A DEMAND-ORIENTED POLICY FRAMEWORK TO EXTEND THE LIFE OF ROAD ASSETS

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Abstract
Transport agencies face problems with ageing road infrastructure assets, yet budgetary constraints and competition for scarce public resources often inhibit or delay maintenance activities. Simultaneously, the demand for road freight transport continues to rise and become more complex. In 2017-2018, the OECD-ITF convened a working group to develop new policy options for extending the life of road assets by mitigating deterioration caused by trucks[1]. Beyond traditional engineering responses, the group considered the role of trucks in road asset deterioration from a broader, demand-oriented perspective. This paper, the first in a set of four papers presented at HVTT16 that explore themes from the ITF report, characterizes the need for the new demand-oriented asset management policy framework. It also introduces international best practices on how to: (1) develop scenarios to anticipate future road freight transport demand and understand trade-offs, (2) characterize the complexity of road freight transport demand, and (3) integrate data governance within road asset management.

Keywords: Heavy vehicles, Asset management, Policy, Digitalization, Data governance, Road freight transport demand

[1] Portions of this paper have been excerpted by permission from: International Transport Forum (ITF). (2018), Policies to Extend the Life of Road Assets, ITF Research Reports, Organisation for Economic Cooperation and Development (OECD) Publishing, Paris.

1. Introduction

Transport agencies in both developed and developing economies face problems with ageing infrastructure, yet budgetary constraints and competition for scarce public resources often inhibit or delay maintenance activities. Simultaneously, the demand for road freight transport continues to rise and become more complex. These trends are likely to continue, making proactive asset management ever more urgent. In this context, the proliferation of unconventional data sources and digitalization offer new opportunities to manage assets in response to road freight transport demand and to regulate and even influence this demand.

In 2017-2018, the OECD-ITF convened a working group to develop new policy options for extending the life of road assets by mitigating deterioration caused by trucks. The working group included 27 renowned practitioners and academics from 17 countries with expertise in asset management, traffic management, vehicle dynamics, logistics and economics, truck operations, and transport regulation and compliance. Beyond traditional engineering responses, the group considered the role of trucks in road asset deterioration from a broader, demand-oriented perspective. This resulted in a new policy framework for maintaining and managing road assets in a cost-effective way and to meet road freight transport demand on a sustainable basis. The new policy framework contains three groups of policy measures: demand-responsive policies; policies that regulate demand; and policies that influence demand (ITF, 2018).

As a special contribution to the HVTT16, members of the working group have elaborated the new demand-oriented policy framework through four thematically-linked papers. The four papers will examine: (1) the need for the new policy framework (this paper), (2) proactive maintenance and asset management, (3) supportive regulatory and compliance frameworks, and (4) traffic and logistics management. Each paper will illustrate policies using best practices and experiences from around the world.

To set the stage, this paper characterizes the need for the new demand-oriented asset management policy framework and outlines the proposed framework. It also examines the role of data and digitalization within road asset management, as agencies aim to better balance the demand for road infrastructure use and the challenge of maintaining ageing infrastructure with constrained budgets. The paper presents three case studies to illustrate the policy framework and to emphasize the importance of data and digitalization within the framework. The first case study demonstrates the application of scenario analysis to quantify future road freight transport demand. The second study discusses the application of a data-driven, sector-based approach for characterizing current road freight transport demand. Finally, the third study describes general tools for making performance-based asset management decisions, with a particular focus on data governance. The paper closes by drawing insights from the case studies and making recommendations for further work.

2. Demand-Oriented Policy Framework for Road Asset Management

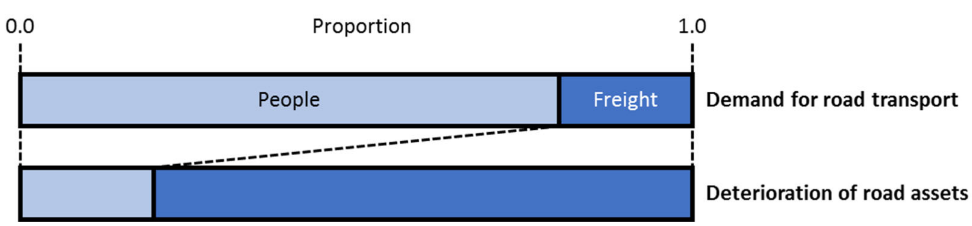
This section characterizes the need for a new policy framework for road asset management, building on practices within the civil engineering domain. It also outlines the proposed demand-oriented policy framework and discusses the importance of data within this framework.

2.1 Need for a New Policy Framework

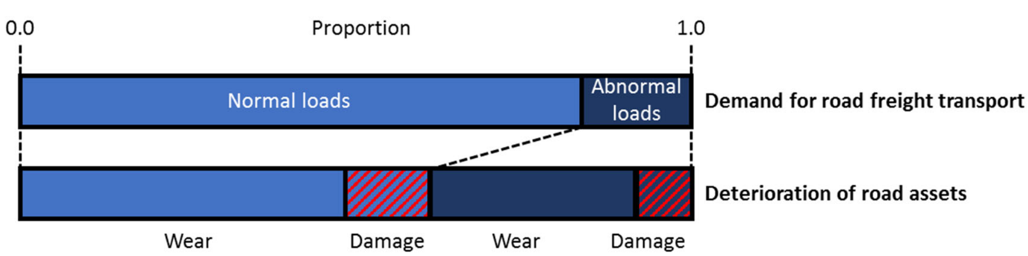
Road infrastructure asset life depends on numerous design, construction, maintenance, environmental, and operational factors. Within these factors, the use of road assets by trucks plays a substantial role (OECD Road Transport Research Programme, 1998; ITF, 2011). The interaction between trucks and road assets is complex, not only because of the wide range of trucking activity, truck types and configurations, loads, and physical and operating characteristics, but also because the condition of the asset influences the dynamic loads imposed by trucks using it. Consequently, the effective design and management of road assets relies on an understanding of how these characteristics and interactions influence asset life. Research and development efforts principally within the civil engineering domain continue to enhance this understanding.

Despite the importance of these ongoing efforts, as a policy-level document, ITF (2018) considers the role of trucks in road asset deterioration from a broader, demand-oriented perspective. By doing so, the report contributes to a more comprehensive view of how to maintain and manage road assets—a view which encompasses policies that respond to current and projected freight transport demand, policies that regulate the demand for truck transportation, and policies that influence the magnitude and nature of freight demand.

Figure 1 conceptually illustrates the relationship between the demand for road transport and road asset deterioration. As shown in Figure 1a, the movement of people and freight comprise the total demand for road transport. While freight transport demand represents a minority share of this demand (when measured in terms of the total distance travelled on a network), the trucks that serve this demand cause a disproportionately high share of road asset deterioration. A similar relationship is evident when considering the demand for road freight transport, as shown in Figure 1b. Here, trucks carrying abnormal loads cause a relatively high proportion of road asset deterioration compared to trucks carrying normal loads, even though they serve a relatively small proportion of total road freight transport demand.



(a)



(b)

Figure 2 – The relationship between road transport demand and the deterioration of road assets (Source: ITF, 2018)

Figure 1.1b also conceptually illustrates the distinction between two components of road asset deterioration: 'wear' and 'damage'. Road assets are designed to wear. Road asset wear occurs when trucks carrying either normal or abnormal loads comply with the maximum axle and total load limits considered in the design process. In contrast, damage (depicted conceptually with the red hatching in the diagram) is inflicted by normal or abnormal loads which exceed permissible maximum limits. While such occurrences may be relatively infrequent, they have the potential to be responsible for a disproportionately high share of road asset deterioration and maintenance costs.

2.2 A New Demand-Oriented Policy Framework

ITF (2018) approaches the development of policy options from a systems perspective—a perspective that acknowledges the complex and interactive nature of various influencing factors, identifies possible trade-offs between alternative courses of action, and highlights issues that policy and decision-makers should consider. The policy framework, depicted in Figure 2, comprises three categories: (1) demand-responsive policies; (2) policies that regulate demand; and (3) policies that influence demand. The following points describe these categories in further detail. The case studies presented in the next section demonstrate how certain agencies are moving forward with this perspective—particularly as regards the demand-responsive policies. The subsequent papers in this thematic series offer further insights and recommendations on the nature of the policies within each category.

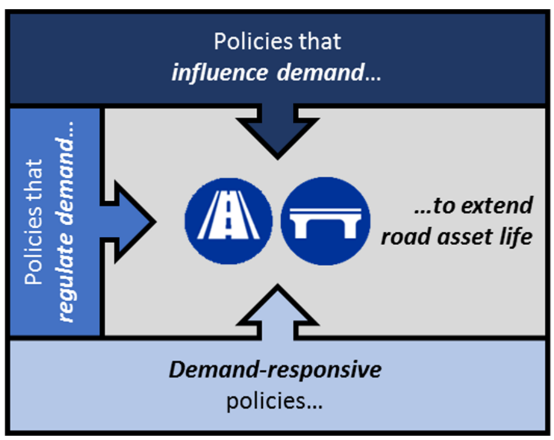


Figure 2 – A demand-oriented policy framework for road asset management (Source: ITF, 2018)

- *Demand-responsive policies*: Policies within this category aim to better align the planning, maintenance, and management of road assets with the current and projected use of these assets by trucks. As illustrated in Figure 2, these policies are foundational and enabling for subsequent policies that aim to regulate and influence road freight transport demand. Traditionally, the management of road assets occurs within the domain of civil engineering. Within this context, considerable improvements have been made in better utilizing financial, human, and technological resources to plan, design, inspect, and maintain road infrastructure. Indeed, current practice has evolved from the concept of reactively managing one's assets (often within a single asset class) to the more holistic concept of asset management throughout the asset's lifecycle and across asset classes.

- *Policies that regulate demand*: Policies within this category focus on developing more effective regulation of truck transportation—including the management of restricted access to specific parts of the road network—and ways to improve compliance with these regulations. While infrastructure protection is commonly cited as a reason for establishing and enforcing regulations, the pursuit of regulatory compliance typically occurs outside the asset management domain.
- *Policies that influence demand*: Policies within this category attempt to influence transport and logistics behaviours—both in real-time and in the longer term—and thereby slow down the process of deterioration of road assets by trucks. As new technologies emerge, opportunities arise to more purposefully direct truck transportation to avoid undue wear and damage of road assets. These policies have seldom been thoroughly considered as opportunities to extend the life of road assets.

2.3 Data as an Asset

The collection, verification, and analysis of good-quality data and the digitalization and application of information comprise the foundation for managing ageing road infrastructure in the context of ever-changing demand. For example, pavement and bridge management systems rely on a well-defined strategy supported by physical condition data, current and future truck traffic and loading data, climate data, and treatment-related data to guide infrastructure investment decisions. Data and information technology needs will intensify as agencies seek to become more proactive, systematic, and strategic in the management of their road assets.

The importance of data within the provision and maintenance of road assets has motivated many transportation agencies to consider data itself as an asset. This emerging perspective creates both opportunities and challenges. New technologies and more advanced computational capabilities enable the collection, processing, and storage of more data than ever before. However, translating these data into useable information that supports effective and timely decisions remains elusive. Technical and institutional challenges occur when attempting to integrate data across diverse platforms. Increasing quantities of data do not always coincide with improved data quality. Privacy concerns pose barriers for data sharing and use. Questions remain about what, where, and when measurements should be made, the thresholds that trigger actions, and the types of actions that should be taken. More determined efforts to manage data are needed to overcome these challenges and enable these data to be used more effectively to manage physical road assets.

3. Case Studies

The section presents three case studies to illustrate the policy framework and to emphasize the importance of data and digitalization within the framework. The first case study demonstrates the application of scenario analysis to quantify future road freight transport demand. The second study discusses the application of a data-driven, sector-based approach for characterizing current road freight transport demand. The third study describes general tools for making performance-based asset management decisions, with a particular focus on data governance.

3.1 Case Study 1: The Trade-Off between Sustainability and Infrastructure

The first case study describes the importance of including scenarios about the future use of road infrastructure by freight transport (and in particular developments in the load spectrum) in the planning of replacement and renovation of ageing infrastructure (Ecorys, 2020).

The average weight of a truck has increased in recent decades. The models used by Rijkswaterstaat (the National Road Authority in the Netherlands) to make decisions about the infrastructure and determine the design standards are only based on truck volumes. Because of the ageing infrastructure in the Netherlands and because of the need for sustainability, life cycling costing and circular thinking have increased in importance. There is a need to make a more precise estimate of the expected load on the road infrastructure by road freight transport. Commissioned by Rijkswaterstaat, the consultancy Ecorys has therefore carried out a scenario study into trends and developments in the future use of road infrastructure by road freight transport with a time horizon of 2040. Figure 3 illustrates the framework for the scenario study.

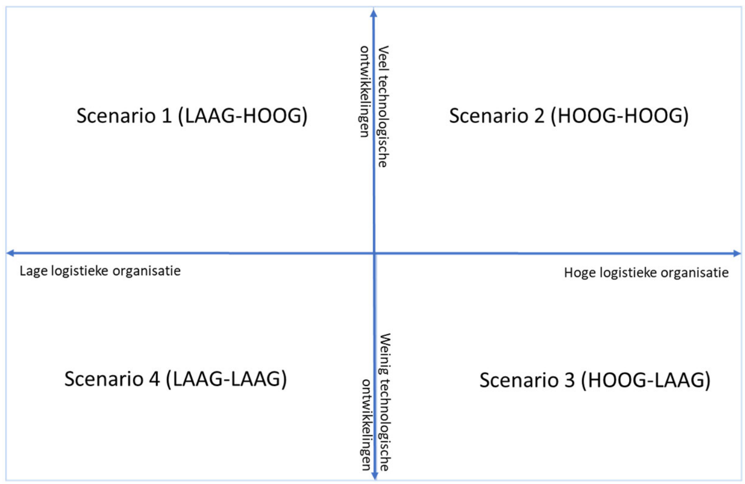


Figure 3 – Framework for the scenario study into the future use of infrastructure by road freight transport, Ecorys (2020)

The horizontal axis of Figure 3 shows the quality of the logistics organization (*logistieke organisatie*) from low (*laag* at left) to high (*hoog* at right). The logistics organization refers to the degree of efficiency and the quality of cooperation within the logistics chain and the transport sector. The vertical axis shows the extent of implementation of new technologies (*technologische ontwikkelingen*) from much (*veel* at top) to little (*weinig* at bottom). New technologies refer to the implementation of new vehicle concepts such as High Capacity Vehicles and automation of the driving task. The load on the infrastructure has been determined for all scenarios. Specifically, the influence on axle loads, total weight, distance between axles, and distance between vehicles was examined. These vehicle characteristics play a decisive role in the premature wear of the infrastructure.

The results show that in scenarios 1, 3 and 4, no additional load on the road infrastructure is to be expected and that the inclusion of truck traffic volumes, as is currently the case, is sufficient to estimate the future load. In scenario 2, however, the load on the road infrastructure increases significantly. In this scenario, the quality of the logistics organization increases, which is reflected in higher truck utilization rates, more bundling of goods, better horizontal and vertical cooperation in the logistics chain, and the far-reaching digitalization of processes to support the transport sector. In addition, more efficient vehicle concepts such as High Capacity Vehicles and truck platooning are given ample opportunity. The downside of this development within this scenario is that the load on the road infrastructure grows because the average weight of the axle loads and the total weight increase, and the distances between the successive passing axles and vehicles may change on average. This is all the more relevant because, under the influence of the climate objectives, this development is envisaged by transport policy.

The research shows that by only including truck volumes, extra load on the road infrastructure by truck traffic is missed, because the increase in the average weight is not taken into account. This calls for regular monitoring of the weight developments in freight traffic. The research also shows that there is a trade-off between sustainability and infrastructure that is often overlooked. The additional burden on the infrastructure can not only lead to additional costs, but also to additional emissions as a result of accelerated wear.

3.2 Case Study 2: Sector-Based Approach to Characterize Road Freight Transport Demand

This case study describes an approach to characterize road freight transport demand, integrating analytical techniques commonly used to model future freight transport demand and practices applied to monitor current truck traffic activity. The case study applies the approach to the petroleum industry in Manitoba, Canada, though it is considered generic and adaptable to any industry sector or geographic region.

In 2012, the southwest portion of the province of Manitoba, Canada experienced significant growth in road freight transport demand, stimulated by advances in multistage hydraulic fracturing and directional drilling and favourable economic conditions in the petroleum (oil and gas) sector. The increased demand induced noticeable shifts in truck traffic volume, the types of trucks used, and trip-making characteristics (e.g., origin, destination, trip length). These shifts represented immediate challenges in the maintenance of highway infrastructure (pavements, bridges, and unsurfaced roads), future highway planning and design, and ongoing asset management. To address these challenges, the Province commissioned a study to develop a comprehensive demand-oriented knowledge base that could help guide near-future infrastructure investment decisions.

The petroleum industry has complex freight transportation demands with dynamic temporal and spatial truck traffic characteristics. Consequently, the study developed and implemented an integrated framework to characterize and assign petroleum-related truck traffic to the regional highway network. The framework, proposed initially by Reimer and Regehr (2014a) and elaborated by Regehr and Hernandez (2018) and Regehr et al. (2020), integrates standard methodologies used for monitoring truck traffic and modelling freight transport demand to arrive at a common outcome: an estimate of current truck traffic activity generated by the petroleum industry. The truck traffic monitoring data provide details on truck traffic volumes, vehicle classification, vehicle and axle mass, and temporal and directional characteristics. The freight demand modelling process examines key economic indicators specific to the petroleum industry to characterize trip generation and link commodity movements with truck traffic.

One of the key results of the study was the development of a map depicting an estimate of daily truck traffic flow generated by the petroleum industry in the region (see Figure 4). The map illustrates network-wide flow in terms of the average number of trucks per day passing a point on a roadway due to petroleum-related activity (referred to as petroleum average daily truck traffic or PADTT). The PADTT shown in the figure reflected "business-as-usual" conditions throughout the region, as at 2013. The map and its underlying data produced insights regarding:

- key origins, destinations, and the spatial distribution of trips generated by the petroleum industry;
- modal inter-relationships (between road, rail, and pipeline) evident for accomplishing the freight transport task;
- temporal characteristics of freight transport demand and truck traffic activity; and
- the unique vehicle classes used within the industry and their mass characteristics.

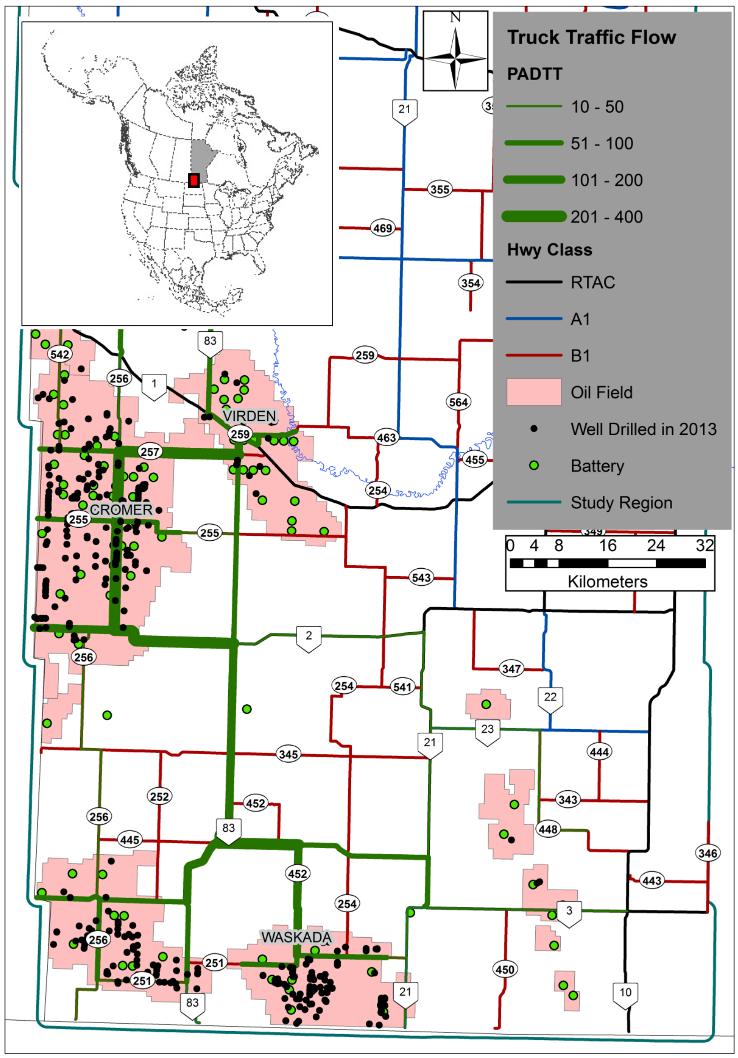


Figure 4 – PADTT flow map for southwest Manitoba, 2013 (Source: Reimer and Regehr, 2014b)

While global economic and energy trends have significantly curtailed petroleum production in Manitoba since 2013, the approach to understanding sector-specific dynamics, the fusion of disparate data sets, and the need to support urgent infrastructure management decisions provide useful lessons for similar developments.

3.3 Case Study 3: Tools for Making Performance-Based Asset Management Decisions

Road transport agencies increasingly implement performance-based decision-making approaches within their asset management programs. While there is broad recognition of the value of such approaches to achieve performance outcomes within the context of fiscal responsibility and accountability, the Transportation Association of Canada (TAC) recognized the need for practical examples and tools to help agencies advance asset management practices and optimize investments. To this end, based on a comprehensive review of literature and current agency practices across Canada, TAC (2021) outlines 14 tools in three categories to support performance-based decision making for asset management.

- *Tools for data management*: The five tools in this category focus on data governance (described in more detail below); quality assurance; data collection planning; data warehousing, storage, and access; and the use of geographic information systems (GIS).
- *Tools for analysis and evaluation*: The seven tools in this category describe various analytical techniques for road infrastructure asset management, including: life-cycle cost analysis, present worth analysis, internal rate of return analysis, benefit/cost analysis, risk assessment and risk management, cross-asset optimization, and multi-objective optimization.
- *Tools for communication*: The two tools in this category focus on the use of asset management data dashboards and report cards.

To illustrate the nature of these tools, this paper describes the data governance tool in further detail. This tool helps agencies (1) identify core data principles, (2) establish a data governance structure, and (3) develop an asset management data dictionary.

Adapting work by AASHTO (2013), the first component of the tool identifies core data principles that underpin the concept of data as an asset. These principles recognize that, like a physical road asset, data about those assets are valuable to the agency and should be maintained within an appropriate data governance structure. This means that for the effective management of data as an asset, those data need to be available and accessible, reliable for multiple use cases, and reside within a clear and efficient data management regime.

The second component of the tool defines the data governance structure in terms of people, processes, and technology (Stickel and Vandervalk, 2014; TRB, 2017). The tool recommends the establishment of a hierarchical arrangement of people involved in data governance. At the top, a steering committee oversees data governance practices and directs agency strategy. Next, enterprise-level data stewards help coordinate priorities across traditional subject areas and business units. Business-focused data stewards ensure data quality for specific data sets and define metadata. Finally, technically-focused data custodians execute day-to-day governance rules and management activities. This hierarchical arrangement of the people involved in data governance meshes with a set of processes required to implement the structure within the organization. For example, a key process for the steering committee is to develop strategy and align actions of various business units. Comparatively, data stewards focus on the process of establishing, enforcing, and maintaining data standards. Finally, technologies are needed to manage, fuse, analyze, model, and report data to serve the various agency needs.

The third component of the tool outlines how an agency can develop a detailed data dictionary to describe and organize data relevant to asset management. As an example, a transportation asset management unit may define several data domains, such as infrastructure data, financial data, and event data. Within these domains, data sub-domains might describe pavements, unpaved roads, and bridges under the infrastructure data domain, current year budget and expenditures under the financial domain, and historical maintenance actions and damage records under the recorded events domain. Establishment and routine updating of data dictionaries helps agencies recognize the inter-relationships amongst data sets normally housed within disparate business units.

As noted by TAC (2021), implementing data governance best practices requires efforts that span across multiple units within an agency, not just asset management. Nevertheless, since asset managers uniquely require multiple types of data to inform decisions, they play a critical role in establishing these practices within an agency. A strong data governance structure facilitates implementation of the other tools focused on data management, various analytical and evaluation methods, and communication.

4. Conclusion

Faced with the task of maintaining ageing infrastructure within constrained budgets, road agencies need a new policy framework for managing road assets so that they effectively serve road freight transport demands. Building on foundational civil engineering principles concerning the interaction of trucks and road infrastructure, this paper proposes a new, demand-oriented policy framework which directs asset managers to consider policies and actions that respond to freight transport demand, regulate that demand, and even influence that demand. The implementation of this framework relies on and is made possible by the availability of new data sources.

Regardless of the type of policy considered—responding, regulating or influencing—a fuller understanding is necessary of current and future road freight transport demand, of the trucks that serve this demand, and of the mechanisms by which their utilization of transport infrastructure deteriorates road assets. The three case studies presented in this paper emphasize this point and lead to the following insights.

First, as is evident from Case Study 1, asset managers need to answer the question: how can you avoid being faced with surprises because you have not given sufficient consideration to the changing use of road infrastructure by road freight transport? The scenario study shows that additional load on the infrastructure as a result of developments in the truck fleet and in the logistics organization can be overlooked if only truck volumes are taken into account and not developments in the average weight of trucks or with regard to distances between axles and/or vehicles. This is all the more important because, under the influence of climate objectives, transport policy aims to achieve higher efficiency in road freight transport, which can lead to a higher average weight of a truck and shorter following distances.

Second, as shown in Case Study 2, implementation of the policy framework necessitates integration of existing methodologies and data sources. By taking a sector-specific approach and fusing readily-available truck traffic and economic data, new information can be generated to inform infrastructure planning, design, and asset management decisions. This helps characterize the multiple dimensions of road freight transport demand.

Finally, agencies around the world recognize the need to make transparent, performance-based asset management decisions. But complexities arise when prioritizing expenditures, especially when there are multiple (and sometimes competing) objectives and when dealing with different classes of assets (e.g., pavements and bridges). Case Study 3 demonstrates the ongoing need to curate research and practice into tools for asset management practitioners—especially tools that help harness the power of data-driven decisions.

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