This section describes key performance indicators (KPIs) for monitoring a city’s progress toward making its urban freight system more efficient, and outlines a data acquisition strategy for monitoring the KPIs.
Evaluation metrics: Urban freight

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Introduction to Freight Performance Measurement

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Introduction to freight performance measurement

Purpose and logic of performance measurement:
Measuring urban freight efficiency is a complex undertaking. Many different causes, which are often mutually interdependent, contribute to the overall efficiency of urban logistics. To isolate each individual cause of inefficiency and attempt to measure it, would require large amounts of data which would be difficult and costly to collect and would create an unwieldy system of hundreds of KPIs which policy makers would not necessarily be able to act on. For that reason, rather than trying to isolate and measure every potential cause of inefficiency, we suggest a set of metrics which are easy to understand and collectively describe key elements of urban freight efficiency that are amenable to action by policy makers. This KPI system is designed to help policy makers understand, at a high level, what goods can be removed from city roads; goods which must travel on city roads; how much vehicle travel to move those goods can be reduced; and finally, for vehicle travel that must occur, how much cost, both internal and external, can be removed from the system. The below diagram describes the logic of that KPI system and how it positions policy makers to intervene.

Figure 1: High level rationale of a performance measurement system for urban logistics
Expanding the logic of the above diagram into more detail produces a metric system that can allow policy makers to quickly understand the performance of their urban logistics system and what categories of solutions could improve performance.

**Metric introduction**
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.

<table>
<thead>
<tr>
<th>Inefficiency Category</th>
<th>Sub-Category</th>
<th>Key Performance Index (KPI)</th>
<th>Calculation Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>Local</td>
<td>1. Freight Intensity of GDP</td>
<td>Ton/RsGDP</td>
</tr>
<tr>
<td></td>
<td>Through</td>
<td>2. Share of Total Freight Demand</td>
<td>Ton-through/Total Tons</td>
</tr>
<tr>
<td>Vehicle Travel</td>
<td>Trips</td>
<td>3. Vehicle Loading Capacity</td>
<td>Tons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Net Load Factor</td>
<td>Ton-km/GVWR*km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Delivery Productivity</td>
<td>Deliveries/hour</td>
</tr>
<tr>
<td></td>
<td>Trip Distance</td>
<td>6. Logistics Sprawl</td>
<td>KM to Barycenter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Routing Efficiency</td>
<td>Deliveries/KM driven</td>
</tr>
<tr>
<td>External Cost</td>
<td>Congestion</td>
<td>8. Travel Time Index on Freight Lanes</td>
<td>Time during peak congestion/free flow</td>
</tr>
<tr>
<td></td>
<td>Safety</td>
<td>9. Truck-related Casualties</td>
<td>Injuries and fatalities/KM driven</td>
</tr>
<tr>
<td></td>
<td>Pollution</td>
<td>10. Logistics Vehicle Emissions</td>
<td>grams/km (CO₂, SOx, NOx, PM, VOC, O₃, etc)</td>
</tr>
</tbody>
</table>
Further explanation of metric definition and potential pathways to improvement are discussed below. Specific examples of actions taken by cities globally to improve performance on these metrics, along with a brief evaluation of results are included in the best practices compendium accompanying this document.

**Caveats on interpretation**
Care must be exercised when interpreting this KPI system for two main reasons. The first is that the analysis of any single metric in isolation is not meaningful. Many of these metrics are inextricably tied together and changes to affect one metric can have knock on effects on many others. For example, a change in average truck size would have knock on effects on many other metrics such as load factor, number of trips, cost per km, delivery productivity, etc. The second is that attempting to use this KPI system to benchmark one city against another is not possible; 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 metric performance. As such this metric system is best evaluated holistically and as a time series, not individually or cross-sectionally. Furthermore when evaluating performance, robust engagement with logistics players, as outlined in the workbook document, can help policy makers interpret why metrics have changed and whether the overall evolution of the system was positive or negative.

**Metric discussion**

1) **Freight intensity of GDP**

Explanation: Producing goods and, to a lesser extent, services entails 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-add manufacturing and heavy industry, on the other hand, tend to produce relatively high freight demand per unit of GDP.

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

Figure 2: 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. That said, the composition of GDP is only partly in control of policy makers. Many other elements, such as land prices, infrastructure layout, access to suppliers, etc. all affect where businesses choose to locate. Furthermore, at certain stages, urban development, freight intensive activities such as fixed asset formation, infrastructure build-out and building stock creation are unavoidable.

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1) **Through-freight share of total demand**

**Explanation:** Goods moving through a city or metropolitan area which is neither produced nor consumed in the area is referred to as through freight. Through freight generates truck traffic, and associated costs in metropolitan areas without bringing significant economic benefit. Through freight accounting for up to 20% of metropolitan freight demand is common. Through freight is a particularly difficult question for urban planners. It tends to bring high external costs to a city while bringing little or no economic benefit, so it makes sense to eliminate it. However, it is typically the product of national transportation network planning, over which municipal policy makers have little control. Furthermore, if municipal policies disrupt national logistics activities, it can be a detriment to the economy as a whole.

![Figure 3: Freight demand in metropolitan Paris (ton/ $ GDP)](image)

**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, policy makers can build infrastructure, such as portside rail, that reduces truck travel generated by through freight. City policy makers can collaborate with national level policy makers on infrastructure creation to reduce the burden which through freight puts on cities, without undermining national logistics systems. Stakeholder engagement, through bodies similar to Metropolitan Planning Organizations (MPOs) described in the workbook document, is crucial for providing the infrastructure to mitigate the impact of national logistics activities on urban logistics efficiency.
2) Truck loading capacity

**Explanation:** The right size of delivery vehicles is a thorny question with multiple factors influencing the decision. Different types of freight, and different operational patterns require different types of vehicles, with vehicle size varying drastically across product segments and use cases. Broadly speaking, however, truck size influences 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.

![Figure 4: Gross vehicle weight rating (GVWR) of Delivery Vehicles in Paris](image)

**Pathways to improvement:** There is no one-size-fits-all answer for what the right size vehicle is and how vehicle size should be regulated. Such decisions must be made with a view towards both 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. On the infrastructure front, policy

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makers can evaluate factors such as turning radii, overhead clearances, road surfaces, lane width, existence and length of acceleration and deceleration lanes, etc. to see if infrastructural shortcomings are imposing unnecessary limits on vehicle size. On the policy front, designing a flexible system which allows heavy truck travel on critical 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, policy makers can continuously evaluate regulations on vehicle size and how the trade-off between trip generation and external cost creation is playing out and can adjust policy accordingly.

3) Net load factor

**Explanation:** Net load factors is 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. Similar to vehicle size, operators typically will seek to maximize net load factors in order to maximize operating margins and the role of policy makers in improving this metric is secondary. The relevance of the metric to policy makers, like vehicle size, 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, policy makers can adjust regulation and enforcement practices to maximize logistics efficiency.

**Pathways to improvement:** Why vehicles are underloaded or why they run empty are complex questions which are influenced by diverse factors such as geography, infrastructure, operational expertise, the willingness to collaborate with competitors, and many others. Broadly speaking, policy makers 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 is imposing unacceptably high costs on society, policy makers can also consider mandating measures, such as required consolidation, to improve load factors.
4) Delivery productivity

**Explanation:** Delivery productivity is closely related to load factor 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 in 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 5: Parisian Tour Times and Their Composition (Minutes)](image)

**Pathways to improvement:** As with other metrics that primarily measure operational efficiency, like net load factor, policy makers can consult with 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 that 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.

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5) Logistics sprawl

Explanation: 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. However, other negative knock-on effects exist as well. When distribution centers are closer to the urban core, final mile delivery can be carried out with smaller vehicles, including two and three-wheelers, which operate easily in the urban core. However, as distribution centers move out of the city, larger vehicles are used for final mile delivery. That is because, it is not economical to make trips back to a distant distribution center to reload during a day; large loads must be carried and delivered all during a single tour. Furthermore, smaller, slower vehicles are often poorly suited for the high-speed arterial roads that link a city to the suburbs, forcing operators to use larger more powerful vehicles. Two main causes of logistics sprawl exist - increasing land prices in urban cores which price out logistics uses and the changing land use practices 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.

Figure 6: Average Change Warehouse Distance From City Center (Kilometers) in select global cities

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.

6) Routing efficiency

Explanation: 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 in the urban core. This metric is particularly important in urban logistics where the process of planning delivery routes is complex and often computationally intensive. Like other metrics that are closely related to operational efficiency, the routing efficiency metric is primarily the concern of the private sector. However, 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, policy makers should seek to understand how elements of infrastructure, urban planning and access policy, all influence the ability of private sector actors to optimize their activities.

Pathways to improvement: For policy makers, the goal for routing efficiency is to attempt to create a solution space that enables maximum routing efficiency for

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logistics operators without compromising quality of life for urban residents. To that end, policy makers can examine infrastructure or policies, such as truck routes and road conditions, for inefficiencies which force operators to choose suboptimal routes. As with vehicle size, however, policy makers must keep an eye on minimizing total systemic cost, not merely maximizing metric performance. Full elimination of all access restrictions in a city would allow for maximum flexibility and efficiency in routing decisions. However, the use conflicts created by allowing heavy trucks to move through residential roads would far outweigh any efficiencies gained in route optimization. These tradeoffs must be considered when designing truck access policies. 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 intelligent transportation systems (ITS), or the provision of infrastructure, such as consolidation centers, can enhance routing efficiency.

7) Time travel index on freight lanes

Explanation: Logistics uses can cause congestion by illegal parking and by using vehicles that are poorly suited to urban roads both of which hurt traffic fluidity. However, delivery vehicles also suffer from congestion. The costs which congestion imposes on logistics operators, which typically are directly passed on to consumers, are oftentimes 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. 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.

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 on those corridors. As policy makers 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 on freight corridors can all reduce congestion on key freight corridors.
8) Truck-related casualties

**Explanation:** 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.

9) Truck emissions

**Explanation:** 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 of the lives of their inhabitants.

**Pathways to improvement:** Policymakers can restrict access to cities for trucks that do not comply with required emissions criteria. In the most ambitious cases, policymakers can require zero emissions logistics vehicles, such as electric, for all urban deliveries.

10) Unit costs

**Explanation:** 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, base driver 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. However the metric is of interest for policy makers for two reasons. First policy makers should always evaluate the effect policy changes will have on operator costs. Because urban logistics costs are typically entirely passed through to the consumer, increased costs to logistics players represent a direct burden to the urban economy and that impact should be understood. Second policy makers 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.

Pathways to improvement: Because fixed costs do not vary with truck use, the most direct pathway to reduce fixed costs per kilometer is to increase truck productivity. This can be done by enhanced congestion management, better provision of parking spaces for delivery vehicles and well-researched, cautious relaxation of urban entry restrictions for delivery vehicles. As productivity improves, variable costs also have a tendency to fall. That is because trucks with greater utilization require more fuel and maintenance on an annual basis than those that are poorly used. To reduce those high variable costs, operators are more likely to invest in higher quality trucks with better fuel efficiencies and a lower likelihood to break down.