UK and Spain[1]

» Description

Producing goods and to a lesser extent, services entail the movement of freight. However, different economic activities tend to produce different amounts of freight movement. For that reason, the size and composition of the economy, especially the share of the tertiary sector in a city's GDP, heavily influence how much freight demand is created in a city. Broadly speaking, the tertiary sector produces far less demand for freight movement than other sectors. Low value-added manufacturing and heavy industry, on the other hand, tend to produce relatively high freight demand per unit of GDP.

## FREIGHT IN GLOBAL MEGACITIES ( IN TONS/ GDP)

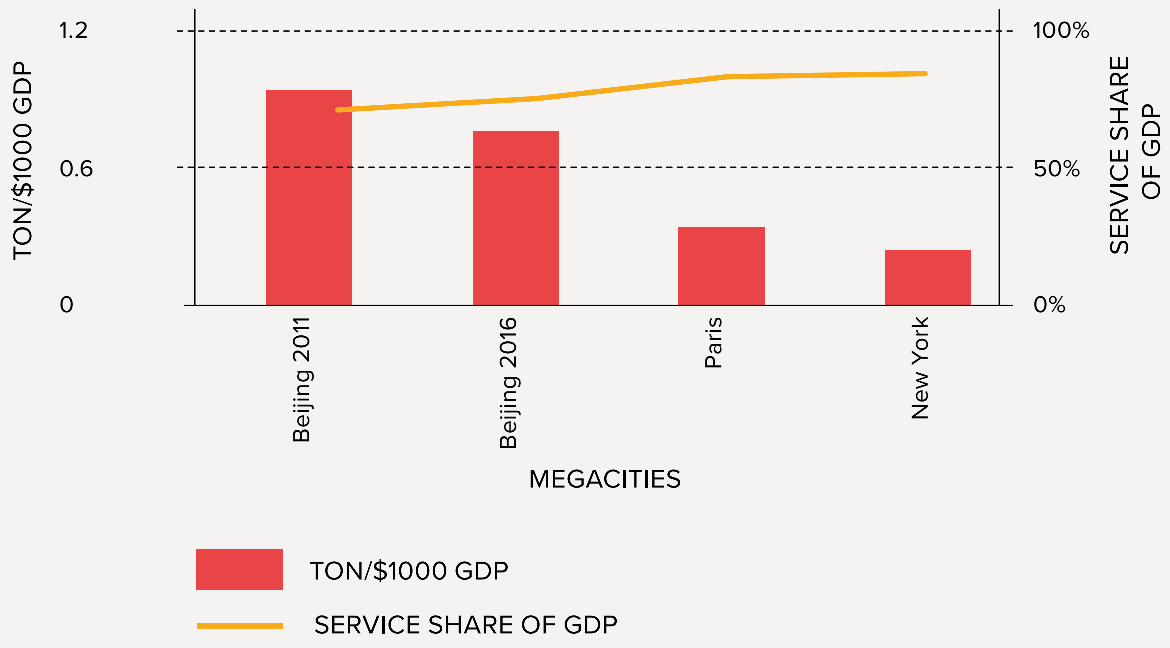



**Figure 3:** Tons of freight/$1000 GDP in global megacities. Service-based economies generate less freight per unit of GDP

» Pathways to improvement

To the extent possible, urban freight should consist of products consumed by urban residents, rather than inputs for industrial or manufacturing processes. Therefore, the primary pathway to improving freight intensity of GDP is to create policy, which encourages urban GDP to consist of economic activities that directly serve the needs of urban consumers. However, the composition of GDP is only partly in control of policymakers. Many other elements such as land prices, infrastructure layout, access to suppliers, etc. all affect where businesses choose to locate.

Furthermore, at certain stages of urban development, freight intensive activities such as fixed asset formation, infrastructure build-out and building stock creation are unavoidable. Therefore, policymakers must view reduction of freight demand as a long-term endeavor, which requires holistic planning well beyond transportation authorities and also is subject to the city's need to invest in fixed assets such as building stock and infrastructure.

## 2.2 Through-freight share of total demand

Through freight movement in a city

» Description

Goods moving through a city or metropolitan area, which are neither produced nor consumed in the area, are referred to as through-freight. Through-freight generates truck traffic and associated costs in metropolitan areas without bringing in significant economic benefit. It is typically the product of national transportation network planning, over which municipal policymakers have little control. Furthermore, if municipal policies disrupt national logistics activities, it can be detrimental to the economy as a whole.

In cities that have ports and other logistics network nodes, which concentrate national or global freight flows in a single metropolitan area, through-freight can become a major issue for policymakers to manage. For example in Chicago, which is a major hub in American freight rail networks, through-freight accounts for approximately 32% of the tonnage moved by trucks in the metropolitan area[2] and 49% of the tonnage moved by rail.[3] Similarly in Los Angeles County, truck trips to and from the Los Angeles

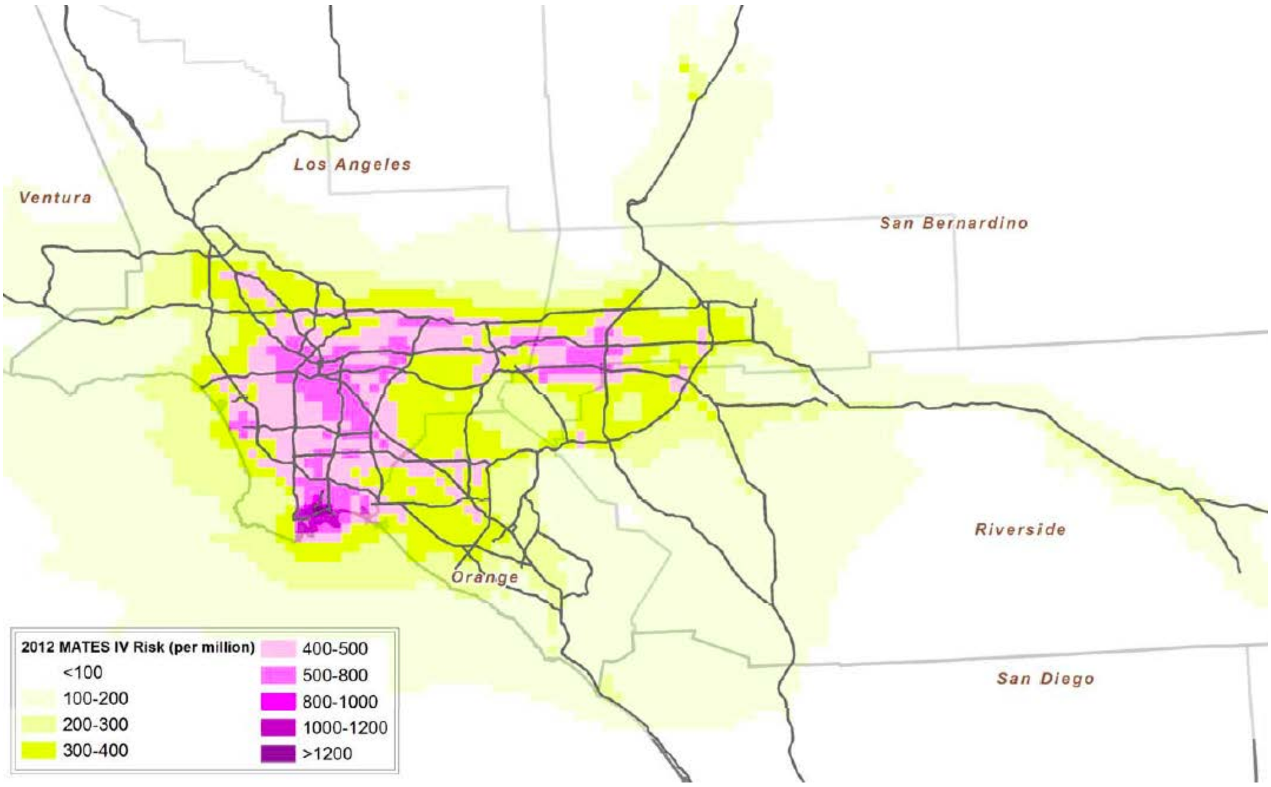



**Figure 4:** Cancer risks along the 710 freeway in L.A., due to air pollution
Source: South Coast Air Quality Management District Draft Multiple Air Toxics Exposure Study IV (October 2014)

Long Beach port complexes generate nearly 8% of total truck trips in the county.[4] Furthermore, because these trips are carried out by heavy-truck concentrated routes, they tend to produce high external costs. For example, in LA, the corridor that serves the ports is known as the 'diesel death zone' due to the markedly higher cancer risks experienced by residents living along the corridor.

| | |
|---|---|
| » Pathways to improvement | Infrastructure such as ring roads or bypasses, can route through-freight around cities rather than through it. When a trade node that is not easily relocated such as a port is in a city, policymakers can build infrastructure such as portside rail, which reduces truck travel generated by through-freight. City policymakers can collaborate with national-level policymakers on infrastructure creation to reduce the burden, which through-freight puts on cities, without undermining national logistics systems. |

## 2.3 Truck loading capacity

**DELIVERY VEHICLES WEIGHT RATING (IN GVWR)**

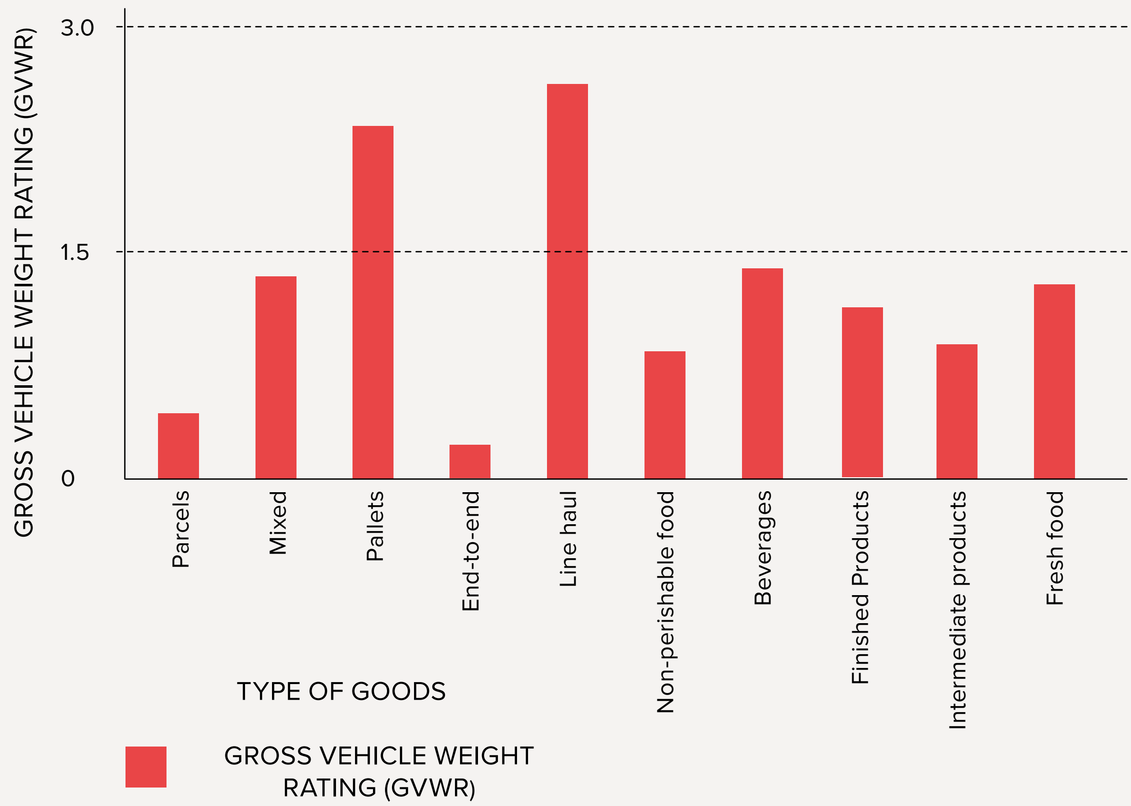
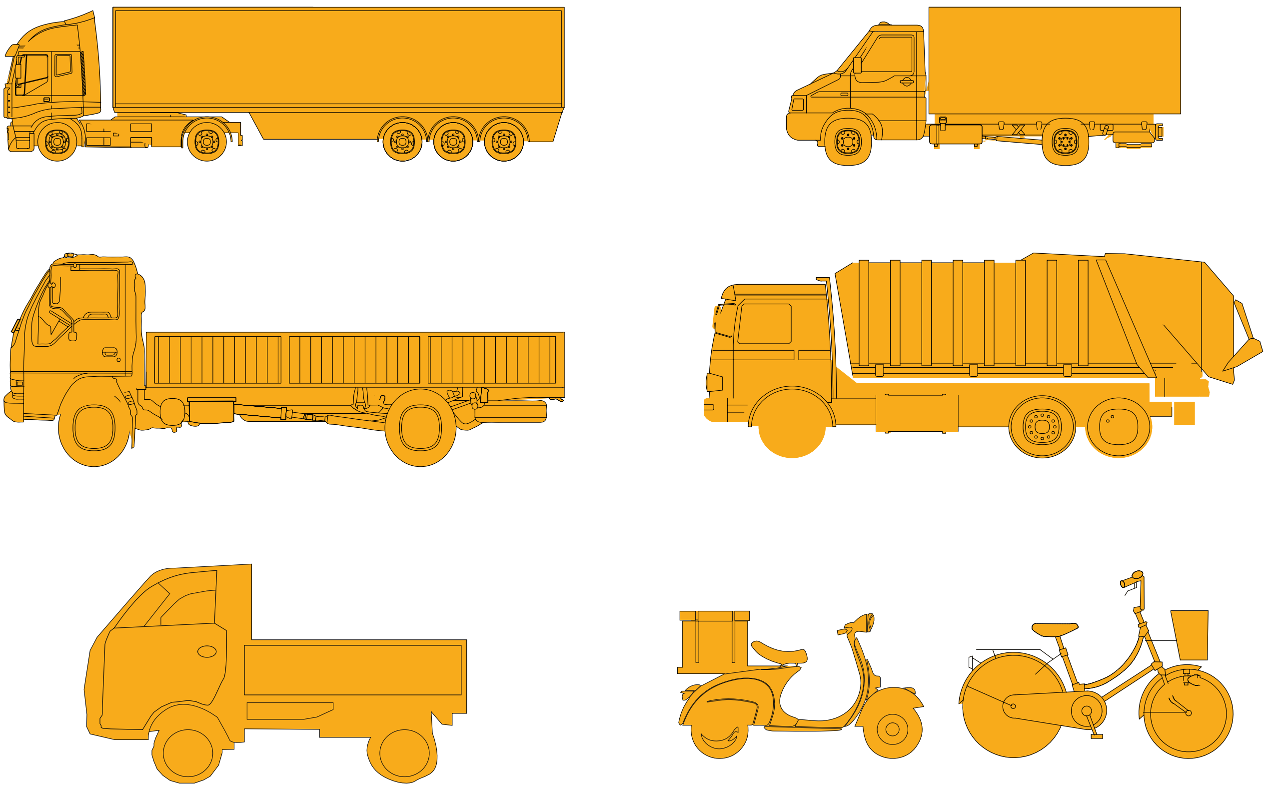



**Figure 5:** Gross vehicle weight rating (GVWR) of Delivery Vehicles in Paris[5]

» Description

The right size of delivery vehicles is a thorny question with multiple factors influencing the decision. Broadly speaking, however, truck size influences the overall urban logistics efficiency in two ways, trip generation and creation of external costs. If a truck is too small to carry a load, it may be split into multiple loads and create extra trips, arguing for larger delivery trucks. However, larger trucks are often much more disruptive to urban quality of life on a per-kilometer basis than smaller vehicles. The goal of truck size regulation should be to minimize the overall systemic cost, looking at both trip generation and unit costs, direct and external, per kilometer of vehicle travel.



Types and sizes of vehicles that carry urban freight

» Pathways to improvement

There is no one-size-fits-all answer for what the right-sized vehicle is and how it should be regulated. Such decisions must be made with a view towards the requirements of logistics system users and also the capability of infrastructure to handle different types of vehicle traffic. That entails both improving infrastructure to allow heavy vehicles where appropriate and banning them where they are inappropriate. Designing a flexible system, which allows heavy truck travel in suitable corridors but restricts it in sensitive areas and at sensitive times, can help cities achieve efficient use of all types of vehicles. As infrastructural capabilities on key corridors improve, policymakers can continuously evaluate regulations on vehicle size, how the trade-off between trip generation and external cost creation is playing out and can adjust the policy accordingly.

## 2.4 Net load factor

| | |
|---|---|
| » Description | Net load factor is the average share of vehicle loading capacity that is productively used. That encompasses two factors: the share of rated loading capacity, which is used when a vehicle is loaded and the share of driving, which a vehicle does when it is not loaded. Vehicles that run empty or partially loaded generate extra travel and associated costs, without generating commensurate economic value. Operators typically will seek to maximize net load factors in order to maximize operating margins and the role of policymakers in improving this metric is secondary. The relevance of the metric to policymakers is to evaluate whether infrastructural and regulatory factors are imposing constraints on operators that increase total systemic costs or whether operators are achieving high net load factor at the cost of society, for example through overloading. In either case, policymakers can adjust regulation and enforcement practices to maximize efficiency. |

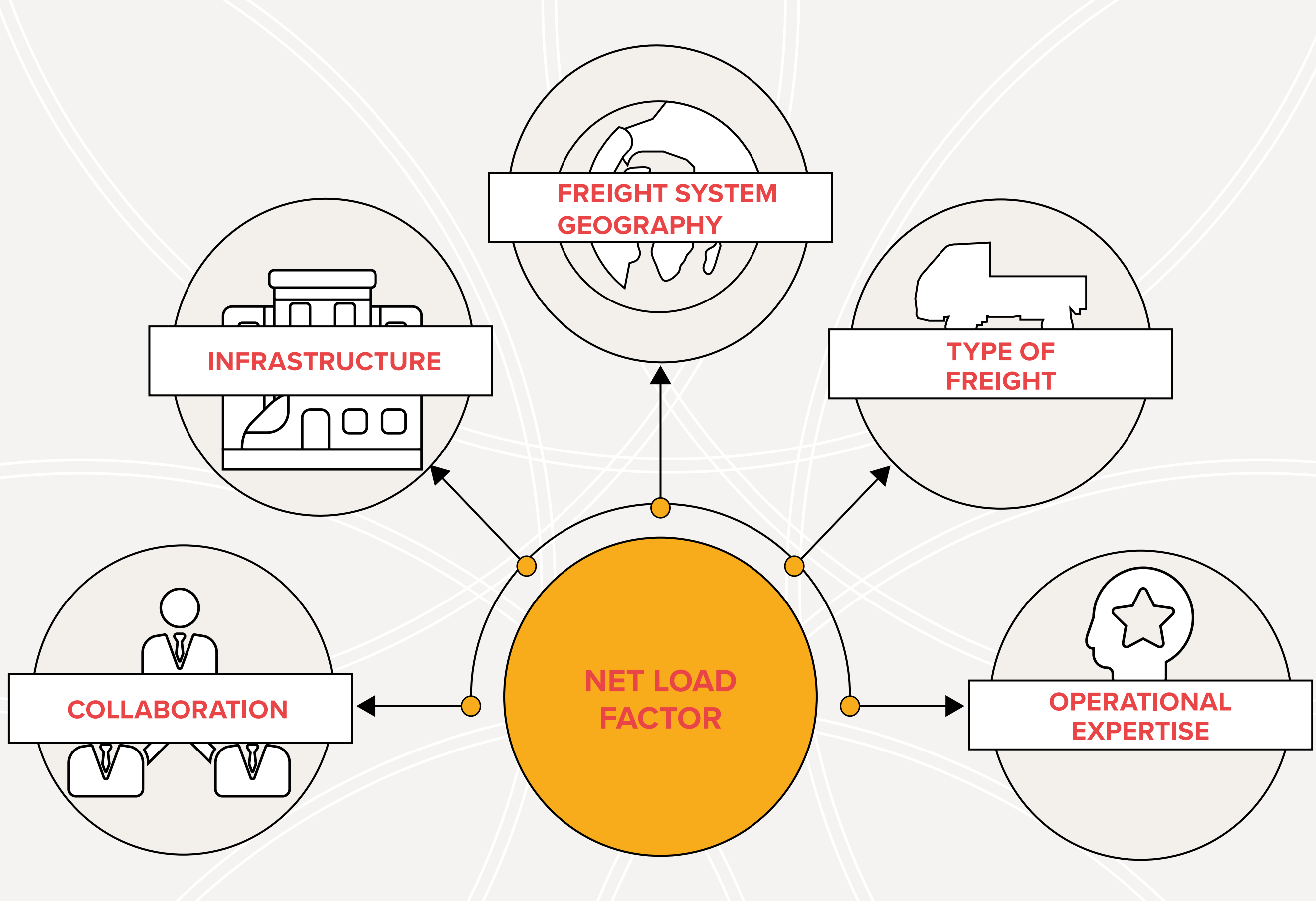



**Figure 6:** Factors that affect net load factor

» Pathways to improvement

Why vehicles are underloaded or why they run empty are complex questions, which are influenced by diverse factors such as freight type, freight system geography, infrastructure, operational expertise and the willingness to collaborate with competitors. Broadly speaking, policymakers should consult with industry players to identify factors that are decreasing load factors in a way that creates a net value loss to the city. Many times, resolving those issues will enhance the revenue and profitability of industry players. In other cases, where excessive travel due to low load factors is imposing unacceptably high costs on society, policymakers can also consider mandating measures such as required consolidation to improve load factors.

## 2.5 Delivery productivity

**PARISIAN TOUR TIMES ( IN MINUTES)**

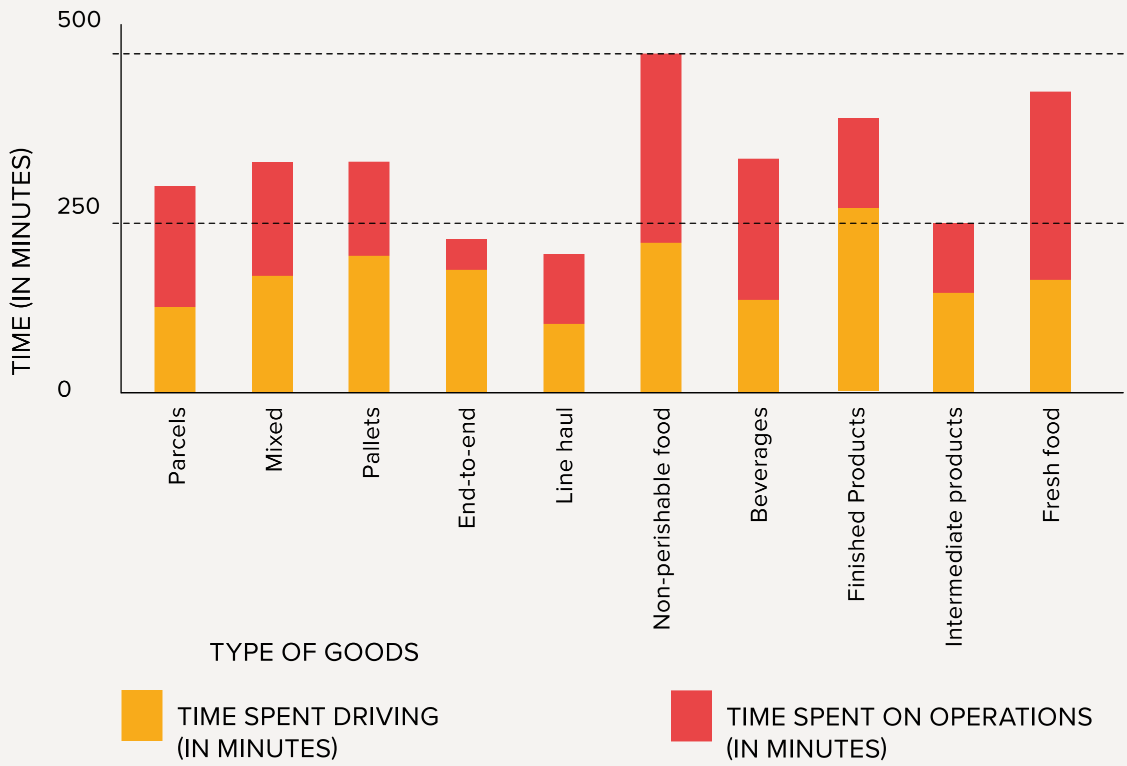



**Figure 7:** Parisian Tour Times and Their Composition (minutes)[6]

» Description

Delivery productivity measures how many deliveries a vehicle can accomplish in a day. It is closely related to load factor and in that it seeks to shed light on how the efficiency of vehicle use influences trip generation. Delivery vehicles typically only load as much freight as they can deliver on a single day. The time that delivery vehicles spend driving to and from the distribution center to the first delivery point, the time they spend on each delivery and the time they spend driving between deliveries, all influence how many deliveries they can make in a given day. In many cases, greater delivery productivity could lead to larger loads and fewer trips reducing overall urban driving.


**Figure 8:** Loading and unloading of trucks

» Pathways to improvement

As with other metrics that primarily measure operational efficiency such as net load factor, policymakers can consult with the industry to identify policy or infrastructural causes of low-delivery productivity and work to resolve them. Common causes of lowered productivity include congestion on freight routes, lack of access to convenient parking for delivery trucks and long or circuitous travel distances between stops.

For this reason, poor delivery productivity can often be addressed by a portfolio of measures that also influence other metrics in the KPI system such as congestion, routing efficiency, logistics sprawl, etc.

## 2.6 Logistics sprawl

### DISTANCE OF WAREHOUSE FROM CITY CENTER (IN KM)

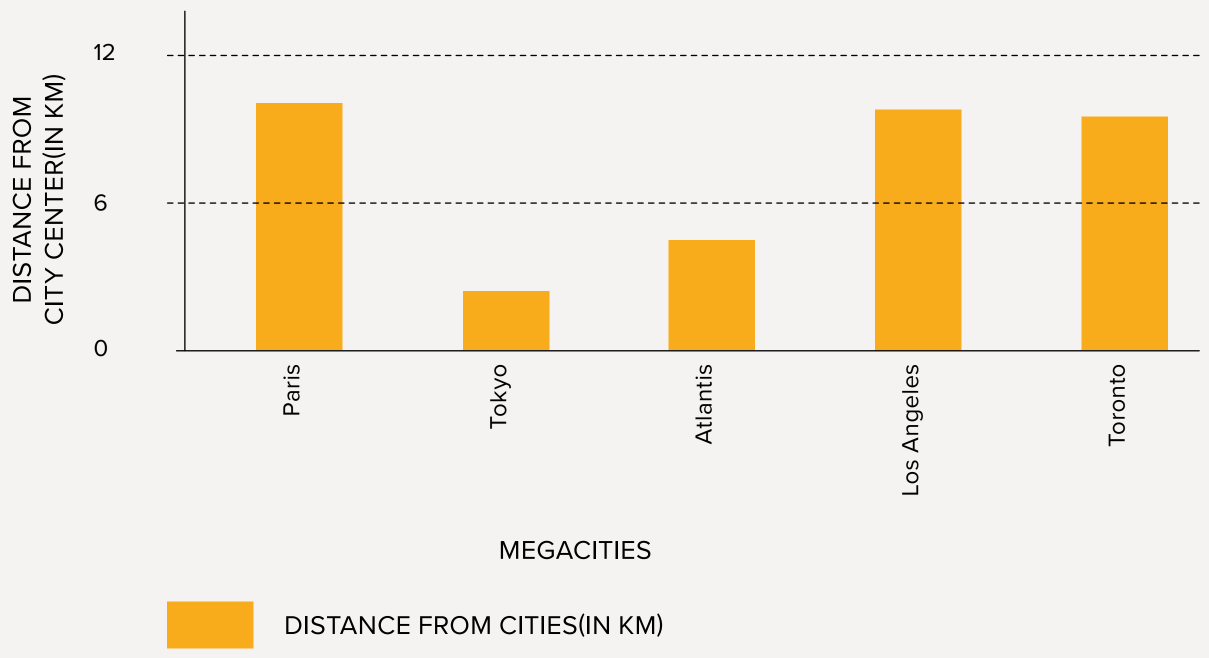
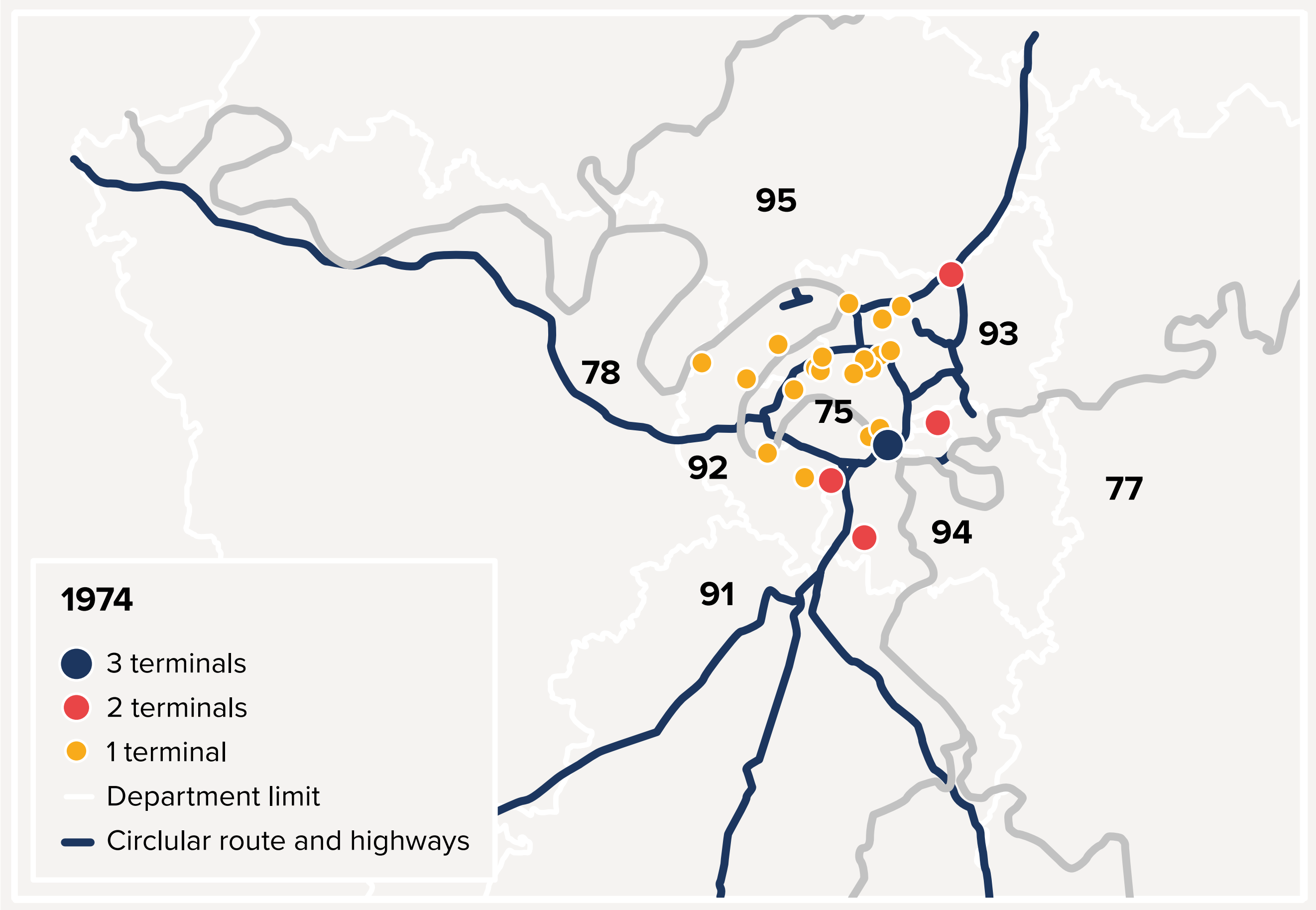
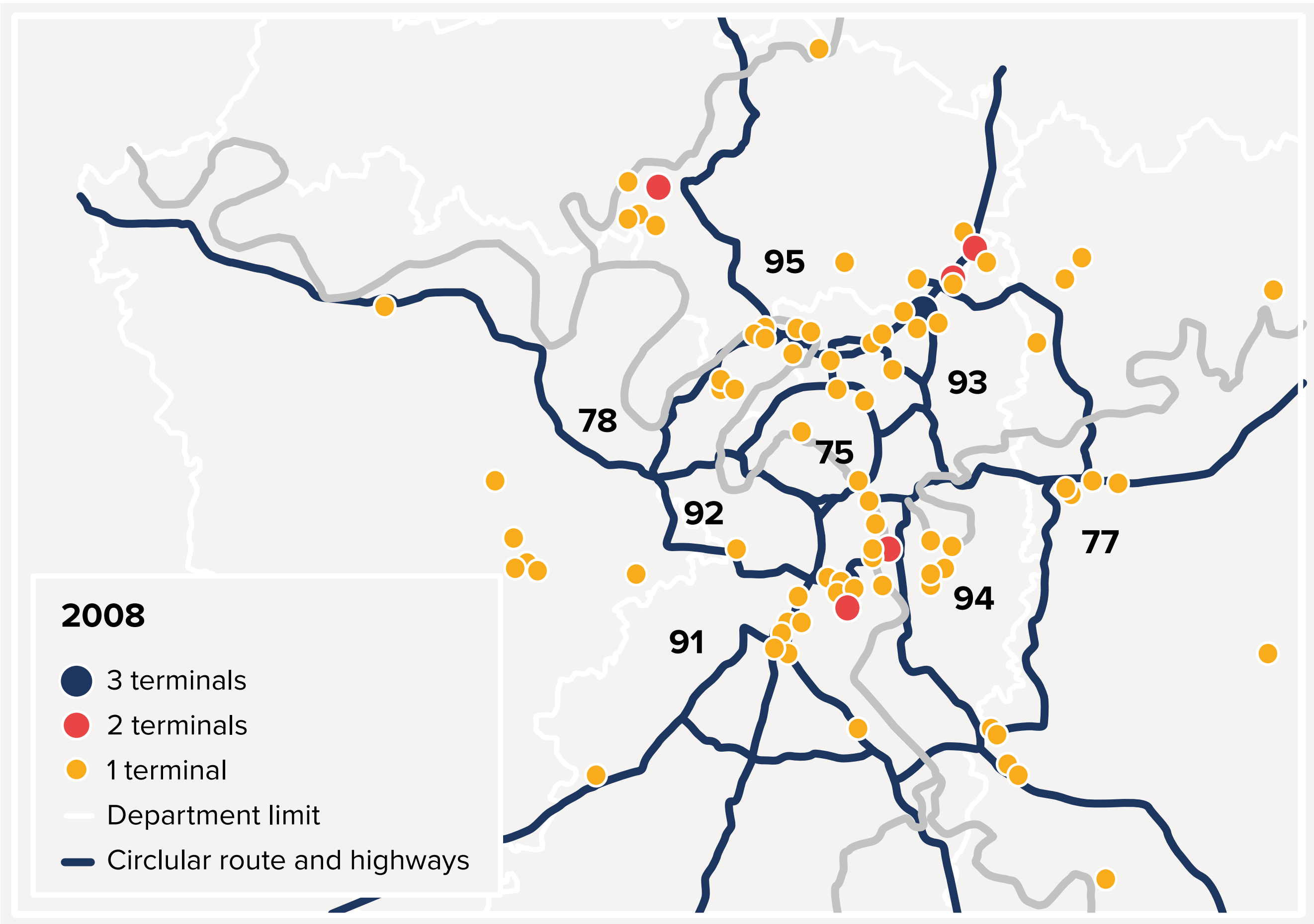



**Figure 9:** Average change warehouse distance from city center (kilometers) in select global cities

| | |
|---|---|
| » Description | Logistics sprawl is the propensity for the distribution centers, which serve urban freight demand to move progressively further from the city center. The immediate effect of logistics sprawl is that each trip from a distribution center grows longer, increasing vehicle kilometers required to meet freight demand. Two main causes of logistics sprawl exist – increasing land prices in urban cores, which price out logistics uses and the changing land-use regulations, which zone out logistics facilities. In some cases, when logistics establishments generate large volumes of heavy truck travel, their exit from the urban core may be a net positive. However, for goods consumed in the city such as food and consumer goods, if logistics sprawl increases total vehicle travel and forces the use of larger delivery vehicles, it is typically a net negative. |




**Figures 10 & 11:** Logistics Sprawl in Parisian Parcel Distribution Centers in 1974 and 2008[8]

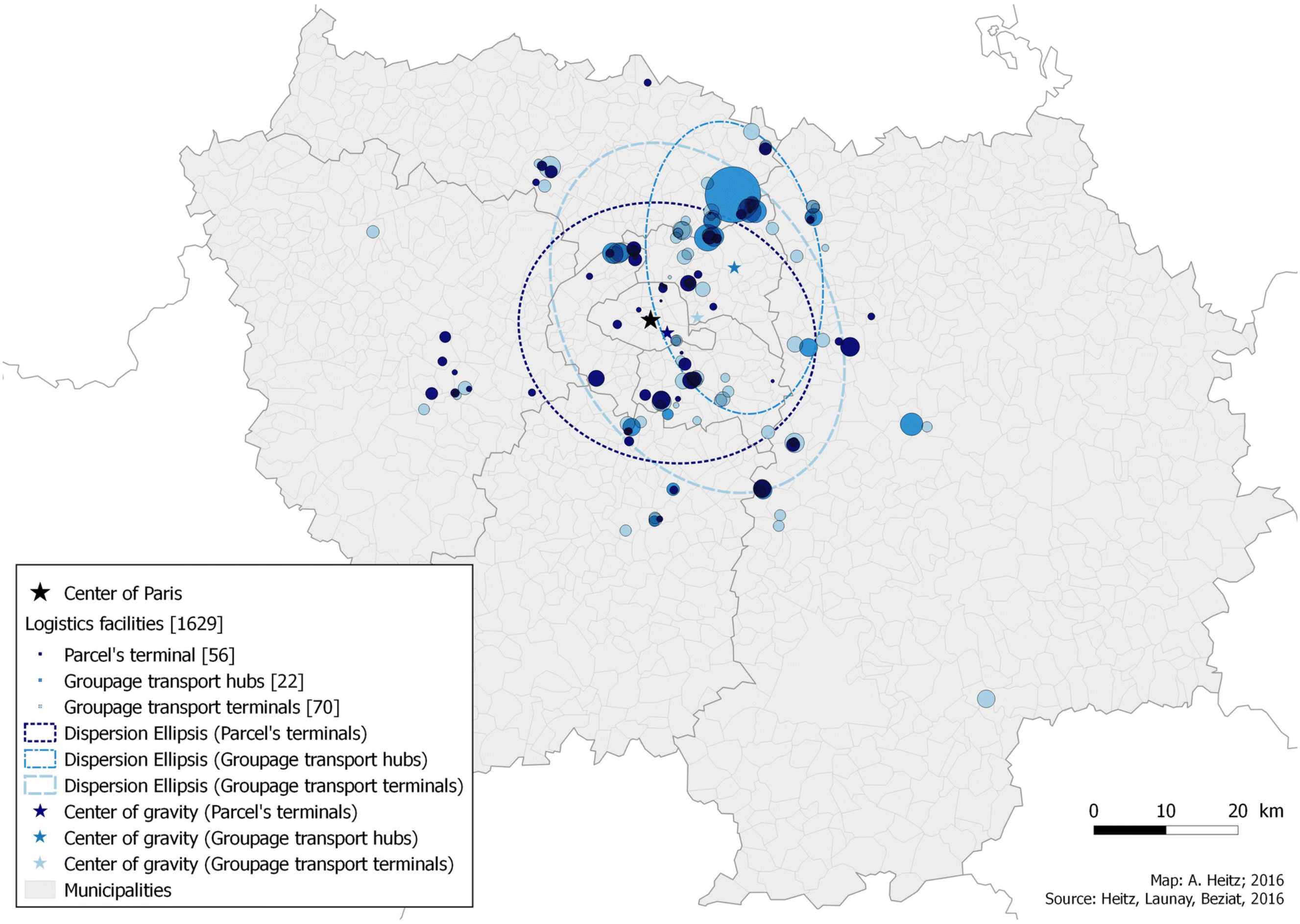
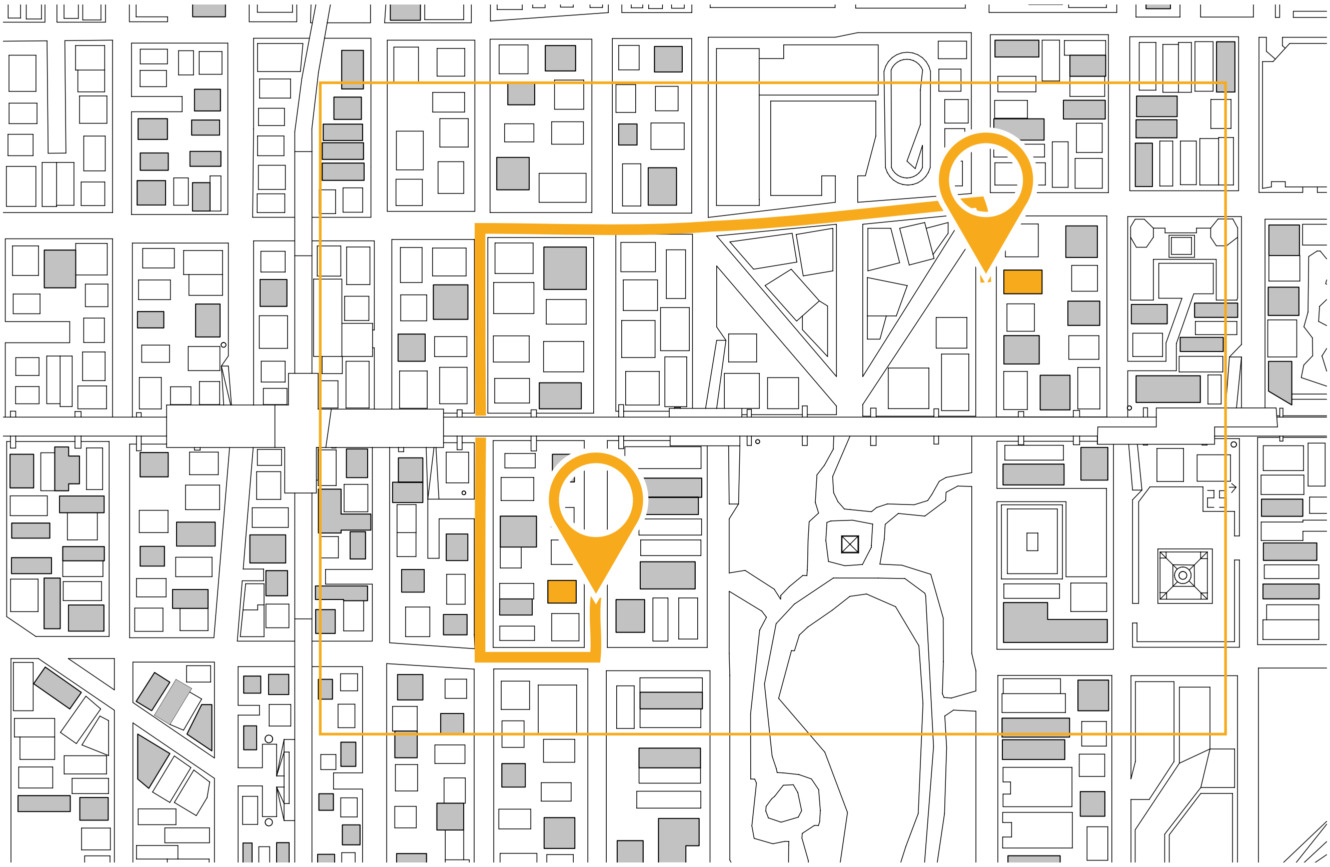



**Figure 12:** Spatial distribution of groupage network of hubs and terminals
Source: Heitz, Adeline, Pierre Launay, and Adrien Beziat. "Heterogeneity of logistics facilities: an issue for a better understanding and planning of the location of logistics facilities." European Transport Research Review 11.1 (2019): 5.

» Pathways to improvement

The primary pathway to combat logistics sprawl is to identify sectors of urban delivery, which serve the demand of urban consumers such as inventory restocks to shops and restaurants or e-commerce deliveries and actively seek to keep warehousing infrastructure serving that demand in the urban core. Measures may include preferred pricing of brownfield land for logistics development or modifications to planning and zoning laws that encourage logistics use of suitable land in the urban core.

## 2.7 Routing efficiency



Efficient deliveries minimizing vehicle travel

» Description

Routing efficiency is closely related to delivery productivity and focuses specifically on one aspect of delivery productivity— how efficiently operators string together various stops on a delivery tour and therefore their ability to minimize vehicle travel while making deliveries. While arriving at the optimal sequence of deliveries to minimize total driving is a private sector concern, policy decisions can constrain the solution space. For that reason, policymakers should seek to understand how elements of infrastructure, urban planning and vehicle access policy all influence the ability of private sectors to optimize their activities.

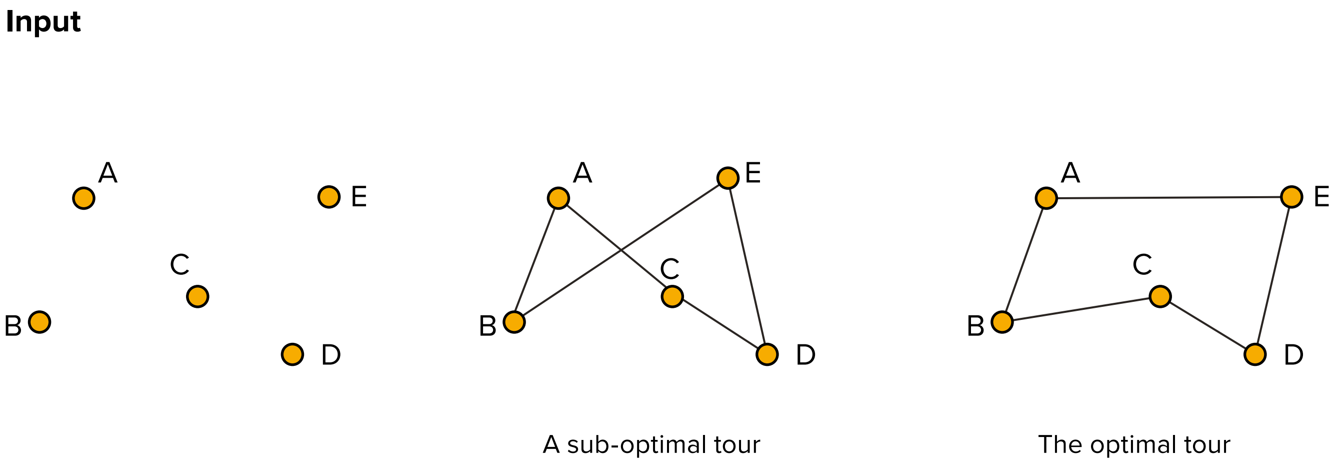
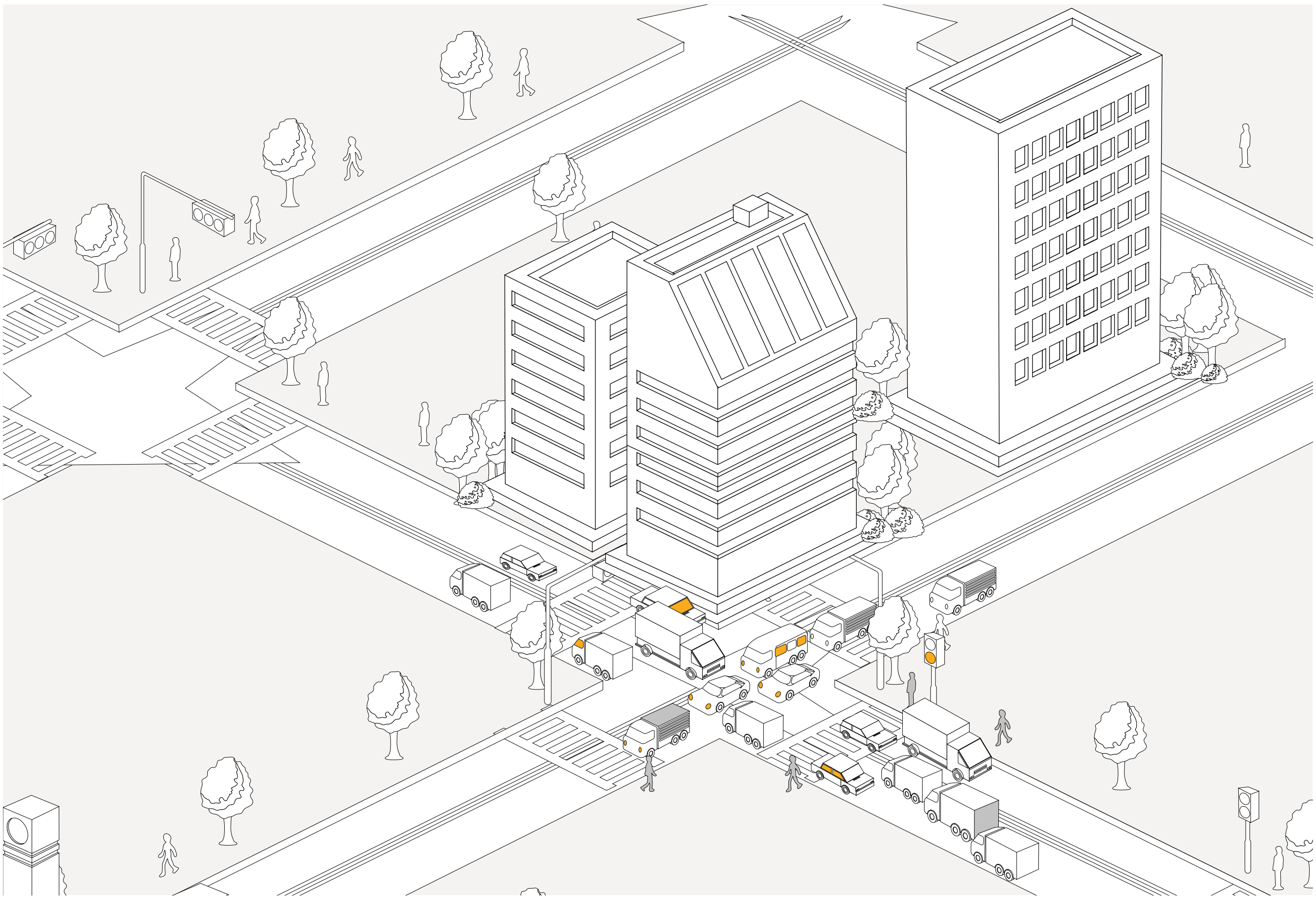



**Figure 13:** Optimal and sub-optimal routes on delivery tours.

» Pathways to improvement

For policymakers, the goal for routing efficiency is to create a system that enables maximum routing efficiency for logistics operators without compromising on the quality of life for urban residents. To that end, policymakers can examine infrastructure or policies, which force operators to choose suboptimal routes. As with vehicle size, however, policymakers must keep an eye on minimizing total systemic cost, not merely maximizing metric performance. Other circumstances where policymakers can positively influence routing efficiency is when operators are lacking either the information or scale to route trucks efficiently themselves. In such cases, provision of information, for example through either intelligent transportation systems (ITS) or the provision of infrastructure such as consolidation centers, can enhance routing.



## 2.8 Travel time index on freight lanes

» Description

Logistics uses can cause congestion by illegal parking and by using vehicles that are poorly suited to urban roads. Both hurt traffic fluidity. However, delivery vehicles also suffer from congestion. The costs that congestion imposes on logistics operators, which typically are directly passed on to consumers, are often under appreciated. For example, in US cities, the cost of congestion per vehicle hour is estimated at $94.04, much higher than the $17.67 cost per vehicle hour for passenger vehicles[9]. For this reason, efficient urban logistics must focus not only on reducing congestion caused by logistics uses but also seek to mitigate the effects of congestion on delivery vehicles themselves.

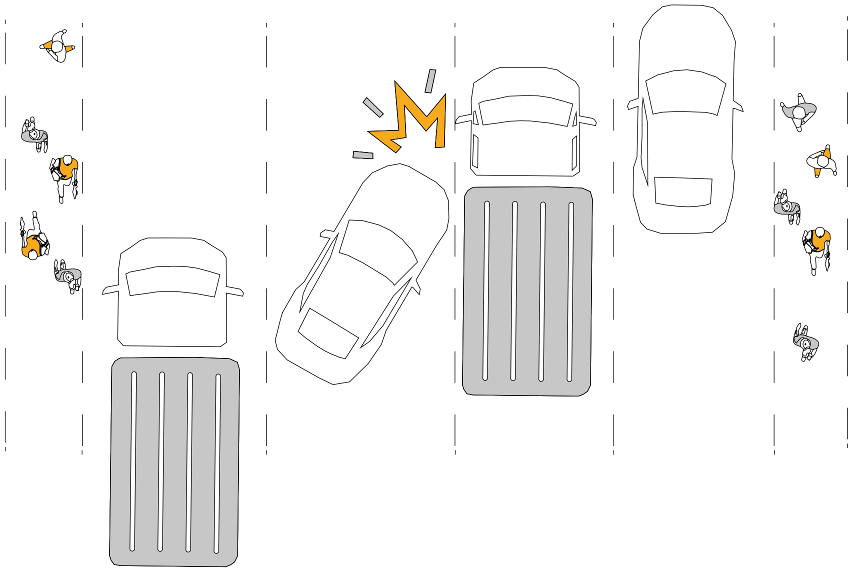
Intelligent transport systems

» Pathways to improvement

Restricting truck access to certain routes can ensure the smooth functioning of urban mobility systems. However, concentrating logistics uses onto certain corridors also increases the cost of congestion in those corridors. As policymakers reduce the flexibility of delivery vehicles to certain corridors, they must pay particular care to the performance of those corridors.

Policies such as congestion pricing and tolling, regular maintenance of road surfaces, ITS to provide real-time updates on corridor conditions, access restrictions for incompatible uses such as walking, cycling or other slow-moving vehicles and high priority resolution of traffic bottlenecks along freight corridors can all reduce congestion in key freight corridors.

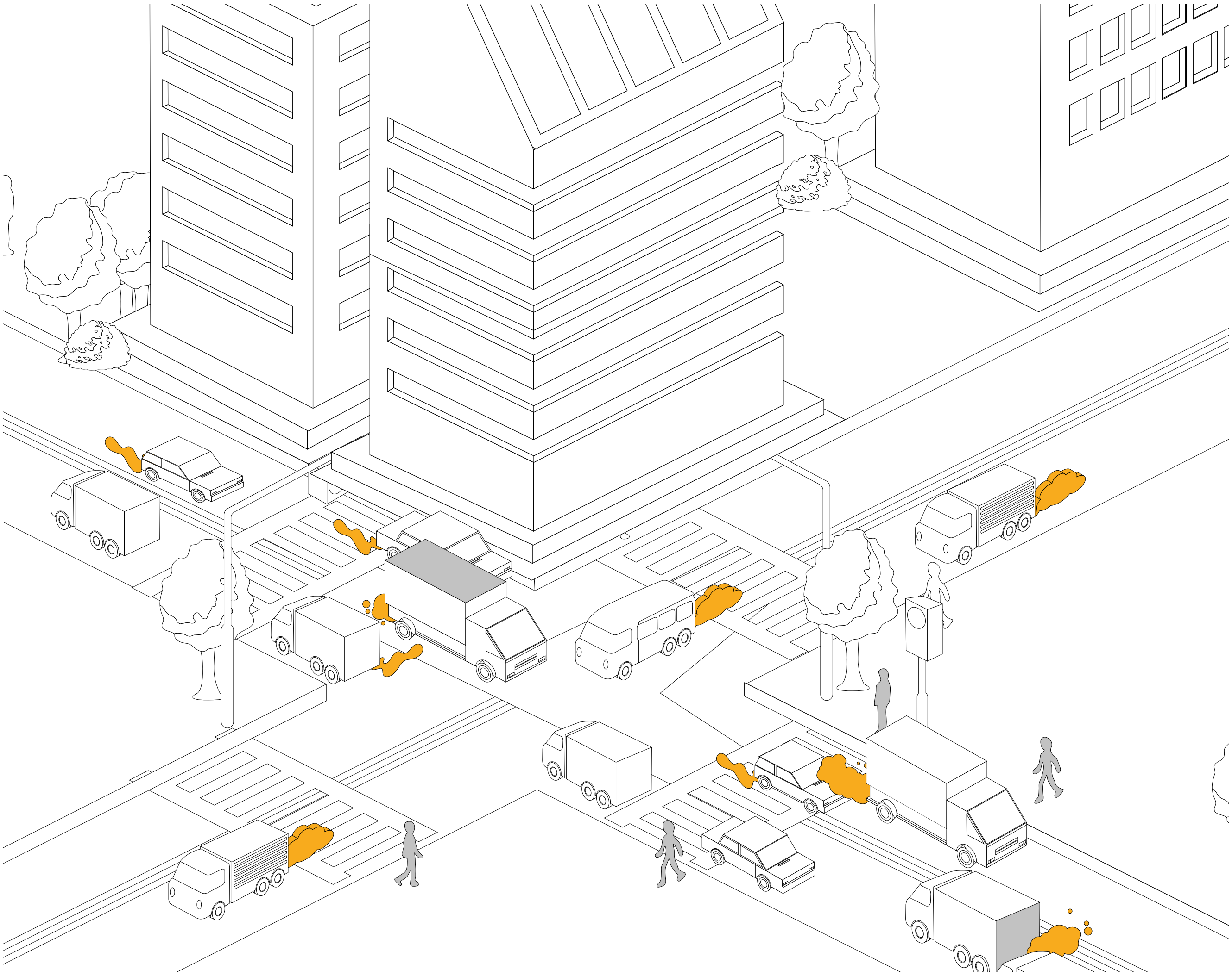
## 2.9 Truck-related casualties



Traffic injuries and fatalities

| | |
|---|---|
| » Description | Logistics vehicles, in particular heavy trucks, are disproportionately responsible for traffic injuries and fatalities. This is especially true when they are mixed with non-motorized, two and three-wheeler traffic. Heavy vehicles with poor maneuverability, large blind spots and long braking distances tend to produce very destructive collisions. |
| » Pathways to improvement | In order to mitigate safety problems without undermining the efficient functioning of urban distribution systems, policymakers can develop truck routes, which concentrate truck travel onto suitable high capacity roads where conflicts with other types of vehicles are minimized. Policymakers can also enhance enforcement of illegal overloading and poorly maintained vehicles. Furthermore, regulations such as speed limits should be robustly enforced to protect vulnerable user groups where infrastructure must be shared. Similarly, system design decisions, for example signal timing or robust physical barriers separating vehicular traffic from non-vehicular traffic, can be adjusted to favor the safety of pedestrians. |

## 2.10 Truck emissions



Tailpipe emissions from truck

| | |
|---|---|
| » Description | Logistics vehicles, especially diesel trucks, account for a disproportionately large amount of transport emissions, both air pollutants and greenhouse gases. These pollutants reduce livability of cities and take years off the lives of their inhabitants. |
| » Pathways to improvement | Policymakers can restrict access to cities for trucks that do not comply with the required emissions criteria. In the most ambitious cases, policymakers can require zero emissions logistics vehicles such as electric ones for all urban deliveries. |

## 2.11 Unit costs

» Description

Unit costs are the direct costs incurred by delivery vehicles per kilometer that they drive. Unit costs typically consist of fixed and variable costs. Fixed costs do not vary with vehicle use. They are composed of vehicle costs, financing costs, basedriver wages and items such as insurance and registration fees. Variable costs on the other hand, vary linearly with vehicle use and consist of fuel, maintenance, tires and any variable driver wages. Cost reduction is at the core of competitiveness and therefore is mostly a commercial matter.

**» Unusually low-unit costs can be an indicator that operators are externalizing costs onto urban residents such as through overloading, the use of low-quality fuel or the use of obsolete or non-compliant trucks. «**

However, the metric is of interest for policymakers for two reasons:

**01** Policymakers should always evaluate the effect policy changes will have on operator costs because urban logistics costs are typically entirely passed on to the consumer; increased costs to logistics players represent a direct burden to the urban economy and that impact should be understood.

**02** Policymakers should be on the lookout for unusually low-unit costs; it can be an indicator that operators are externalizing costs onto urban residents such as through overloading, the use of low-quality fuel or the use of obsolete/ non-compliant trucks.

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